GE Healthcare

LightSpeed 2.X

Service Manual - General

OPERATING DOCUMENTATION

2243314-100
Rev 22

Book 1 of 6:

- Master TOC
- Preface
- Chapter 1 (Safety)
- Chapter 2 (Service Desktop, Tools and Diagnostics)

Pages # - 162

Effectivity

The information in this manual applies to the following GE Healthcare LightSpeed 2.X CT Scanners:

- LightSpeed Plus (SDAS)
- LightSpeed QX/i (SDAS)

IMPORTANT PRECAUTIONS

LANGUAGE

Предупреждение

(BG)

- ТОВА УПЪТВАНЕ ЗА РАБОТА Е НАЛИЧНО САМО НА АНГЛИЙСКИ ЕЗИК.
- АКО ДОСТАВЧИКЪТ НА УСЛУГАТА НА КЛИЕНТА ИЗИСКА ЕЗИК, РАЗЛИЧЕН ОТ АНГЛИЙСКИ, ЗАДЪЛЖЕНИЕ НА КЛИЕНТА Е ДА ОСИГУРИ ПРЕВОД.
- НЕ ИЗПОЛЗВАЙТЕ ОБОРУДВАНЕТО ПРЕДИ ДА СТЕ СЕ КОНСУЛТИРАЛИ И РАЗБРАЛИ УПЪТВАНЕТО ЗА РАБОТА.
- НЕСПАЗВАНЕТО НА ТОВА ПРЕДУПРЕЖДЕНИЕ МОЖЕ ДА ДОВЕДЕ ДО НАРАНЯВАНЕ НА ДОСТАВЧИКА НА УСЛУГАТА, ОПЕРАТОРА ИЛИ ПАЦИЕНТ В РЕЗУЛТАТ НА ТОКОВ УДАР ИЛИ МЕХАНИЧНА ИЛИ ДРУГА ОПАСНОСТ.

警告

(ZH-CN)

- 本维修手册仅提供英文版本。
- 如果维修服务提供商需要非英文版本，客户需自行提供翻译服务。
- 未详细阅读和完全理解本维修手册之前，不得进行维修。
- 忽略本警告可能对维修人员，操作员或患者造成触电、机械伤害或其他形式的伤害。

VÝSTRAHA

(CS)

- Tento provozní návod existuje pouze v anglickém jazyce.
- V případě, že externí služba zákazníkům potřebuje návod v jiném jazyce, je zajištění překladu do odpovídajícího jazyka úkolem zákazníka.
- Nesnažte se o údržbu tohoto zařízení, aniž byste si přečetli tento provozní návod a pochopili jeho obsah.
- V případě nedodržování této výstrahy může dojít k poranění pracovníka prodejního servisu, obslužného personálu nebo pacientů vlivem elektrického proudu, respektive vlivem mechanických či jiných rizik.

ADVARSEL

(DA)

- Denne servicemanual findes kun på engelsk.
- Hvis en kundes tekniker har brug for et andet sprog end engelsk, er det kundens ansvar at sørge for oversættelse.
- Forsøg ikke at servicere udstyret medmindre denne servicemanual har været konsulteret og er forstået.
- Manglende overholdelse af denne advarsel kan medføre skade på grund af elektrisk, mekanisk eller anden fare for teknikeren, operatøren eller patienten.

WAARSCHUWING

(NL)

- Deze onderhoudshandleiding is enkel in het Engels verkrijgbaar.
- Als het onderhoudspersoneel een andere taal vereist, dan is de klant verantwoordelijk voor de vertaling ervan.
- Probeer de apparatuur niet te onderhouden voordat deze onderhoudshandleiding werd geraadpleegd en begrepen is.
- Indien deze waarschuwing niet wordt opgevolgd, zou het onderhoudspersoneel, de operator of een patiënt gewond kunnen raken als gevolg van een elektrische schok, mechanische of andere gevaren.

WARNING

(EN)

- This Service Manual is available in English only.
- If a customer's service provider requires a language other than English, it is the customer's responsibility to provide translation services.
- Do not attempt to service the equipment unless this service manual has been consulted and is understood.
- Failure to heed this warning may result in injury to the service provider, operator, or patient, from electric shock or from mechanical or other hazards.

HOIATUS

(ET)

- Käesolev teenindusjuhend on saadaval ainult inglise keeles.
- Kui klienditeeninduse osutaja nõuab juhendit inglise keelest erinevas keeles, vastutab klient tõlketeenuse osutamise eest.
- Ärge üritage seadmeid teenindada enne eelnevalt käesoleva teenindusjuhendiga tutvumist ja sellest aru saamist.
- Käesoleva hoiatuse eiramine võib põhjustada teenuseosutaja, operaatori või patsiendi vigastamist elektrilöögi, mehaanilise või muu ohu tagajärjel.

VAROITUS

(FI)

- Tämä huolto-ohje on saatavilla vain englanniksi.
- Jos asiakkaan huoltohenkilöstö vaatii muuta kuin englanninkielistä materiaalia, tarvittavan käännöksen hankkiminen on asiakkaan vastuulla.
- Älä yritä korjata laitteistoa ennen kuin olet varmasti lukenut ja ymmärtänyt tämän huolto-ohjeen.
- Mikäli tätä varoitusta ei noudateta, seurauksena voi olla huoltohenkilöstön, laitteiston käyttäjän tai potilaan vahingoittuminen sähköiskun, mekaanisen vian tai muun vaaratilanteen vuoksi.

ATTENTION

(FR)

- Ce manuel de service n'est disponible qu'en anglais.
- Si le technicien du client a besoin de ce manuel dans une autre langue que l'anglais, c'est au client qu'il incombe de le faire traduire.
- Ne pas tenter d'intervenir sur les équipements tant que le manuel service n'a pas été consulté et compris
- Le non-respect de cet avertissement peut entraîner chez le technicien, l'opérateur ou le patient des blessures dues à des dangers électriques, mécaniques ou autres.

WARNUNG

(DE)

- Diese Serviceanleitung existiert nur in Englischer Sprache.
- Falls ein fremder Kundendienst eine andere Sprache benötigt, ist es aufgabe des Kunden für eine Entsprechende Übersetzung zu sorgen.
- Versuchen Sie nicht diese Anlage zu warten, ohne diese Serviceanleitung gelesen und verstanden zu haben.
- Wird diese Warnung nicht beachtet, so kann es zu Verletzungen des Kundendiensttechnikers, des Bedieners oder des Patienten durch stromschläge, Mechanische oder Sonstige gefahren kommen.

ΠΡΟΕΙΔΟΠΟΙΗΣΗ
(EL)

- Το παρόν εγχειρίδιο σέρβις διατίθεται στα αγγλικά μόνο.
- Εάν το άτομο παροχής σέρβις ενός πελάτη απαιτεί το παρόν εγχειρίδιο σε γλώσσα εκτός των αγγλικών, αποτελεί ευθύνη του πελάτη να παρέχει υπηρεσίες μετάφρασης.
- Μην επιχειρήσετε την εκτέλεση εργασιών σέρβις στον εξοπλισμό εκτός εαν έχετε συμβουλευτεί και έχετε κατανοήσει το παρόν εγχειρίδιο σέρβις.
- Εαν δε λάβετε υπόψη την προειδοποίηση αυτή, ενδέχεται να προκληθεί τραυματισμός στο άτομο παροχής σέρβις, στο χειριστή ή στον ασθενή από ηλεκτροπληξία, μηχανικούς ή άλλους κινδύνους.

FIGYELMEZTETÉS
(HU)

- Ezen karbantartási kézikönyv kizárólag angol nyelven érhető el.
- Ha a vevő szolgáltatója angoltól eltérő nyelvre tart igényt, akkor a vevő felelőssége a fordítás elkészíttetése.
- Ne próbálja elkezdeni használni a berendezést, amíg a karbantartási kézikönyvben leírtakat nem értelmezték.
- Ezen figyelmeztetés figyelmen kívül hagyása a szolgáltató, működtető vagy a beteg áramütés, mechanikai vagy egyéb veszélyhelyzet miatti sérülését eredményezheti.

AÐVÖRUN
(IS)

- Þessi þjónustuhandbók er eingöngu fáanleg á ensku.
- Ef að þjónustuveitandi viðskiptamanns þarfnast annas tungumáls en ensku, er það skylda viðskiptamanns að skaffa tungumálaþjónustu.
- Reynið ekki að afgreiða tækið nema að þessi þjónustuhandbók hefur verið skoðuð og skilin.
- Brot á sinna þessari aðvörun getur leitt til meiðsla á þjónustuveitanda, stjórnanda eða sjúklings frá raflosti, vélrænu eða öðrum áhættum.

AVVERTENZA
(IT)

- Il presente manuale di manutenzione è disponibile soltanto in inglese.
- Se un addetto alla manutenzione richiede il manuale in una lingua diversa, il cliente è tenuto a provvedere direttamente alla traduzione.
- Si proceda alla manutenzione dell'apparecchiatura solo dopo aver consultato il presente manuale ed averne compreso il contenuto
- Il non rispetto della presente avvertenza potrebbe far compiere operazioni da cui derivino lesioni all'addetto, alla manutenzione, all'utilizzatore ed al paziente per folgorazione elettrica, per urti meccanici od altri rischi.

警告
(JA)

- このサービスマニュアルには英語版しかありません。
- サービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。
- このサービスマニュアルを熟読し理解せずに、装置のサービスを行わないでください。
- この警告に従わない場合、サービスを担当される方、操作員あるいは患者さんが、感電や機械的又はその他の危険により負傷する可能性があります。

경고
(KO)

- 본 서비스 지침서는 영어로만 이용하실 수 있습니다 .
- 고객의 서비스 제공자가 영어 이외의 언어를 요구할 경우 , 번역 서비스를 제공하는 것은 고객의 책임입니다 .
- 본 서비스 지침서를 참고했고 이해하지 않는 한은 해당 장비를 수리하려고 시도하지 마십시오 .
- 이 경고에 유의하지 않으면 전기 쇼크 , 기계상의 혹은 다른 위험으로부터 서비스 제공자 , 운영자 혹은 환자에게 위해를 가할 수 있습니다 .

BRDINJUMS

(LV)

- Šī apkalpes rokasgrāmata ir pieejama tikai angļu valodā.
- Ja klienta apkalpes sniedzējam nepieciešama informācija citā valodā, nevis angļu, klienta pienākums ir nodrošināt tulkošanu.
- Neveiciet aprīkojuma apkalpi bez apkalpes rokasgrāmatas izlasīšanas un saprašanas.
- Šī brīdinājuma neievērošana var radīt elektriskās strāvas trieciena, mehānisku vai citu risku izraisītu traumu apkalpes sniedzējam, operatoram vai pacientam.

ĮSPĖJIMAS

(LT)

- Šis eksploatavimo vadovas yra prieinamas tik anglų kalba.
- Jei kliento paslaugų tiekėjas reikalauja vadovo kita kalba – ne anglų, numatyti vertimo paslaugas yra kliento atsakomybė.
- Nemėginkite atlikti įrangos techninės priežiūros, nebent atsižvelgėte į šį eksploatavimo vadovą ir jį supratote.
- Jei neatkreipsite dėmesio į šį perspėjimą, galimi sužalojimai dėl elektros šoko, mechaninių ar kitų pavojų paslaugų tiekėjui, operatoriui ar pacientui.

ADVARSEL

(NO)

- Denne servicehåndboken finnes bare på engelsk.
- Hvis kundens serviceleverandør trenger et annet språk, er det kundens ansvar å sørge for oversettelse.
- Ikke forsøk å reparere utstyret uten at denne servicehåndboken er lest og forstått.
- Manglende hensyn til denne advarselen kan føre til at serviceleverandøren, operatøren eller pasienten skades på grunn av elektrisk støt, mekaniske eller andre farer.

OSTRZEŻENIE

(PL)

- Niniejszy podręcznik serwisowy dostępny jest jedynie w języku angielskim.
- Jeśli dostawca usług klienta wymaga języka innego niż angielski, zapewnienie usługi tłumaczenia jest obowiązkiem klienta.
- Nie próbować serwisować wyposażenia bez zapoznania się i zrozumienia niniejszego podręcznika serwisowego.
- Niezastosowanie się do tego ostrzeżenia może spowodować urazy dostawcy usług, operatora lub pacjenta w wyniku porażenia elektrycznego, zagrożenia mechanicznego bądź innego.

ATENÇÃO

(PT)

- Este manual de assistência técnica só se encontra disponível em inglês.
- Se qualquer outro serviço de assistência técnica solicitar estes manuais noutro idioma, é da responsabilidade do cliente fornecer os serviços de tradução.
- Não tente consertar o equipamento sem ter consultado e compreendido este manual de assistência técnica.
- O não cumprimento deste aviso pode pôr em perigo a segurança do técnico, do operador ou do paciente devido a choques elétricos, mecânicos ou outros.

ATENȚIE

(RO)

- Acest manual de service este disponibil numai în limba engleză.
- Dacă un furnizor de servicii pentru clienți necesită o altă limbă decât cea engleză, este de datoria clientului să furnizeze o traducere.
- Nu încercați să reparați echipamentul decât ulterior consultării şi înțelegerii acestui manual de service.
- Ignorarea acestui avertisment ar putea duce la rănirea depanatorului, operatorului sau pacientului în urma pericolelor de electrocutare, mecanice sau de altă natură.

ОСТОРОЖНО!

(RU)

- Данное руководство по обслуживанию предлагается только на английском языке.
- Если сервисному персоналу клиента необходимо руководство не на английском, а на каком-то другом языке, клиенту следует самостоятельно обеспечить перевод.
- Перед обслуживанием оборудования обязательно обратитесь к данному руководству и поймите изложенные в нем сведения.
- Несоблюдение требований данного предупреждения может привести к тому, что специалист по обслуживанию, оператор или пациент получат удар электрическим током, механическую травму или другое повреждение.

UPOZORNENIE

(SK)

- Tento návod na obsluhu je k dispozícii len v angličtine.
- Ak zákazníkov poskytovateľ služieb vyžaduje iný jazyk ako angličtinu, poskytnutie prekladateľských služieb je zodpovednos″ou zákazníka.
- Nepokúšajte sa o obsluhu zariadenia skôr, ako si neprečítate návod na obluhu a neporozumiete mu.
- Zanedbanie tohto upozornenia môže vyústi″ do zranenia poskytovateľa služieb, obsluhujúcej osoby alebo pacienta elektrickým prúdom, do mechanického alebo iného nebezpečenstva.

ATENCION

(ES)

- Este manual de servicio sólo existe en inglés.
- Si el encargado de mantenimiento de un cliente necesita un idioma que no sea el inglés, el cliente deberá encargarse de la traducción del manual.
- No se deberá dar servicio técnico al equipo, sin haber consultado y comprendido este manual de servicio.
- La no observancia del presente aviso puede dar lugar a que el proveedor de servicios, el operador o el paciente sufran lesiones provocadas por causas eléctricas, mecánicas o de otra naturaleza.

VARNING

(SV)

- Den här servicehandboken finns bara tillgänglig på engelska.
- Om en kunds servicetekniker har behov av ett annat språk än engelska ansvarar kunden för att tillhandahålla översättningstjänster.
- Försök inte utföra service på utrustningen om du inte har läst och förstår den här servicehandboken.
- Om du inte tar hänsyn till den här varningen kan det resultera i skador på serviceteknikern, operatören eller patienten till följd av elektriska stötar, mekaniska faror eller andra faror.

DIKKAT

(TR)

- Bu servis kilavuzunun sadece ingilizcesi mevcuttur.
- Eğer müşteri teknisyeni bu kilavuzu ingilizce dişinda bir başka lisandan talep ederse, bunu tercüme ettirmek müşteriye düşer.
- Servis kilavuzunu okuyup anlamadan ekipmanlara müdahale etmeyiniz.
- Bu uyariya uyulmamasi, elektrik, mekanik veya diğer tehlikelerden dolayi teknisyen, operatör veya hastanin yaralanmasina yol açabilir.

DAMAGE IN TRANSPORTATION

Check for damage to property which may have occurred at the site during delivery, such as damage to floors, door frames or walls. If damage is found, notify the install specialist.

All packages should be closely examined at time of delivery. If damage is apparent, have notation “damage in shipment” written on all copies of the freight or express bill before delivery is accepted or “signed for” by a General Electric representative or a hospital receiving agent. Whether noted or concealed, damage MUST be reported to the carrier immediately upon discovery, or in any event, within 14 days after receipt, and the contents and containers held for inspection by the carrier. A transportation company will not pay a claim for damage if an inspection is not requested within this 14-day period.

To file a report:

- Call 1-800-548-3366 and use option 8.
- Fill out a report on http://egems.med.ge.com/edq/home.jsp
- Contact the local service coordinator for more information on this process.

Rev. Jan. 5, 2005

CERTIFIED ELECTRICAL CONTRACTOR STATEMENT

All electrical Installations that are preliminary to positioning of the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations and testing shall be performed by qualified GE Medical personnel. The products involved (and the accompanying electrical installations) are highly sophisticated, and special engineering competence is required. In performing all electrical work on these products, GE will use its own specially trained field engineers. All of GE’s electrical work on these products will comply with the requirements of the applicable electrical codes.

The purchaser of GE equipment shall only utilize qualified personnel (i.e., GE’s field engineers, personnel of third-party service companies with equivalent training, or licensed electricians) to perform electrical servicing on the equipment.

IMPORTANT...X-RAY PROTECTION

X-ray equipment if not properly used may cause injury. Accordingly, the instructions herein contained should be thoroughly read and understood by everyone who will use the equipment before you attempt to place this equipment in operation. The General Electric Company, Medical Systems Group, will be glad to assist and cooperate in placing this equipment in use.

Although this apparatus incorporates a high degree of protection against x-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly exposing themselves or others to radiation.

It is important that anyone having anything to do with x-radiation be properly trained and fully acquainted with the recommendations of the National Council on Radiation Protection and Measurements as published in NCRP Reports available from NCRP Publications, 7910 Woodmont Avenue, Room 1016, Bethesda, Maryland 20814, and of the International Commission on Radiation Protection, and take adequate steps to protect against injury.

The equipment is sold with the understanding that the General Electric Company, Medical Systems Group, its agents, and representatives have no responsibility for injury or damage which may result from improper use of the equipment.

Various protective materials and devices are available. It is urged that such materials or devices be used.

LITHIUM BATTERY CAUTIONARY STATEMENTS

CAUTION Risk of Explosion

Danger of explosion if battery is incorrectly replaced. Replace only with the same or equivalent type recommended by the manufacturer. Discard used batteries according to the manufacturer's instructions.

ATTENTION Danger d'Explosion

Il y a danger d'explosion s'il y a replacement incorrect de la batterie. Remplacer uniquement avec une batterie du même type ou d'un type recommandé par le constructeur. Mettre au rébut les batteries usagées conformément aux instructions du fabricant.

OMISSIONS & ERRORS

Customers, please contact your GE Sales or Service representatives. GE personnel, please use the GE Healthcare PQR Process to report all omissions, errors, and defects in this publication.

TRADEMARKS

All products and their name brands are trademarks of their respective holders.

Revision History

Rev.	Date	Reason for change
0	10/03/00	Initial Release - Document supports LightSpeed Plus Systems.
1	10/13/00	Updated for Full Production (M3).
2	02/22/01	Added procedure for FlexTrial Options. Added Sony Monitor Adjustments to Console Chapter (from Install Manual). CQA 1010858: Modified text in illustration for scan window installation. Updated for SCSI & Pegasus IG Upgrades.
3	04/11/01	CQA 101028 - Added Panic Error T/S (to Chapter 5). CQA 1008176 - Added Daily IQ Check to FastCal information (in Chapter 2). Removed Incomplete Tables (6-11 thru 6-14) from Chapter 7, section 1.2.7. Added warm-up process to DAS cleaning procedure (in Chapter 7). Removed X-Windows Overview (former Appendix A). Removed various references to O2, SBC.
4	08/31/01	CQA 1014513 - Updated Table 7-16 to reflect change in product: RCIB Termination moved from J4 to J5 on DCB. CQA 1010126 - Updated and added information to MOD Troubleshooting. Updated flowchart and added t-shooting procedures (Common Problems). Saber Project 31713 - Added Scan Window Alignment procedure. Added “Saving System State” to Chapter 3. Added Gantry Service Balance information to Chapter 8. Moved Camera information to its own chapter (Chapter 4). Reorganized Chapter 3 (OS & Apps), Chapter 5 (Console) &Chapter 7 (DAS).
5	10/10/01	CQA 1015910 - Gantry Tilt Belt Tension Spec. Added Mobile Supplement (Appendix A) Additions to Console Chapter (Chapter 5): • New Scan Data Disk (ST318452LW) • Octane 2 Computer • LCD Monitor (NEC LCD1850X)
6	10/25/01	CQA 1012603 - Updated kV Troubleshooting Theory (Results Screen Values) CQA 1019015 - Updated Required Tool lists for HV Tank Replacement procedures (Chapter 9, sections 5.3.1 & 5.4.1) CQA 10110175 - Updated specs for BOW Adjustment procedure (Chapter 12) CQA 10110189 - Added Push Force Gauge part number Added Octane2 Replacement Procedure to Console Chapter (Chapter 5)
7	11/30/01	CQA 1015270 - Added definition of TNC to ETC-IF section (in Chapter 6). CQA 10110720 - Corrected jumper settings shown in illustration of RIP board. CQA 10111092 - Updated Tilt Pot & Belt Adjustment Procedure (in Chapter 8). CQA 10111708 - Corrected labeling of Tilt Speed Adjustment Screws.

Rev.	Date	Reason for change
8	02/19/02	CQA 10110557 - 1.5GB max memory specified and GE specific memory configuration tables added. Chapter 5: Added new Sony MOD (SMO-F551-SD) info Chapter 6: Updated "Required Tools" lists for ETC & ETC-IF bd. replacement procedures. Chapter 11: Updated Section 2.0 - "Image Series" Appendix E: LightSpeed Family Hardware Compatibility added. Expanded/enhanced Index
9	05/01/02	CQA 1024165 - Added missing OBC Error Info CQA 1024127 - Added OBC Troubleshooting Info CQA 1024125 - Corrected OBC Info error CQA 1020262 - Tube Change Flowchart updates FPR 1016957 - Artifacts caused by collimator grease. Tube Change procedure addition and Image Quality Troubleshooting addition. Added Appendix B - "Torque" (moved Torque conversion table from Chapter 1).
10	08/30/02	Corrected ETC, STC & OBC CPU Self-Test LED information Chapter 6: Added Section 2.1 "Cradle Shimming" Chapter 9: Updated Section 5.5 - "HP Anode/Cathode Inverter"
11	10/07/02	CQA 1028683: Updated DCB installation procedure in Chapter 7. Corrected inconsistent terminology. Chapter 3: Removed incorrect nbsClient info & updated "List of nbsClient commands for controllers"
12	04/04/03	Changed name from "LightSpeed Plus System Service Manual" to "LightSpeed 2.X System Service Manual," to more accurately reflect product line. Chapter 5: • Corrected SCSI & DIP identification in pciDeviceShow examples Chapter 6: • Corrected Table 6-3 Cradle Shimming materials. Chapter 7: • Moved ESD information to (new) Appendix G • Removed Detector Replacement procedure (Refer to Direction 2335850-100, *LightSpeed Family Detector Change Procedure*) Chapter 12: Added Tube Temp Verification procedures. Added Appendix G - ESD Management and Device Handling
13	09/03/03	CQA 1020335 – Added DIP Stats Reset Procedure to Gantry Retest Matrix for HSDCD Replacement Chapter 12: Added wording about avoiding re-use of old bolts when changing tube; added warning about using only the correct (new) bolts when replacing tube. Removed references to respirator requirement throughout manual.
14	11/18/03	Chapter 12: Updated Tube Bolt Reuse Avoidance language.
15	01/13/04	Chapter 12: Added Section 12.0 - "Gantry Rotation Safety Check"; Updated Tube Installation Procedure
16	05/10/04	Chapter 12: Updated Tube Removal; Tube Installation; Gantry Rotation Safety Check.
17	08/25/04	PQR 13016849: Updated Collimator torque specs, in Chapter 9.
18	11/02/04	PQR 13018911 - Corrections to "Verify mA Meter" in Chapter 9. PQR 13019034: Added LightSpeed Motorola Board Configuration to Chapter 5.

Rev.	Date	Reason for change
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20	11/9/06	Added SmarTube(TM) Updates; PQR13072839: corrections to “CT Number Uniformity” in Chapter 9; PQR 13065938 & 13065949: corrections to “Scan Data Disk and SCSI Controller” in Chapter 5
21	4/25/07	PSR 13095642: Changes to Chapter 1 (*System Safety and Service*), and Chapter 8, Section 3.0 (*Replacement Procedures: Hydraulic Tilt Motor Assembly*). Updated the Warnings section to include new languages.
22	11/21/07	PQR 13101336 Updated Chapter 9, Section 5.3.2: Adapter bushings for the HV Tank replacement. Updated Important Precautions section to include new language.

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Preface
Publication Conventions

Please become familiar with the conventions used within this publication before proceeding.

Section 1.0
Safety & Hazard Information

1.1 Text and Character Representation

Within this publication, different paragraph and character styles have been used to indicated potential hazards. Paragraph prefixes, such as hazard, caution, danger and warning, are used to identify important safety information. Text (Hazard) styles are applied to the paragraph contents that is applicable to each specific safety statement. Words describe the type of potential hazard that may be encountered and are placed immediately before the paragraph it modifies. Safety information will normally include:

- Type of potential hazard
- Nature of potential injury
- Causative condition
- How to avoid or correct the causative condition

EXAMPLES OF HAZARD STATEMENTS USED

A few examples are provided below. They include paragraph prefixes and modified text styles.

⚠ **CAUTION**
Pinch Points
Loss of Data
Sharp Objects

Caution is used when a hazard exists that can or could cause minor injury to self or others if instructions are ignored. They include for example:

- **Loss of critical patient data**
- **Crush or pinch points**
- **Sharp objects**

⚠ **DANGER**
EXCESSIVE VOLTAGE
CRUSH POINT

DANGER IS USED WHEN A HAZARD EXISTS THAT WILL CAUSE SEVERE PERSONAL INJURY OR DEATH IF INSTRUCTIONS ARE IGNORED. THEY CAN INCLUDE:

- **ELECTROCUTION**
- **CRUSHING**
- **RADIATION**

⚠ **WARNING**
ROTATING EQUIPMENT
BARE WIRES

WARNING IS USED WHEN A HAZARD EXISTS WHICH COULD OR CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH IF INSTRUCTIONS ARE IGNORED. THEY CAN INCLUDE:

- Potential for shock
- Exposed wires
- Failure to Tag and lockout system power could allow for un-command motion.

NOTICE
Equipment Damage Possible

Notice is used when a hazard is present that can cause property damage but has absolutely no personal injury risk.They can include:

- Disk drive will crash
- Internal mechanical damage, such as to the x-ray tube
- Coasting the rotor through resonance.

It's important that the reader not ignore hazard statements in this document.

1.2 Graphical Representation

Important information will always be preceded by the exclamation point ⚠ contained within a triangle, as seen throughout this chapter. In addition to text, several different graphical icons (symbols) may be used to make you aware of specific types of hazards that could possibly cause harm.

ELECTRICAL

MECHANICAL

RADIATION

LASER

HEAT

PINCH

Some others make you aware of specific procedures that should be followed.

AVOID STATIC ELECTRICITY

TAG AND LOCK OUT

WEAR EYE PROTECTION

1.3 Spatial Orientation While Servicing the System

When servicing the system, spatial orientation is defined from the perspective of an observer standing at the end of the patient table, looking toward the Gantry Display board, through the gantry. This orientation defines a negative, or minus, gantry position, which places the top of the gantry leaning away from the observer. See Figure 0-1.

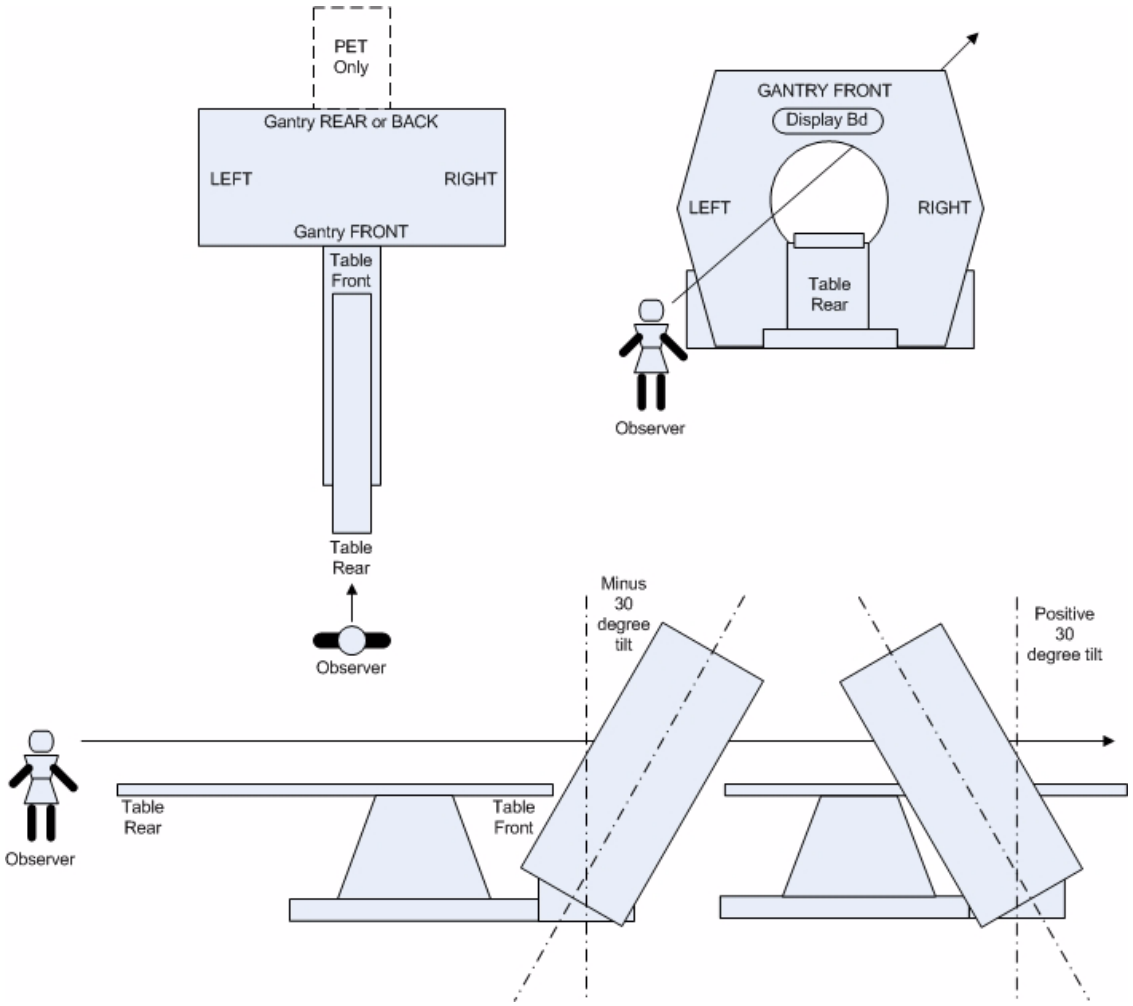


Figure 0-1 Service Orientation

1.4 Service Procedure Readability, Interpretation, and Clarification

This publication and its many service procedures are written at a level meant for Field personnel who have been trained and are qualified to work on this system. They are not designed to be used for self-directed, on-the-job training of Field Service personnel. If you have not done a specific procedure before, it is highly recommended that you seek the supervision and expertise of your Filed Leadership team. Procedures change periodically. All procedures should be read thoroughly regardless of training level and experience prior to beginning a procedure. If you do not clearly understand the steps within the procefure, or how to safely proceed, STOP the service action immediately and consult your Field Leadership before proceeding.

Section 2.0
Publication Conventions

2.1 General Paragraph and Character Styles

Prefixes are used to highlight important non-safety related information. Paragraph prefixes (such as Purpose, Example, Comment and Note) are used to identify important but non-safety related information. Text styles are also applied to text within each paragraph modified by the specific prefix.

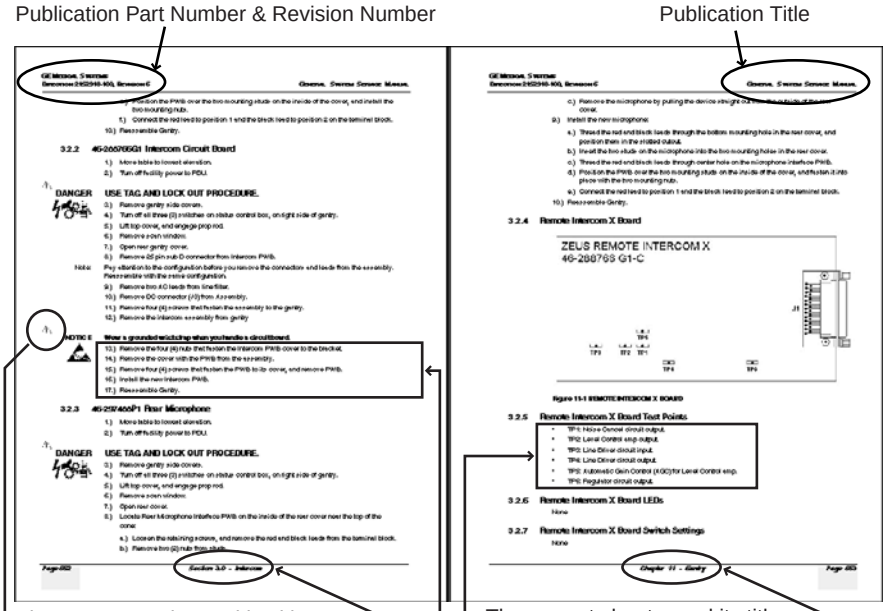
EXAMPLES OF PREFIXES USED FOR GENERAL INFORMATION

Note: Conveys information that should be considered important to the reader.

Example: Used to make the reader aware that the paragraph(s) that follow are examples of information possibly stated previously.

Comment: Represents "additional" information that may or may not be relevant.

2.2 Page Layout



Headers and footers in this publication are designed to allow you to quickly identify your location. The document's part number and revision number appears in every header on every page. Odd numbered page footers indicate the current chapter, its title, and current page number. Even page footers show the current section and its title, as well current page number.

2.3 Computer Screen Output/Input Character Styles

Within this publication different character styles are used to indicate computer input and output text. Character (input, output, and variable) styles are used and applied to the text within a paragraph so as to indicate directions. Computer screen output and input is also formatted using mono (fixed width) spaced fonts.

Example: Fixed Output — This paragraph denotes computer screen fixed output. It's output is fixed from the sense that it does not vary from application to application.It's the most commonly used style used to indicate filenames, paths, and text.

Example: Variable Output — *This paragraph denotes computer screen output that is variable. Its output varies from application to application. Variable output is sometimes found placed between greater than and lesser than operators. For example: <variable_ouput>*

Example: Fixed Input — **This paragraph denotes fixed input. It's typed input that will not vary from application to application. Fixed text the user is required to supply as input.**

Example: Variable Input — ***This paragraph denotes computer input that can vary from application to application. Variable text the user is required to supply as input. Variable input sometimes is placed between greater than and lesser than operators. For example: <variable_input>. In these cases, the (<>) operators are dropped prior to input. Exceptions are noted in the text.***

2.4 Buttons, Switches and Keyboard Inputs (Hard & Soft Keys)

Different character styles are used to indicate actions requiring the reader to press either a hard or soft button, switch, or key. Physical hardware, such as buttons and switches, are called hard keys because they are hard wired or mechanical in nature. A keyboard or on/off switch would be a hard key. Software or computer generated buttons are called soft keys because they are software generated. Software driven menu buttons are an example of such keys. Soft and hard keys are represented differently in this publication.

Example: Hard Keys — A power switch **ON/OFF** or a keyboard key like **ENTER** is indicated by applying a character style that uses both over and under-lined bold text that is bold. This is a hard key.

Example: Soft Keys — Whereas the computer MENU button that you would click with your mouse or touch with your hand uses over and under-lined regular text. This is a soft key.

Chapter 1
General System Safety & Service

NOTICE **This section contains general safety information. Individual service procedures contain specific safety information related to the service task and take priority over this general information.**

The Lightspeed Plus is GE's next generation of fast and user friendly CT scanners. The system features a scanning capability of 2 revolutions per second and remote tilt. In addition, the gantry has been completely redesigned. As a result of this revolutionary new product, the emphasis on patient, operator and service safety must be stressed.

The LightSpeed Plus is designed to be safely operated only when all system covers are in place. Removal of a cover for any reason, defeats the protection they provide, and potentially exposes patients and operators to hazards. If any of the covers should become damaged, you should contact your local GE Sales or Service representative immediately for replacement or repair. Only qualified service personnel trained in the service and operation of this scanner should remove any cover or service this equipment.

Safety features have been incorporated into the design for everyone's protection. Equipment covers remain the primary means of protection to patients, operators and service personnel. Secondary protection covers are also employed to protect service personnel.

Section 1.0
Normal System Operational Safety

This section describes operational safety (when the system covers are all in place).

1.1 Potential Hazards

Two potential hazards exist during the operation of this equipment, unless proper safety precautions are followed:

- X-Rays - Radiation generated during a patient or service scan.
- Laser Alignment Lights - Eye damage from looking directly into the alignment light beam for an extended period of time.

To prevent injury from these potential hazards, the following precautions must be taken:

- Provide proper radiation training and shielding for operators and service personnel. Check that the scan room is clear prior to scanning.
- Instruct patients and operators to refrain from looking directly into the patient alignment beams.

1.2 Safety Awareness Indicators

Numerous devices are employed throughout your LightSpeed Plus system to create safety awareness.

1.2.1 Labels

Figure 1-1 Laser Light Warning & Regulatory Compliance Labels

Figure 1-2 X-Ray ICON

1.2.2 Lights & Lamps

1.2.2.1 Gantry and Console X-Ray "ON" Indicator Lamps

Both the gantry and the console have x-ray indicator displays. The system does not have an audible x-ray ON indicator, nor is it required by FDA. The visual indicator is illuminated when x-ray is generated. The x-ray "ON" icon on the gantry's front cover display is shown in Figure 1-3. The same icon is on the gantry's rear cover display.

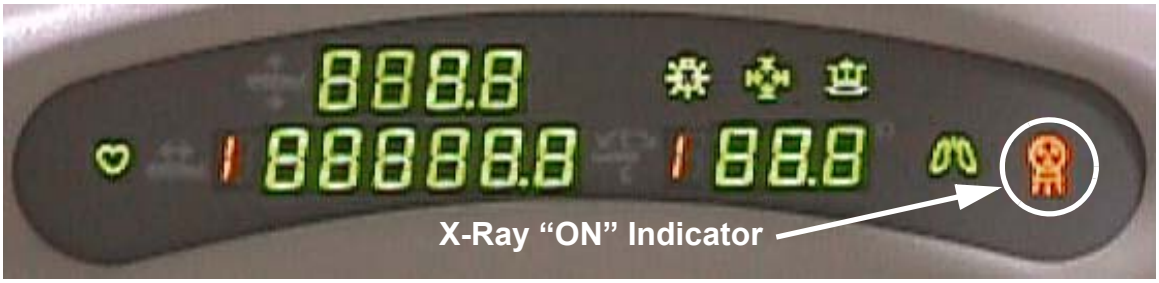


Figure 1-3 Gantry Display (Front) and X-ray "ON" Icon

A backlit x-ray "ON" indicator is located on the SCIM. It illuminates when x-ray is present. See Figure 1-4.

Figure 1-4 Operator Console and Gantry X-ray Exposure Warning Lights

1.2.2.2 Room Warning Light *(customer supplied)*

If a room warning light has been installed and connected to the CT system correctly, the room warning light will illuminate whenever X-rays are present, by default. The room warning light can also be configured to illuminate whenever high voltage is present.

See your system installation manual for wiring and configuration details.

1.3 Emergency Switches, Buttons & Locks

1.3.1 System Emergency OFF (E-OFF) Switch

The “E-OFF” switch removes all power to a CT system immediately. If for any reason the operator needs to remove all power supplied to the CT system at the main distribution panel, the E-OFF switches should be employed. Using this switch except in the case of an emergency could cause damage to hardware. Typically, one or more E-OFF switches are located in or near the operator console or gantry. KNOW THEIR LOCATIONS.

1.3.2 System Emergency Stop (E-STOP) Switches

In the unlikely event they are needed, user accessible “E-stop” (emergency stop) switches have been placed on both the console and the gantry covers. When an E-Stop circuit is engaged, it:

- brings the gantry rotation to a controlled stop.
- disables cradle power and unlatches the cradle.
- terminates high voltage and x-ray generation immediately.

Above each gantry control panel, you’ll find an emergency stop button. The E-Stop buttons are labelled with two inverted equilateral triangles inside a circle with red lettering. See Figure 1-5.

If for any reason you need to disable gantry rotation, x-ray generation and table drive functions, the E-stop switches should be employed. The E-Stop switches are momentary contacts that latch the system into the E-Stop state.

Figure 1-5 Gantry E-Stop ICON

To re-enable (remove the E-Stop condition) the system for operation again, press the reset button on any of the gantry’s control panels or at the console. See Figure 1-6.

Figure 1-6 Gantry E-Stop Reset Button

Figure 1-7 Console E-Stop Location

Do not use the scan stop buttons on the console or the gantry control panels , if it is necessary to stop gantry rotation immediately. Use the E-stop. The scan abort switch only terminates x-ray generation and does not stop gantry rotation. See Figure 1-6.

1.3.3 Table Latch and Tape Switches

Pressure sensitive “tape” switches are located on both sides of the cradle and base. The purpose of these switches is to sense obstructions during cradle movement. When activated, the switch disables cradle drive power. The cradle unlatches when cradle drive power is removed.

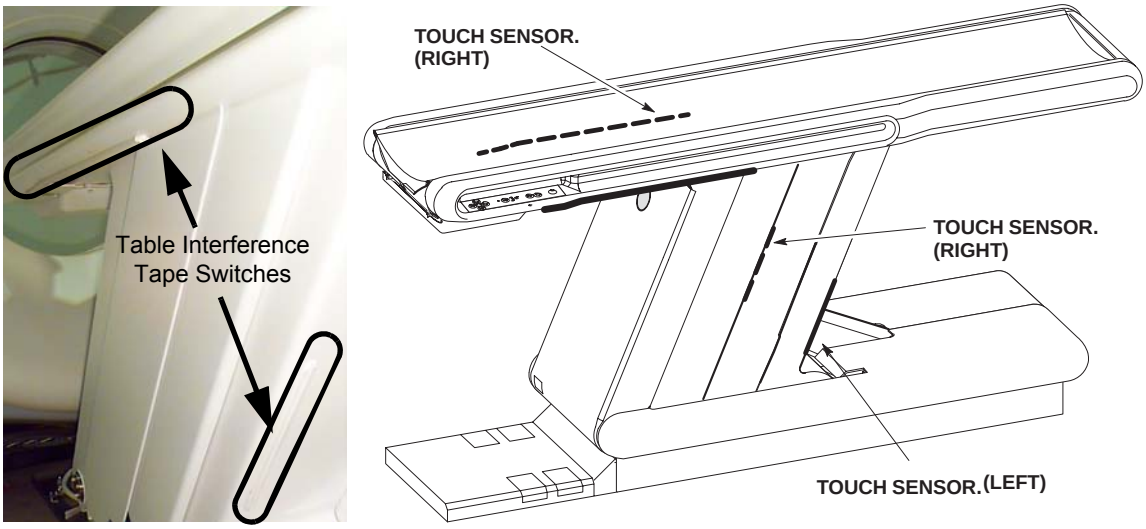


Figure 1-8 Table Tape Switches

In case of an emergency, a cradle latch button is provided on the gantry control panel. It is a toggle switch. When engaged, it unlatches the cradle, but doesn’t remove power to the cradle’s drive. To latch the cradle again, simply press the cradle latch button again.

Never use the cradle latch button to position patients. Use the cradle’s positioning buttons instead. Sudden movement of the cradle when it is unlatched can cause the system to lose track of positioning information, specially during use of an injector.

Figure 1-9 Cradle Latch Button

1.3.4 Tilt Interference Switch Pads

There are two (2) tilt interference switch pads located immediately above where the patient is positioned during scanning. They're located on both the front and rear gantry covers. When either pad is activated, remote (prescribed) tilt of the gantry is inhibited. It takes 10lbs of force (pressure) to activate either of these switches.

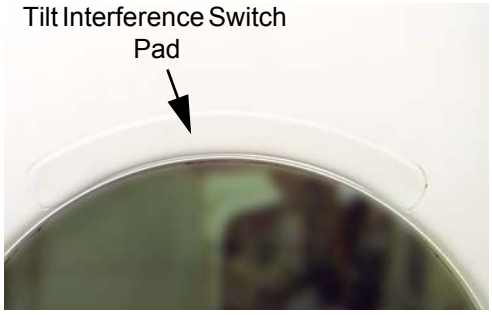


Figure 1-10 Tilt Interference Switch (front cover)

To continue tilting the gantry in the direction of the interference, the operator must manually press the tilt button. The gantry will move one half (1.2) degree each time the tilt button is depressed. Full tilt functionality is not restored until the interference has been removed.

1.3.5 Power Distribution Cover Lock

The top cover of the PDU locks. It should be kept locked at all times, unless being serviced. If unlocked, it is possible to remove the PDU covers protecting the front of the PDU.

Figure 1-11 PDU Lock

Section 2.0
Equipment Service

⚠ DANGER HIGH POTENTIAL FOR INJURY

EQUIPMENT SERVICE CAN ONLY BE PERFORMED SAFELY WITH THE MAIN POWER "DISCONNECT" TAGGED AND LOCKED OUT.

Follow these general rules:

- Only qualified service personnel trained in the service and operation of this scanner should perform any service on this equipment.
- Equipment fuses, switches and circuit breakers are for fire and equipment protection only. Do not rely on them to protect you against electrical shock or un-commanded equipment motion.
- Personal Protection Equipment (PPE) is required and must be worn.

The service switches and circuit breakers described hereafter are not to be relied on as personal protection devices. They do not replace tag and lockout of main power to ensure personal safety. Switches and breakers are intended to only inhibit particular system functions and equipment operation. They do not eliminate or remove the electrical or mechanical hazards that exist. Because hardware can fail and defeat the functionality of these devices, only Lockout/Tagout ensures protection from unattended gantry rotation and electrocution.

Personal protection equipment must always be used when performing service on this equipment. Always use PPE when working with hazardous chemicals or materials.

2.1 Gantry

2.1.1 Overview

With the gantry's primary covers removed, secondary covers are used to help prevent accidental contact with electrical contacts. The most electrically dangerous area in the gantry is the exposed slip ring plater. The system should be tagged and locked out whenever the gantry covers are removed.

When the gantry is rotating, the left and right sides of the gantry are where objects are most likely to be ejected, if not properly fastened. **IT IS IMPORTANT THAT ALL HARDWARE BE PROPERLY FASTENED (TORQUED) TO THEIR PROPER SPECIFICATION.**

Take the following precautions when working on, near or around the gantry:

- Never wear loose clothing or jewelry. Clothing might become entangled in the rotating assembly and jewelry can short to high voltages.
- Avoid standing near the rotating assembly when it is operational, to avoid being struck by the assembly or ejected objects. **ALWAYS TORQUE FASTENERS TO THEIR PROPER SPECIFICATION.**
- Avoid standing or kneeling near the slip ring platter. High voltages exist on the exposed rings. Always disable power to the rings by using the switches on the STC before performing service.
- Never put any part of your body into the gantry, unless the gantry is locked. Axial drive power must be disabled. The tilt bracket should be installed, if working on the tilt assembly.
- Wear and use personal protection equipment.
- Tag and lockout power at the main disconnect.

Always use and follow procedures described in your service documentation, when servicing this equipment.

2.1.2 Electrical

2.1.2.1 Potential Hazards

All un-insulated electrical contacts—including the slipring—have secondary covers in place to protect service personnel from accidental contact. Removal of any secondary cover exposes service personnel to potentially deadly voltages (see Figure 1-12). All secondary covers must be in place before primary covers are installed, and during routine service.

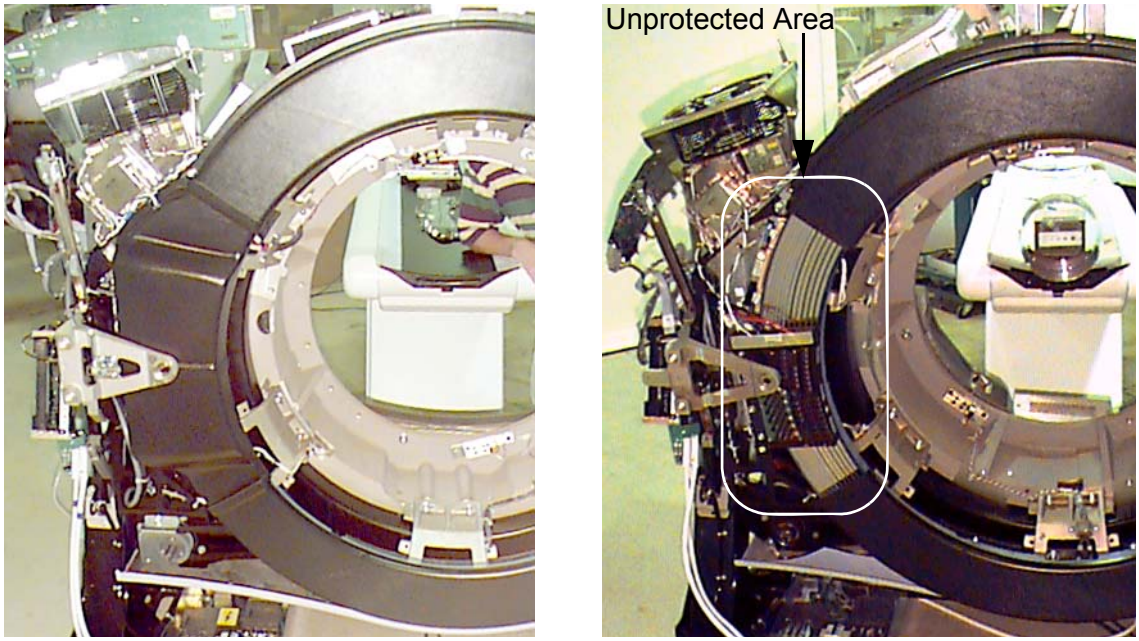


Figure 1-12 Gantry Slip Ring Platter Cover (with and without brush-block cover)

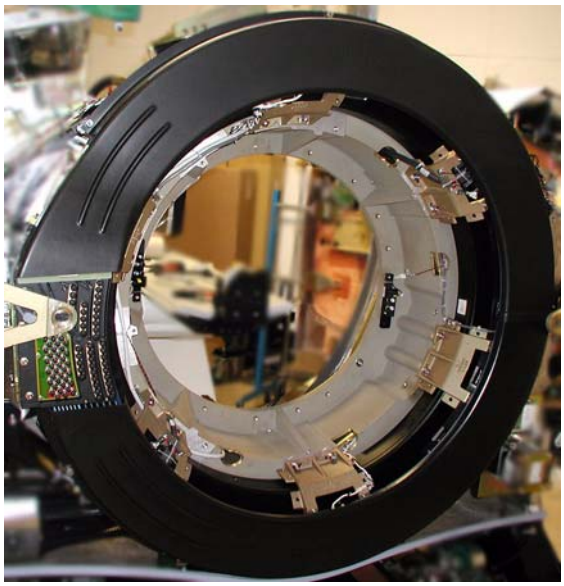


Figure 1-13 “New” Style Slip Ring Covers

Un-insulated high voltage areas in the brush-block area include:

- High voltage DC for X-ray generation. Only measurement equipment isolated from ground can be used to measure HVDC on this system. Use of grounded measurement equipment can result in serious personal injury and/or equipment damage.
- 120VAC for power supplies.

2.1.2.2 Safety Awareness Indicators

LABELS - ELECTRICAL HAZARDS

Figure 1-14 Gantry Electrical Hazard Labels

If a secondary cover can be removed and it potentially exposes a service person to an uninsulated electrical hazard, a warning label is applied to or near the secondary cover. In the gantry, voltage hazards in excess of 120VAC have been labeled. However, the 120VAC present in the gantry is of sufficient amperage to cause electrocution. See Figure 1-14 for the types of labels you will find used in the gantry.

LAMPS & LEDS

There are a number of lamps/LEDs on the STC chassis backplane (see Figure 1-16) that indicate the functional state of the gantry. See Table 1-1, for a functional description.

LED #	COLOR	LABEL	DESCRIPTION
DS1	Green	C Pulse	C Pulse indicator from Axial Encoder.
DS2	Green	RST	Indicates status of the HVDC & gantry drives circuit in PDU. On steady = HVDC & Drives Enabled Slow Flash = E-Stop activated. HVDC & Drives Disabled Fast Flash = Table Tape Switch activated. Cradle, Tilt & Elevation Disabled
DS3	Yellow	AX DR ON	Indicates the Axial Drive Contactor in the PDU is energized.
DS4	Green	ENBL	Indicates the Axial Drive Contactor in the PDU is enabled.
DS5	Yellow	HVDC ON	Indicates the HVDC Contactor in the PDU is energized.
DS6	Green	ENBL	Indicates the HVDC Contactor in the PDU is enabled.
DS7	Yellow	120VAC ON	Indicates the Gantry 120Vac Contactor in the PDU is energized.
DS8	Green	ENBL	Indicates the Gantry 120Vac Contactor in the PDU is enabled.

Table 1-1 STC Lamp Descriptions

The descriptions in Table 1-1, for DS1 through DS8, apply when the associated LED is illuminated.

2.1.2.3 Service Outlets

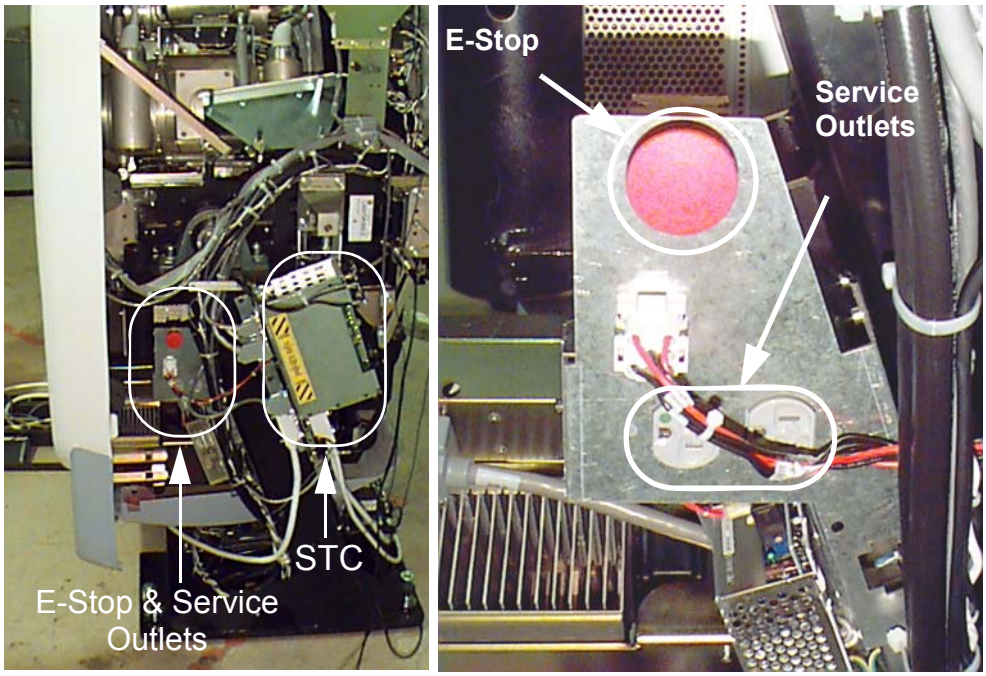


Figure 1-15 Gantry E-Stop and Service Outlets (Right Side of Gantry)

2.1.2.4 Service Switches & Circuit Breakers

A number of service switches have been provided as means of disabling hazards at particular points in the gantry, for ease of service. The gantry service switches are the:

- STC Service Switches
- Power Pan Circuit Breaker
- Gantry E-Stop

STC SERVICE SWITCHES

The STC Service switches are located at the top of the STC, on the backplane (see Figure 1-16). UP (enabled) is the normal operational position for these switches.

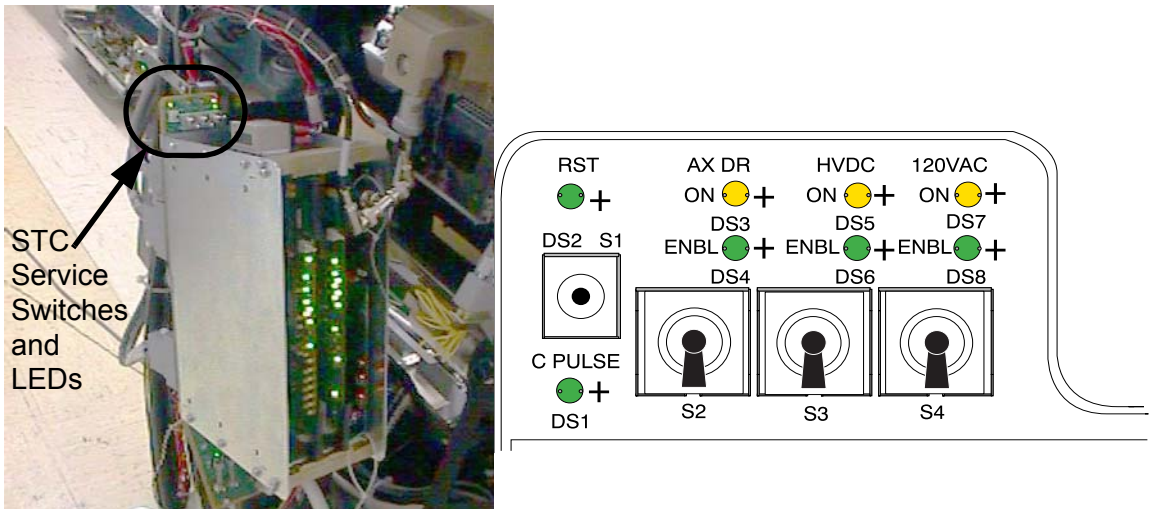


Figure 1-16 Location of STC Service Switches and LEDs (Switches shown in OFF position)

LABEL	DESCRIPTION
S1	Momentary Push button - Resets gantry drives enable circuit in PDU.
S2	Switch enables or disables the Axial Drive function - Default position up (enable)
S3	Switch enables or disables the HVDC function. Default position up (enable)
S4	Switch enables or disables Gantry 120VAC function - Default position up (enable). With S4 OFF, 120VAC to the gantry and table service outlets is controlled by CB3 in the PDU only.

Table 1-2 STC Service Switch Descriptions

2.1.2.5 Power Pan Circuit Breaker

The circuit breaker in the power pan, located at the rear of the gantry base, protects both the 170VDC and tilt drives (table and gantry respectively).

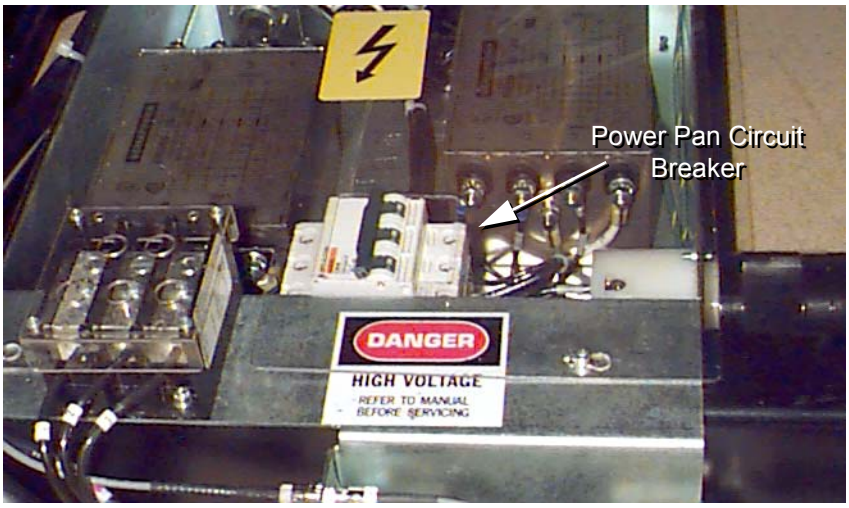


Figure 1-17 Power Pan Circuit Breaker

2.1.2.6 Gantry E-Stop

The gantry's internal E-Stop performs the same function as the E-Stops mounted to the console and the gantry covers. See Figure 1-15.

2.1.3 Mechanical

2.1.3.1 Hazards

Within the Gantry are several hazards that can cause personal injury from:

- moving assemblies (rotational and tilt)
- assembly weights (tube and covers)
- chemicals (slip ring brush dust and oils {Tube, HV Tank and Tilt Drive Hydraulic Oil})
- heat sources (tube)

2.1.3.2 Fastener Torque Specifications

To prevent assembly and part separations from the rotating assembly, *all fasteners must be torqued to their proper specification, using a calibrated torque wrench*. The torque specification for a fastener is specified in its associated replacement procedure. Refer to Appendix B for further information on torque, including conversion factors.

2.1.3.3 Rotational Locking Pin

To prevent un-commanded motion of the rotating assembly, the rotational locking pin must be engaged anytime the rotating assembly is serviced.

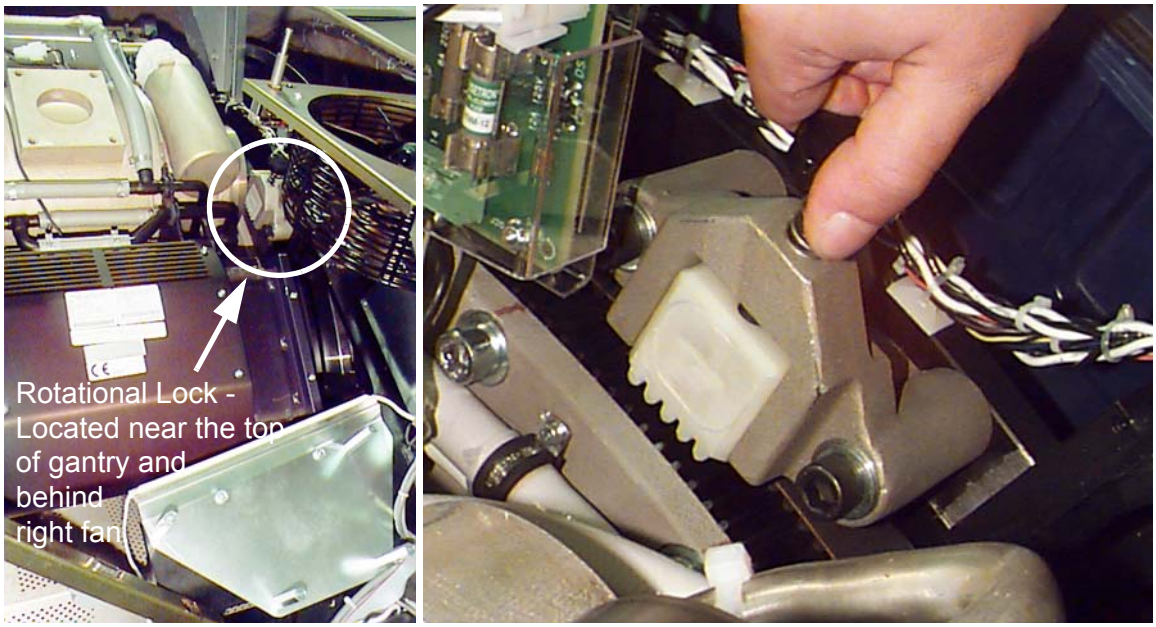


Figure 1-18 Rotational Lock Assembly

The rotational lock is located on the rear side of the gantry, near its top. It is positioned directly across from the teeth in the rotational assembly. To operate the lock:

- Turn the handle clockwise until the teeth on the lock fully engage the teeth on the rotating assembly. You can rock the rotating assembly slightly, if its necessary to align the teeth. Hand tighten until snug. Do not over tighten. Visually verify that the teeth are engaged.
- Turn the handle counter-clockwise until the teeth on the lock and the rotating assembly are fully disengaged and the teeth clear each other sufficiently.

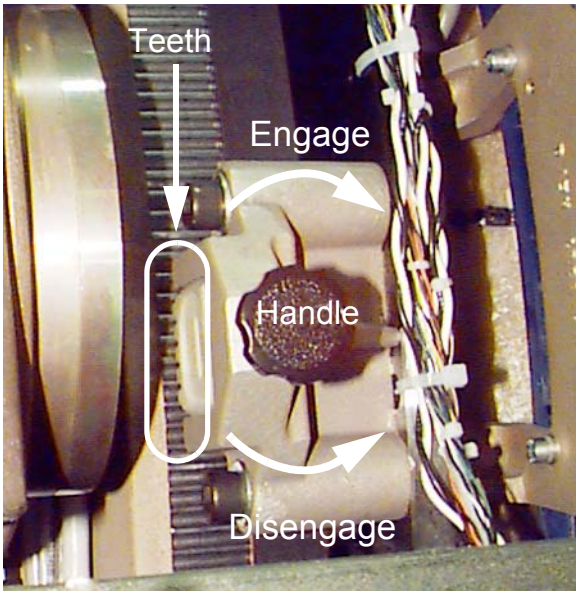


Figure 1-19 Rotational Lock Assembly Operation

2.1.3.4 Tilt Function Lock-out Using the "Locking" Brackets

WARNING Do not use this procedure when replacing or servicing the tilt hydraulic cylinders. The appropriate method for safely inhibiting gantry movement is defined in the steps of the replacement procedure.

NOTICE This procedure is used under the following conditions:

- If a gantry is being moved from one room to another during the gantry's de-installation.
- If a gantry is being permanently removed from the system.
- If another procedure specifically directs service personnel to install these locking brackets to immobilize the gantry tilt fucntion for a very specific purpose.

1.) Position the gantry at zero degrees. Start on one side.

2.) While holding the bracket in place (see Figure 1-20), secure the bracket to the stationary frame at locations 1 and 2. [Note: The two tilt brackets are identical.]

3.) Next, secure the bracket to the pivoting frame at location 3.

4.) Repeat these steps on the other side.

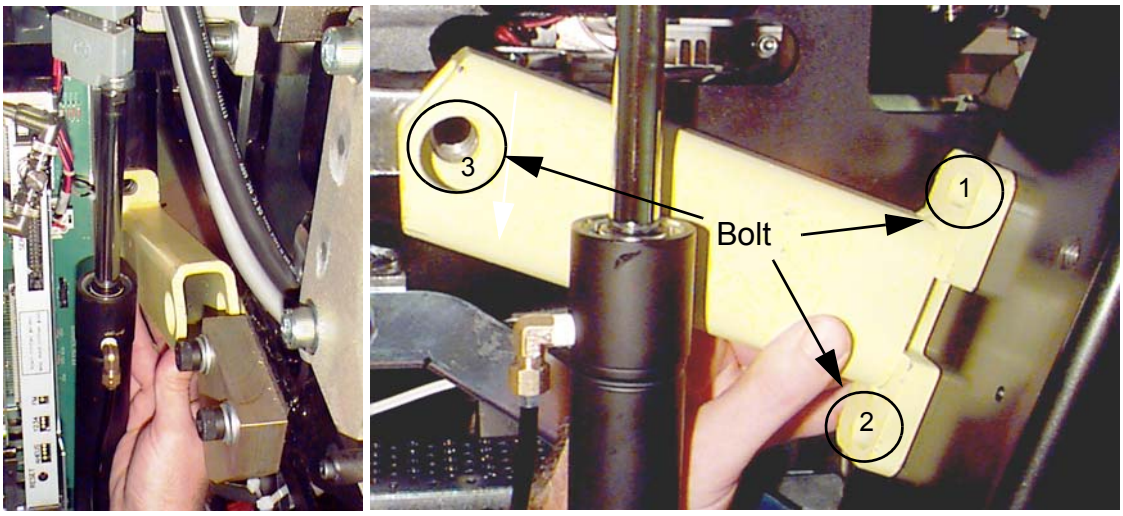


Figure 1-20 Tilt Locking Bracket (Right (STC) and Left Sides)

When the brackets and associated hardware are not being used, store them in the top compartment of the PDU.

5.) To remove the brackets, refer to Spatial Orientation While Servicing the System on page 31:

a.) On the left side of the gantry, remove the two bolts at the base of the Locking Bracket.

b.) Keep your hands and body well clear of the gantry. Use a socket wrench with an extension and remove the final bolt from the rotating side of the gantry, allowing the bracket to fall freely (being held by the wrench and final bolt being removed).

c.) Carefully remove the Locking Bracket with one hand, minimizing any exposure to potential pinch points.

d.) On the right side of the gantry, remove the two bolts at the base of the Locking Bracket.

e.) Keep your hands and body well clear of the gantry and any potential pinch points. Use a socket wrench with an extension to ONLY LOOSEN the final bolt from the rotating side of the gantry three (3) full turns. There should be NO movement of the gantry when this final bolt is loosened.

f.) If even a SLIGHT gantry movement is observed, and/or the bolt feels like it is binding excessively, DO NOT proceed with its removal. Escalate the issue and seek Field Leadership direction immediately for instructions on how to proceed safely.

6.) If NO gantry movement is observed when the bolt was loosened, use a socket wrench with an extension to complete the final removal of the final bolt allowing the bracket to fall freely (being held by the wrench and final bolt being removed).

7.) Carefully remove the Locking Bracket with one hand, minimizing any exposure to potential pinch points.

2.1.3.5 X-Ray Tube Hoist

Whenever the x-ray tube is removed or installed, a tube hoist must be used. When the tube hoist is used, one (1) person can perform a x-ray tube change.

2.1.3.6 Front and Rear Cover Dollies

The front and rear covers have been designed to safely removed by one (1) person, using the cover dollies supplied with your system. These cover dollies must always be used, because the weight of these covers could cause injury. Both the installation manual and system manual describe how to assemble and use these devices.

2.2 Chemicals & Materials

Always wear personal protection equipment to prevent inhalation, digestion and absorption of any substance through the skin, eyes, nose or mouth.

2.2.1 Slip Ring Brush Dust and Debris

Avoid inhalation and digestion of slip-ring brush dust. The slip ring brushes are made of carbon (refer to the MSDS for these materials). Carbon is the conductive material used to pass power and signals to the slip ring platters. As the slip ring brushes wear, fine particles of carbon are released. This dust may become an inhalation hazard for individuals with respiratory aliments or diseases.

2.2.1.1 Cleaning Equipment

Use a HEPA (High Efficiency Particulate Air) vacuum cleaner to remove residual brush debris. Do not use a standard vacuum cleaner, because it cannot filter out all of the debris and will exhaust it back into the air. If a HEPA vacuum cleaner is not available, use alcohol soaked paper toweling to wipe surfaces clean. This method must be followed up by vacuuming with a HEPA vacuum, when available.

2.2.1.2 Personal Protection Equipment (PPE)

- Safety Glasses
- Neoprene or Nitrite Gloves

2.2.1.3 Recommended Cleaning Procedure

⚠ DANGER TAG AND LOCKOUT SYSTEM POWER BEFORE WORKING AROUND OR PERFORMING ANY SLIP-RING MAINTENANCE.

To clean the slip rings, proceed as follows: Remove all existing brush debris from the brush blocks, brackets, and surrounding areas, using a HEPA (High Efficiency Particulate) vacuum cleaner. Use the HEPA vacuum cleaner to remove all brush debris that may have been deposited on the gantry base and floor during servicing. Never use rags or cloths on the slip ring and brushes.

NOTICE
Potential for Equipment Damage

When cleaning the slip ring and brush area, do not touch the slip ring or the brushes with your bare fingers. Skin oil can damage the rings and brushes.

2.2.1.4 Clean-up and Personal Hygiene

After servicing slip ring component and the area, wash your hands thoroughly with soap and water. Dispose of personal protection equipment and rags properly.

Place all materials that contain brush debris (such as the HEPA vacuum cleaner filter, paper toweling, gloves, and old brush assemblies) in a sealed plastic bag and return to the GE Recycling Center:

GE Healthcare Recycling Center
% ACE Warehouse
Building #11
2200 E. College Avenue
Cudahy, WI. 53110

2.2.2 Oils (Tube, Tank and Hydraulic)

Oil resistant gloves should be worn when working with oil or performing clean-up of it. Dispose of chemicals, rags and materials in accordance with hospital and local government environmental and safety requirements.

2.2.3 Lead

Wear gloves and wash hands after handling lead. The CT detector uses a small amount of lead tape and a trace amount of Chromium (Cr) in its construction. The lead tape is located on the corners of the detector. Detectors can be returned to GE Healthcare for proper disposal.

2.2.4 Heat Sources

The X-Ray tube casing, plumbing and radiator can become hot enough to cause minor burns, if not allowed to cool sufficiently. Please allow sufficient time for this equipment to cool adequately before performing any service.

2.3 Table

2.3.1 Electrical

2.3.1.1 Potential Hazards

The table base contains several lethal voltages. There are a number of points in the table where the voltages are dangerous (120 VAC and 170DC present). Theses points pose a potential electrical hazard to anyone that accidentally comes in contact with them.

2.3.1.2 Safety Awareness Indicators

A power lamp is located on the table power assembly. It is illuminated whenever power is present at the table service outlets. See Figure 1-21.

2.3.1.3 Service Outlet

A service outlet is located on the table's power assembly (see Figure 1-21). It is protected by CB3 in the PDU.

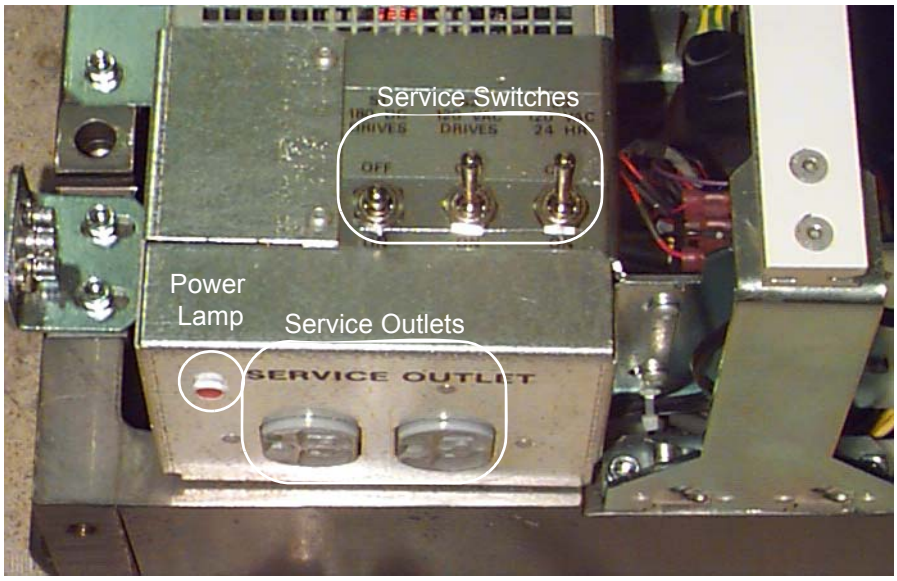
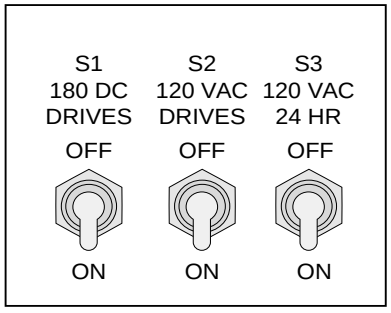


Figure 1-21 Table Service Outlet and Safety Switches

2.3.1.4 Switches

The Table Safety Service switches are located on top of the power assembly. See Figure 1-21. These switches are a subset of the 120VAC switch on the gantry.



S1 180 DC Drives - Enables/disables 170VDC Power Supplies for table elevation.

S2 120VAC Drives - Enables/disables 24V Power Supply for table cradle & elevation.

S3 120VAC 24 HR- Enables/disables 120 VAC Table Power.

Figure 1-22 Table Switches

2.3.2 Mechanical

TOUCH SENSOR (JUMPER) SERVICE JUMPER

During service, the table touch sensors must remain operable for the table to fully function. To operate the table with the covers removed, the sensors must be jumpered.

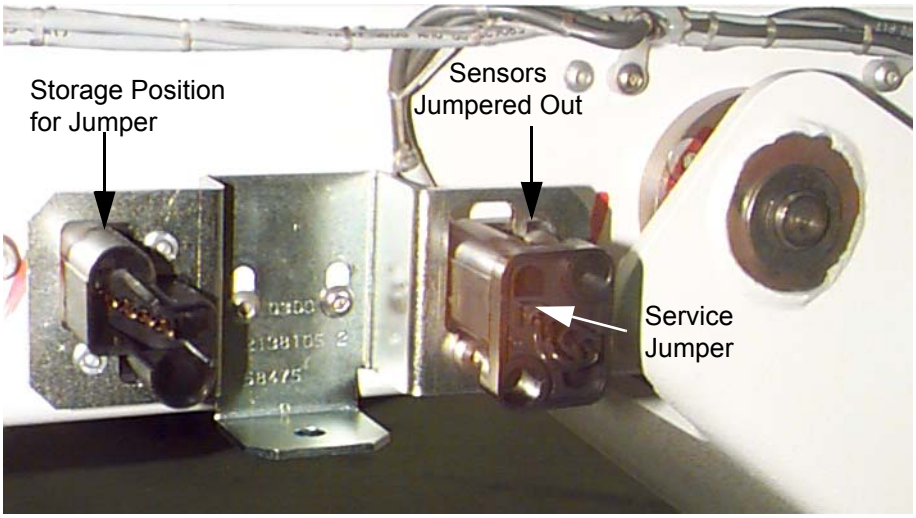


Figure 1-23 Table Touch Sensor Jumpered Out

2.3.3 Chemical

Always wear personal protection equipment that prevents inhalation, digestion and absorption through skin of chemicals.

2.4 Console

CONSOLE ON/OFF POWER SWITCH.

Figure 1-24 Console ON/OFF Power Switch (Front cover removed)

2.5 Power Distribution Unit (PDU)

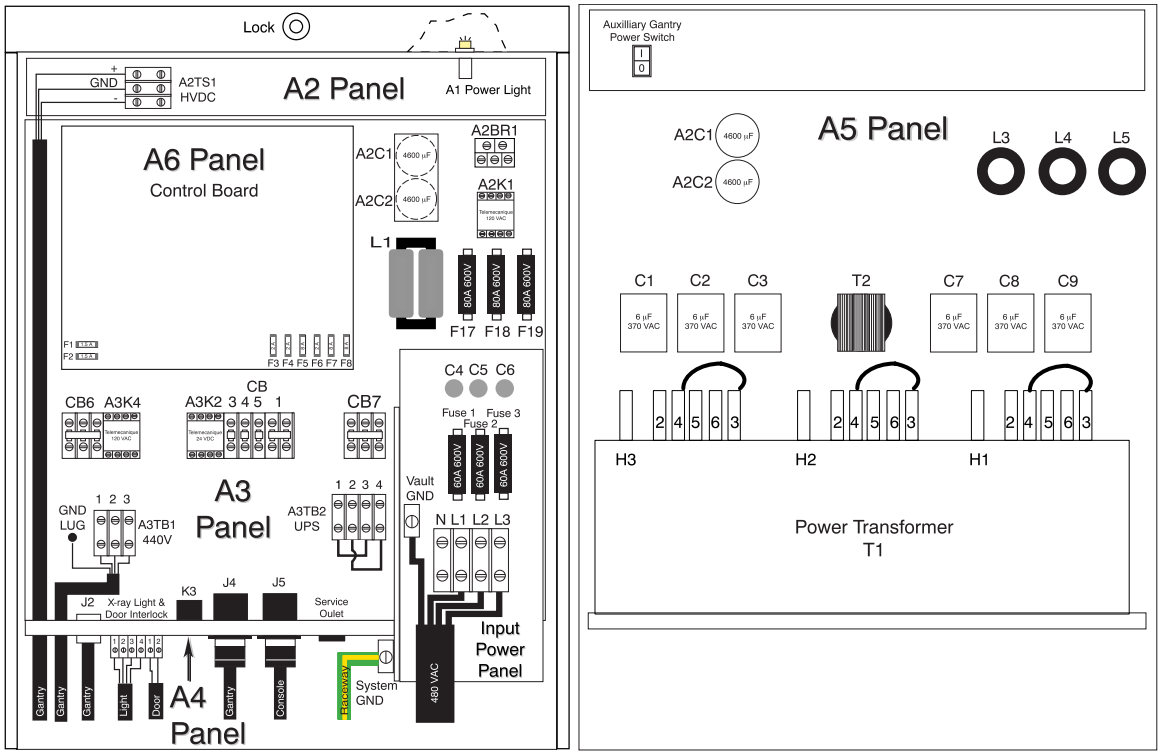


Figure 1-25 PDU Front & Rear (exposed view)

Do not perform any work within the PDU, unless it is de-energized. More than 100 Kilowatts of power exists in the PDU at various periods of time. Therefore, consider all points in the PDU as hazardous.

- Connect voltage measuring equipment only when power is removed and the wall power box is locked and tagged.
- Always wear safety glasses because of the high voltages that exist in the PDU. Components can literally explode when power is applied.

Be sure that all secondary protective covers on the PDUs are in place before the PDU is energized.

2.5.1 Electrical

2.5.1.1 Potential Hazards

- Axial drive power for gantry rotation (AC)
- High voltage DC for X-ray generation (floating DC)
- Distributed console, table and gantry power (AC)

2.5.1.2 Hazard Awareness Indicators

With the PDU's top cover hinged open, a small power lamp is visible. When illuminated, this lamp indicates power is present within the PDU. See Figure 1-26.

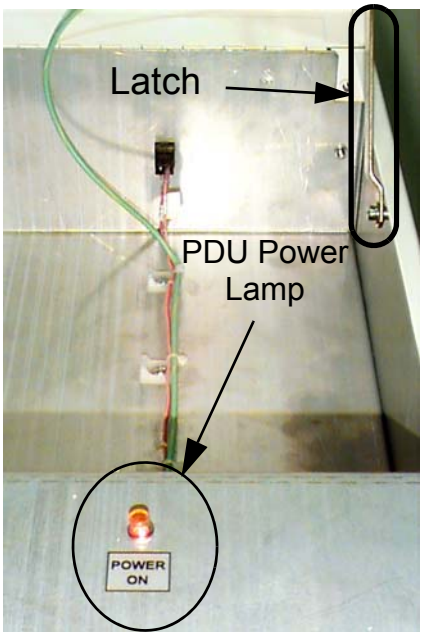


Figure 1-26 PDU Power Lamp (PDU Top Cover Opened and Latched)

2.5.1.3 Protected Service Outlets

The service outlet is protected by a circuit breaker. The outlet is located on the A4 panel. See Figure 1-25.

2.5.1.4 Circuit Breakers and Switches

CIRCUIT BREAKERS

There are three (3) groups of circuit breakers in the PDU used to protect various parts of the system.

CB1 - Console AC power.

CB3 - Table and Gantry AC service outlets.

CB4 - Table and Gantry AC to stationary electronics.

CB5 - Gantry rotating power, tilt power and communications.

CB6 - Main Axial drive power.

CB7 - Master 120/208VAC power (CB1, 3, 4 and 5).

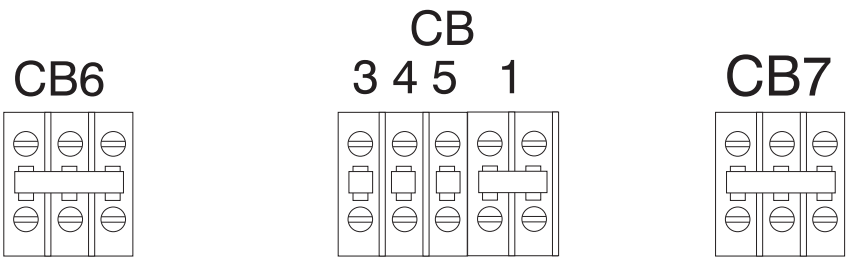


Figure 1-27 PDU Circuit Breakers

AUXILIARY GANTRY POWER SWITCH

Auxiliary gantry power switch should be left “ON” at all times. Used to disable 120VAC.

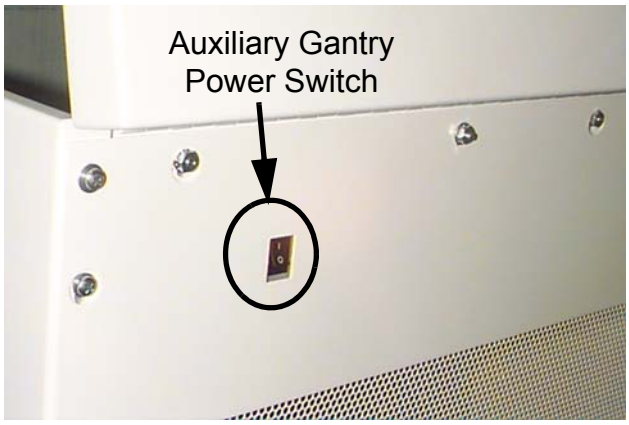


Figure 1-28 Auxiliary Gantry Power Switch (PDU Rear)

2.5.2 Mechanical

The PDU’s top cover employs latches on both sides to hold the cover in the open position. See Figure 1-26.

Chapter 2
Service Desktop, Tools, and Diagnostics

Section 1.0
Service Desktop

1.1 Using the Mouse

Use the mouse to access and operate diagnostics and tools from the right-hand display monitor, or open a shell and type/enter a UNIX command line. The system displays the Service Desktop Manager along the left-hand side of the right side display monitor, as shown in Figure 2-2.

Use the mouse to make screen selections on the service desktop.

Typical mousebutton functions:

- Press mousebutton one to select.
- Press mousebutton two to extend a selection.
- Press mousebutton three to access pop-up menus.

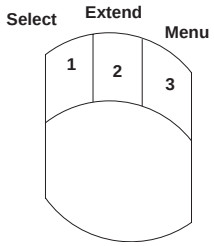


Figure 2-1 Mousebutton Definitions

1.2 Service Desktop - Main Menu (Overview)

The Service Desktop (Figure 2-2) is the entry point for all service tools and diagnostics. The desktop is designed with nine major functional menu areas each with its own purpose. These areas are:

- Error Logs - Select and review system logs (refer to section 1.9, on page 64).
- Diagnostics - Select and execute all diagnostic applications (refer to section 1.8, on page 60).
- Image Quality Tools - Image quality tools not requiring communications via firmware with the system (such as scan analysis). (Refer to section 1.10, on page 64.)
- Calibration Applications - Tools for mechanical, electrical, and imaging calibrations of the system (refer to section 1.11, on page 64).
- Configuration Applications - Save/restore system state and configuration information (refer to section 1.12, on page 65).
- Utilities - Tools useful to the field engineer while installing or servicing a system (refer to section 1.13.1, on page 66).
- Replacement Parts/Repair Procedures - Links to tools required when replacing major field replaceable units (FRUs). (Refer to section 1.14, on page 68.)
- Planned/Preventive/Proactive Maintenance - Information to execute a PM visit (refer to section 1.15, on page 68).

- Service Desktop Home Page - Icon descriptions and eventually system health status information.

Refer to the appropriate sections and pages for detailed information. References to those pages have been provided above.

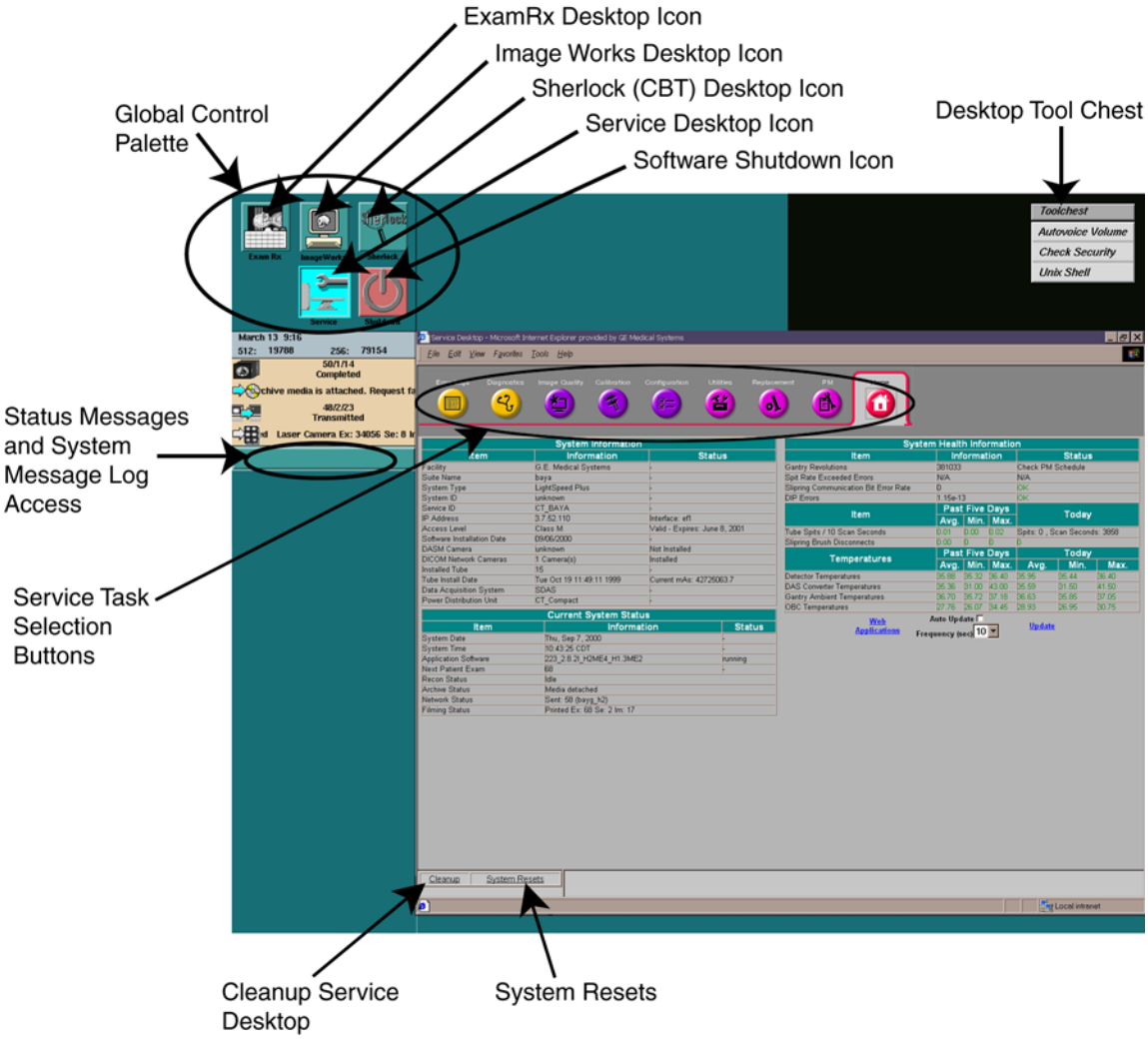


Figure 2-2 Service Desktop, Display Screen Overview

1.3 Menu Function Descriptions

The first part of this chapter briefly describes the basic service diagnostics and tools menus. The second part describes their procedures.

The product has five distinct desktops, one of which is the Service Desktop. The user may move between desktops with the touch of a button on the Global Control Palette, which is always visible on all desktops. When changing desktops, the palette below the Global Control Palette is replaced with the appropriate desktop specific Control Palette. Switching desktops does not modify the current view of a desktop. Even though it may no longer be visible, it is still in the same state as when the switch occurred.

The users of the Service Desktop have different needs than the technologists, radiologists, doctors, and other users of the system. Therefore, the functionality for the Service Desktop differs from that of the other desktops. Windows can be resized, iconified, overlapped, and scrolled. This allows for greater flexibility for the user, especially in the area of troubleshooting where access to many different functions may be needed at the same time.

1.4 Procedural User Interface

The Service Desktop contains a mixture of tools and diagnostics to be used by a Service Engineer. The main philosophy behind the user interface for the Service Desktop is to provide a **procedural** approach to servicing the scanner. All the necessary tools and diagnostics are available at the same time for the procedure at hand, whether it be troubleshooting, replacing a part, performing routine maintenance, or integrating the system for a new install.

Figure 2-3 shows the Service Desktop Service Task selection buttons. Selecting one of the buttons at the top of the window will cause a new list to be displayed in the left-hand frame of the window. In the example shown, REPLACEMENT PROCEDURES has been selected, and a general service list, containing software elements needed to perform Replacement Related Procedures, is shown.

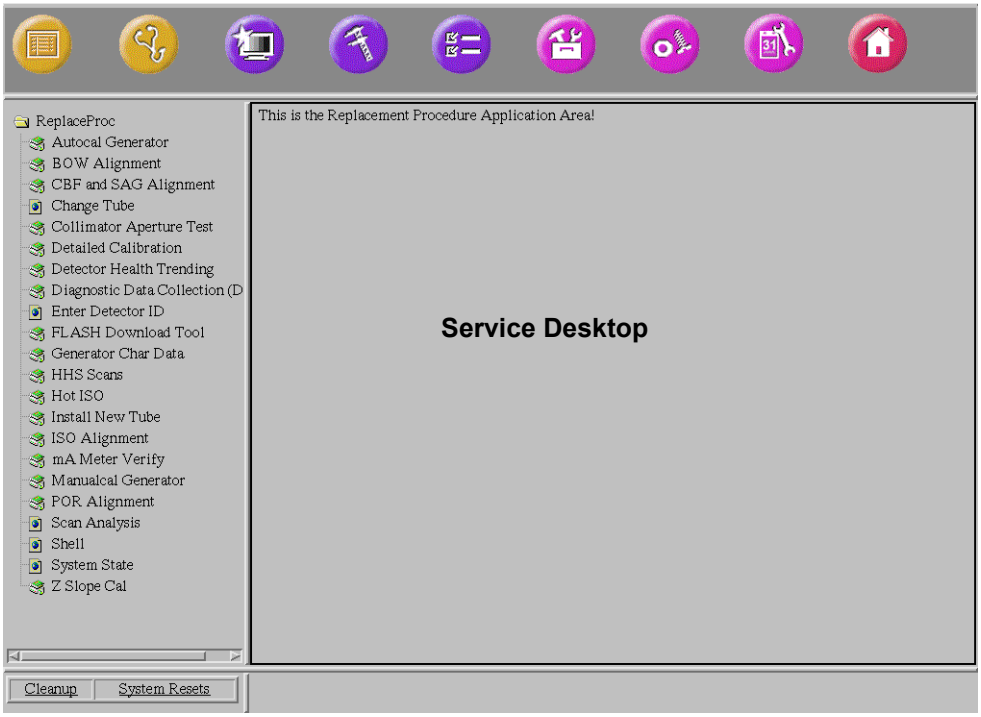


Figure 2-3 General Service Desktop Control Palette (Example)

1.5 Service Desktop Management

Change desktops by selecting the corresponding desktop icon from the Global Control Pallet (see Figure 2-2). Launch, or start each service tool or diagnostic by clicking the mouse on the tool.

The CLEANUP button on the bottom of the desktop cleans up any previously opened windows, and restores the desktop to its original state, rather than closing or dismissing each individual application visible on the Service Desktop. The CLEANUP button should be selected whenever the user is done with the Service Desktop, or whenever it is desired to return the desktops to a known state.

Figure 2-4 Desk Top Management Buttons

Note: CLEANUP reloads applications firmware

If you ran diagnostics that required diagnostic firmware, the CLEANUP button will also reload the application firmware.

The DISMISS button cleans up, then returns to the Service Desktop diagnostics menu.

The SYSTEM RESETS button displays the reset menu for various product or application firmware.

1.6 System Resets

The SYSTEM RESETS function allows the user to reset and download the scanner hardware as required, preparing the system for scanning operation. Access SYSTEM RESETS as follows:

1.) Select SYSTEM RESETS from the Service Desktop (refer to Figure 2-4). The reset applications selections include (refer to Figure 2-5):
- SCAN - Resets and downloads all controllers in the gantry and table.
- RECON - Resets the recon subsystem (PEG-IG and RIP boards).
- DAS/COLL - Resets the DAS control and collimator control board.
- DATA ACQUISITION - Resets the DAS, control, collimator control, and DIP boards.

2.) Select RESET from the displayed screen.

3.) Select RUN.

The status box displays the status of the selected reset.

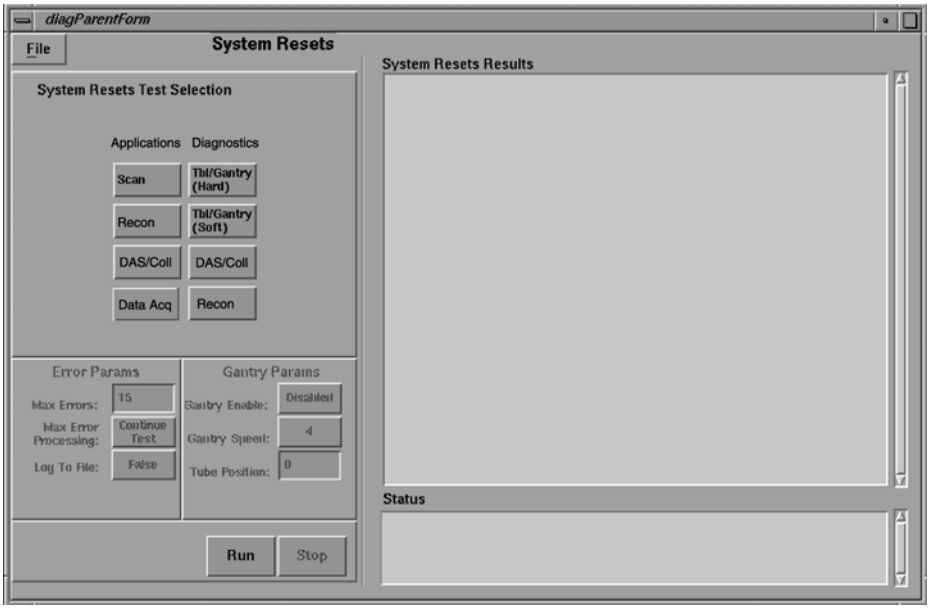


Figure 2-5 System Resets Screen

1.7 Diagnostic Graphical User Interface *(X-Windows)*

Selecting a diagnostic from the Service Desktop brings up a diagnostic GUI. The diagnostic interface is broken up into four different areas: specific test control, generic test control (including error parameters and gantry parameters), test results, and test status. Refer to Figure 2-6 and the descriptions that follow.

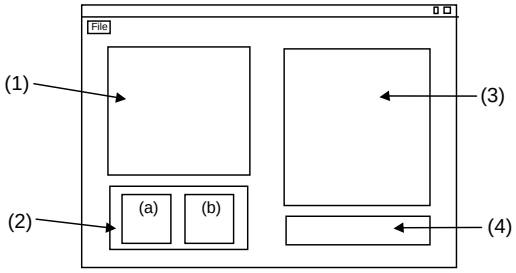


Figure 2-6 Diagnostic Graphical User Interface *(x-windows)*

Callout numbers (1, 2, a, b, 3, and 4) from Figure 2-6 include:

1.) **Specific Test Control** - Use this area for selecting a test and associated parameters.

2.) **Generic Test Control** - Use this area to control the error parameters and gantry parameters:

a.) **Error Parameters Area** - These choices are shown in every diagnostic interface (see Figure 2-7). Click on the error parameter icons to view the choices.

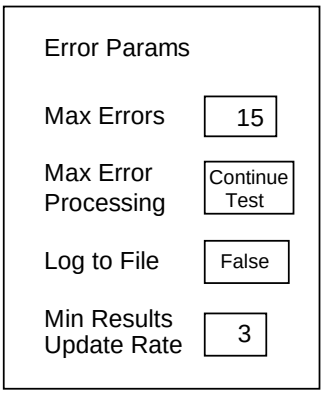


Figure 2-7 Error Parameters

Max Errors - Determines the number of errors that have to occur before processing of errors is changed. Type in any number you like.

Max Error Processing - Determines what to do when the max error count has occurred. Choices are CONTINUE THE TEST, STOP LOGGING ERRORS, and STOP THE TEST.

Log to File - Determines if the results screen should be put into a log file titled DiagSession.log. Choices are TRUE or FALSE.

Min Results Update Rate - Determines how often the results screen section should be updated. Any faster than three seconds is difficult to read.

b.) **Gantry Parameters Area** - This area defines what you want the gantry to do during a diagnostic, and is available for most tests. It is useful for reproducing errors that occur only when the gantry is rotating. Click on the gantry parameters icons to view the available choices.

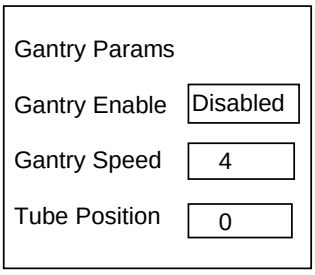


Figure 2-8 Gantry Parameters

Gantry Enable/Disable - Determines what to do with the gantry during the test. Choices include DISABLE, POSITION, and ROTATION.

Gantry Speed - Determines how fast to rotate, if rotation has been selected. Choices are 1, 2, 4, or 20 seconds per rotation.

Tube Position - Moves the tube to the position entered.

3.) **Test Results Area** - View the output results of the specific diagnostic here.

4.) **Test Status Area** - View the status messages, such as Start, Stop, and Test Aborted, here.

1.8 Diagnostics Menu - General Service

The diagnostics menu provides an alphabetical listing of the diagnostic programs available to the general class user.

1.) Click the SERVICE DESKTOP icon

to display the Service Desktop.

2.) Select the DIAGNOSTICS icon to display the system's top level diagnostics menu (refer to Figure 2-9.)

Note: With no security key installed, the General Diagnostics Menu is displayed as described below.

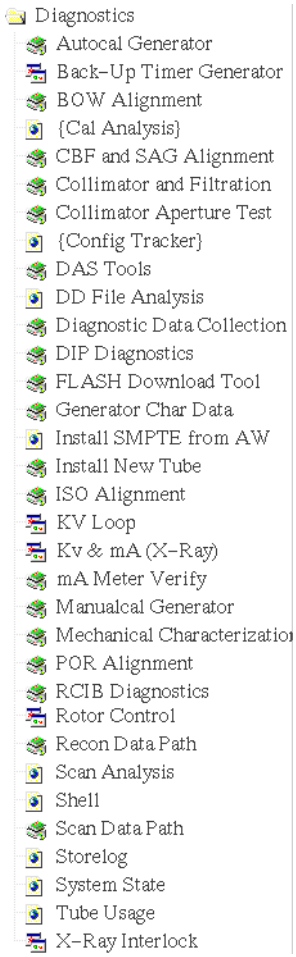


Figure 2-9 General Service Desktop Diagnostics Menu

The Menu has three types of icons:

1.) The first icon represents tools and diagnostics that require the download of diagnostic firmware to the scan control sub-system.

If a selected test finds that application firmware is loaded, and it needs diagnostic firmware, you will have to wait for diagnostic FIRMWARE DOWNLOAD to take place upon confirmation (refer to Figure 2-10).

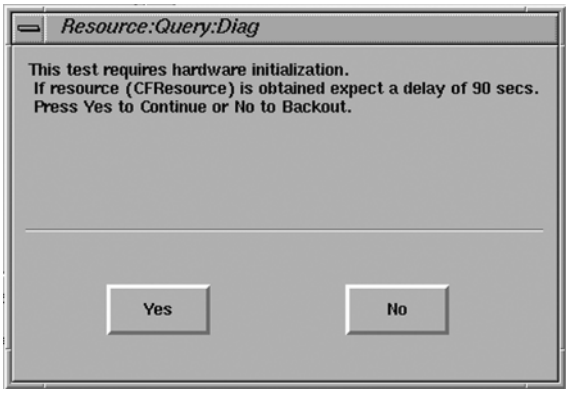


Figure 2-10 Firmware Download Query Pop-Up

2.) The second icon represents tools and diagnostics that require the download of application firmware to the scan control sub-system.

3.) The third icon represents tools and diagnostics that do not require the download of any firmware to the scan control sub-system.

A particular tool or diagnostic is executed by clicking on its icon or on the text next to the icon.

Note: Braces indicate future features

Braces surrounding a name on the menu indicate that it is a planned feature (one not yet implemented). If you select such an item, a UNIX shell tool will probably open.

Use the diagnostics menu to access the following tools and diagnostics:

AUTOCAL GENERATOR

Automatically updates the X-ray generator characterization files.

BACK-UP TIMER GENERATOR

Activates the exposure backup timer.

BOW ALIGNMENT

Use to check the Beam on Window (BOW) alignment, to ensure the x-ray beam is properly aligned to the detector window.

CAL ANALYSIS

Not yet available. Use to examine calibration information.

CBF AND SAG ALIGNMENT

Use to check the Center Body Filter (CBF) and System Angular Geometry (SAG) alignments for the focal spot, relative to the collimator and detector.

COLLIMATOR AND FILTRATION

Provides a means to command the system to move the collimator filter assembly to the various filter selections, and to move the collimator aperture assembly to the various aperture selections.

COLLIMATOR APERTURE TEST

Provides a means to perform scans and verify that the aperture selections produce a scan with the appropriate aperture thickness.

CONFIG TRACKER

Not yet available. Gathers information about the system configuration.

DAS TOOLS

Use to exercise and verify all scan data acquisition functions, such as microphonics.

DD FILE ANALYSIS

Use to view and analyze the diagnostic data files, cal, image, or scan files.

DIAGNOSTIC DATA COLLECTION (DDC)

Performs many service scanning functions and tests. Gathers system data with or without x-ray rotation.

DIP DIAGNOSTICS

Tests the DAS Input Processor (DIP) board and its functions.

FLASH DOWNLOAD TOOL

Allows downloading of FLASH (Firmware Image) to various gantry controllers (such as the CCB-Collimator Control Board and the DCB-DAS Control Board).

GENERATOR CHAR DATA

Use to examine the x-ray generator characterization files.

INSTALL SMPTE FROM AW

Use to install the SMPTE pattern and QA images so they can be displayed as a patient image.

INSTALL NEW TUBE

Updates the system resident tube information file.

ISO ALIGNMENT

Use to complete a tube ISO alignment.

KV LOOP

Tests the kV board.

KV & MA (X-RAY)

Use to perform x-ray functional tests.

MA METER VERIFY

Verifies the mA metering circuit adjustments.

MANUALCAL GENERATOR

Use to manually adjust the x-ray generation characterization files.

MECHANICAL CHARACTERIZATION

Use to set-up the mechanical characterization files.

POR ALIGNMENT

Aligns the tube plane of rotation (POR).

RCIB DIAGNOSTICS

Diagnostic tool that tests the Rotor Controller Interface Board (RCIB).

ROTOR CONTROL

Diagnostic tool that provides a functional test for the rotor controller subsystem.

RECON DATA PATH

Diagnostic tool that provides a functional test for the image reconstruction process.

SCAN ANALYSIS

Use to list/select and examine scan data.

SHELL

Opens a UNIX shell window where you can enter IRIX or UNIX commands.

SCAN DATA PATH

Diagnostic tool that provides a functional test for the scan data collection process.

STORELOG

If apps are shutdown first, it can store log files to MOD, then it removes those files from the system disks making more disk space available. If the host finds it needs more disk space when it boots, it will run storelog to make room.

SYSTEM STATE

Use to save and restore system configuration and calibration files to and from MOD media. The MOD saved with system state information has a UNIX file system that is not compatible with saving images.

⚠ **NOTICE**
Potential for Data Loss

Relabeling the system state MOD as an image MOD will write a DOS filesystem on it, destroying the system state information. DO NOT save image archive data on the side containing the system state information.

TUBE USAGE

Displays x-ray tube related information for current and previous x-ray tubes.

X-RAY INTERLOCK

Tests the exposure interlocks.

1.9 Error Log Viewing Menu - General Service

The error log viewing menu provides access to information about the host hardware and the various versions of software that control the scanner. The tools and diagnostics that can be accessed from the ErrorLog menu are shown below.

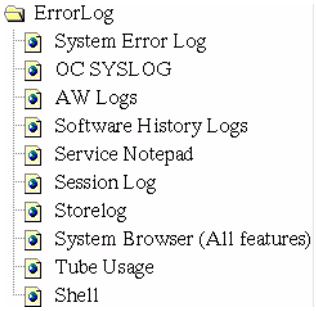


Figure 2-11 ErrorLog Icon and Menu (General)

1.10 Image Quality Menu - General Service

Use the ImageQuality menu to access the tools and diagnostics shown in the figure below.

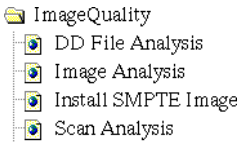


Figure 2-12 Image Quality Icon and Menu (General)

1.11 Calibration Applications Menu - General Service

Use the Calibration menu to access the tools and diagnostics shown in the figure below.

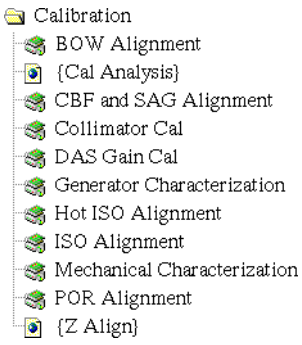


Figure 2-13 General Calibration Applications Icon and Menu (General)

1.12 Configuration Applications Menu - General Service

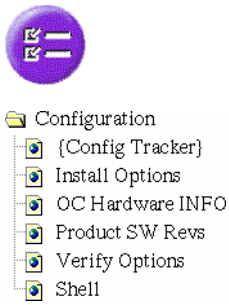


Figure 2-14 Configuration Applications Icon and Menu (General)

Use the configuration menu to access the following tools and diagnostics:

CONFIG TRACKER

Not supported at this time.

INSTALL OPTIONS

Calls the option installation program, which allows you to load/install an option key(s) on the system via MOD to enable software options.

OC HARDWARE INFO

Calls the system browser preset to display OC information. Many options are available to allow you to view such things as product software revisions, disk usage, network information, and hardware configurations.

PRODUCT SOFTWARE REVS

Calls show prods to display the currently installed product software revisions.

VERIFY OPTIONS

Shows the currently installed software option keys.

SHELL

Presents a window that enables you to enter IRIX and UNIX commands, start scrips that perform a series of commands, or start programs. Press **ALT**-**F12** to exit the shell when it is no longer needed.

1.13 Utilities Menu

The Utilities Menu has three sub-menus: Install, Tools and Util. Additionally, the Utilities Menu provides the tools shown in Figure 2-15.

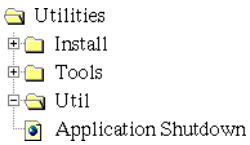


Figure 2-15 Utilities Icon and Main Menu

APPLICATION SHUTDOWN

Stops the scanning level of software, but keeps the OC responsive to IRIX/UNIX commands and GE scripts. Applications need to be shutdown to run programs such as **reconfig** and **storelog**.

1.13.1 Utilities—Install Menu - General Service

The purpose of the install menu is to provide a single access point on the service desktop to work from when integrating and testing a newly installed system prior to turn over to the user.

Use the install menu to access the tools and diagnostics shown in the figure below.

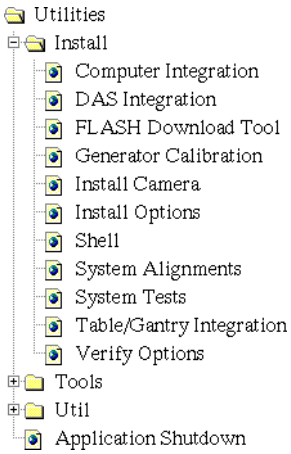


Figure 2-16 General System Installation Menu

1.13.2 Utilities—Tools Menu

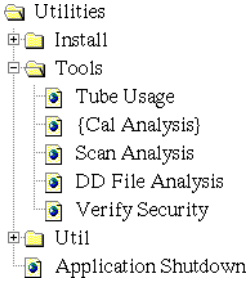


Figure 2-17 Utilities—Tools Menu

Use the tools menu to access the following tools and diagnostics:

TUBE USAGE

Shows you the x-ray tube's serial and model numbers, its meter reading, and install date.

CAL ANALYSIS

Enables you to view and analyze calibration vectors from the calibration database. This tool is not currently available. Use Scan Analysis to plot cal vectors.

SCAN ANALYSIS

Enables you to view and analyze scan data, and plot cal vectors from scan data.

DD FILE ANALYSIS

Use to view and analyze the diagnostic data files.

VERIFY SECURITY

Reports whether you have proprietary or non-proprietary access. This tool also shows the expiration date of your service key, if you have inserted one.

1.13.3 Utilities—Util Menu

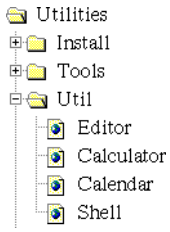


Figure 2-18 Utilities—Util Menu

Use the Util menu to access the following tools and diagnostics:

EDITOR

This opens a "JOT" text editor that enables you to access a file's content. Selecting FILE > OPEN, opens a popup box at default location /usr/g/bin. The default operation is view only.

CALCULATOR

Displays a multi-function scientific calculator.

CALENDAR

Displays the current month's calendar. (This is a perpetual calendar.)

SHELL

Presents a window that enables you to enter IRIX (OC) commands. Example: Enter: **hinv** to get the same information that the OC Hardware Info menu item offers.

1.14 Replacement Procedures - General Service

The Replacement Procedures selection provides access to the most frequently needed tools and diagnostics used to complete tasks associated with FRU part replacement.

Use the ReplaceProc menu to access the tools and diagnostics shown in the figure below.

Note: DETECTOR HEALTH TRENDING is for use by GE Medical Systems CT Engineering for data collection. It is not intended for field use.

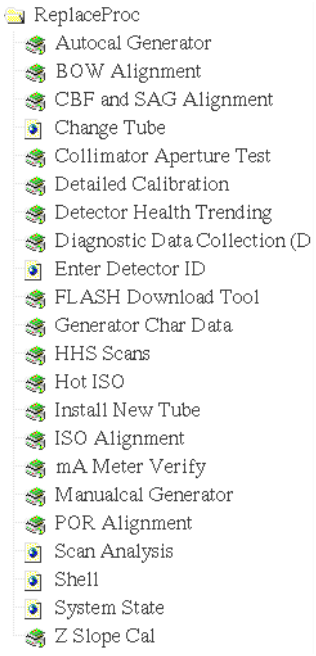


Figure 2-19 Replacement Procedures Icon and Menu (General)

1.15 PM Information Menu - General Service

Use the PM menu to access the tools and diagnostics shown in the figure below.

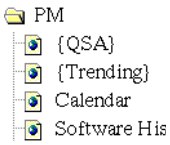


Figure 2-20 PM Icon and Menu (General)

Section 2.0
Scanner Utilities

2.1 Tube Warmup

Tube Warmup resides under the DAILY PREPARATION selection on the Exam Rx top level desktop. TUBE WARMUP includes the scans required to bring the tube to a safe operating point for patient scanning.

2.2 FastCal

Like Tube Warmup, Fast Cal is another daily preparation function. Running Fast Cal generates new Acal, Sine, and Cosine vectors used in the preprocessing stages of image reconstruction. FastCal should be run daily to maintain optimal image quality.

FASTCAL includes additional heating scans required for both AutoMaCal and Fast Calibration Scans. During FASTCAL:

DAS CONVERTER BOARD IDENTIFICATION CHECK

Upon commencing a FastCal operation, the ID's of the converter boards used by channel 762 and the z-channels (boards 47 & 48) should be checked to see if they match the converter boards that were in place when the latest DAS Gain Cal was performed. If there is no match, the user must be directed to perform a DAS Gain Cal. A button should appear that says:

> Additional calibration scans are needed to adjust for gain changes. After these scans are completed you must redo FastCal. After you have read this press **CONTINUE**.

A message should be sent to the GE sys log, stating that the converter boards were swapped without redoing DAS Gain Cal. If converter board check fails, a DAS Gain Cal is required. See “DAS Gain Calibration,” on page 74.

CHECK TIME OF LAST COLLIMATOR CALIBRATIONS

Check the last time Collimator Calibration was performed. If Collimator Cal was performed within 24 hours, it is not necessary to update the Collimator Cal parameters, and the system can skip all steps pertaining to Collimator Cal.

DIRTY MYLAR WINDOW SCAN

The first scan taken, after cold tube warmup, should check to see if there is any contrast or other material on the Mylar window that will corrupt the calibration scans. Four one-second rotating scans, no tracking at this time, should be taken. The scan techniques are to be 80kvp, 20 ma, aperture 4 x 125, 4 x 250, 4 x 375, and 4 x500 respectively. If the 20 point filtered offset corrected channel 762 data vs views divided by the offset corrected view averaged value of channel 762 falls below .90 for any scan, for any row, a message must be displayed to the user and a response from the user is needed before continuing. The user should be allowed to go ahead without further action, or clean the Mylar window and repeat the blockage scan. The message should say:

> Please check Mylar window and clean if necessary to assure proper scanner operation. Indicate if you want to repeat the check scan or continue with the FastCal.

Send message to GE sys log.

- Warmup1 scans raise the target temperature to greater than or equal to 500 degrees Celsius prior to AutoMaCal.
- Warmup2 scans raise the target temperature to greater than or equal to 700 degrees Celsius for FastCal.

SWEEP SCAN

Before the first standard FastCal scan is performed, but after tube warms up, a sweep scan is taken and a Collimator Calibration is performed for that technique. There are eight sweep scans—one for each aperture and focal spot size combination. One sweep scan is performed for every FastCal executed, and therefore the entire set of Collimator Cals will be refreshed after eight FastCals are performed. Also, measure mode calculations will be made, although only the results for large spot with 4x125 or 4x500 apertures will be used.

The new Collimator Cal is compared to the old Collimator Cal in the following way:

1.) Consider the range of the ratios for the old data and pick three ratios: the two ratios 10% from either end of the range, and the ratio in the middle.

2.) Evaluate the new data at these three ratios, and compare to the values obtained with the old data.

3.) Store the new evaluated data to the history log. If the absolute values are greater than a tolerance, the entire set of eight sweep scans will be performed. A button will appear that the user must push. The message should say:

> Additional tracking calibration scans must be performed. After this is completed you must restart FastCal. After reading this message press **CONTINUE**.

4.) A message should be logged to the GE sys log that a complete Collimator Cal was retaken for all eight techniques.

MINI SCAN

After the sweep scan and calibrations have been completed and before the standard FastCal scans begin, a mini scan of 0.1 second that it is rotating and is executed with tracking on so that DCB computes a fresh focal spot position.

BLOCKED CHANNEL CALCULATION

During the FastCal scan, the offset corrected signals are view averaged for the inside rows (1A and 1B) for channel 762. These averaged signals are then normalized with respect to the mAs per view and the DAS Gain, and multiplied by a threshold value referred to as the “blocked channel threshold”. During regular scanning, the normalized signals for each view are compared to the values obtained from the FastCal scan. If the value during the patient scan is lower than the value computed during the FastCal scan, it is assumed that the corresponding row in channel 762 is blocked for the view, and tracking is put on hold.

FASTCAL SCAN

During the FastCal scans, tracking will take place. However, there will be no checking for blockage of **z** channel. Since the FastCal procedure checks for beam obstruction, there should be no blockage. The focal spot position will be computed by the DCB.

The flowchart in Figure 2-21 describes the sequence of actions when tube warm-up or Fast Cal is selected.

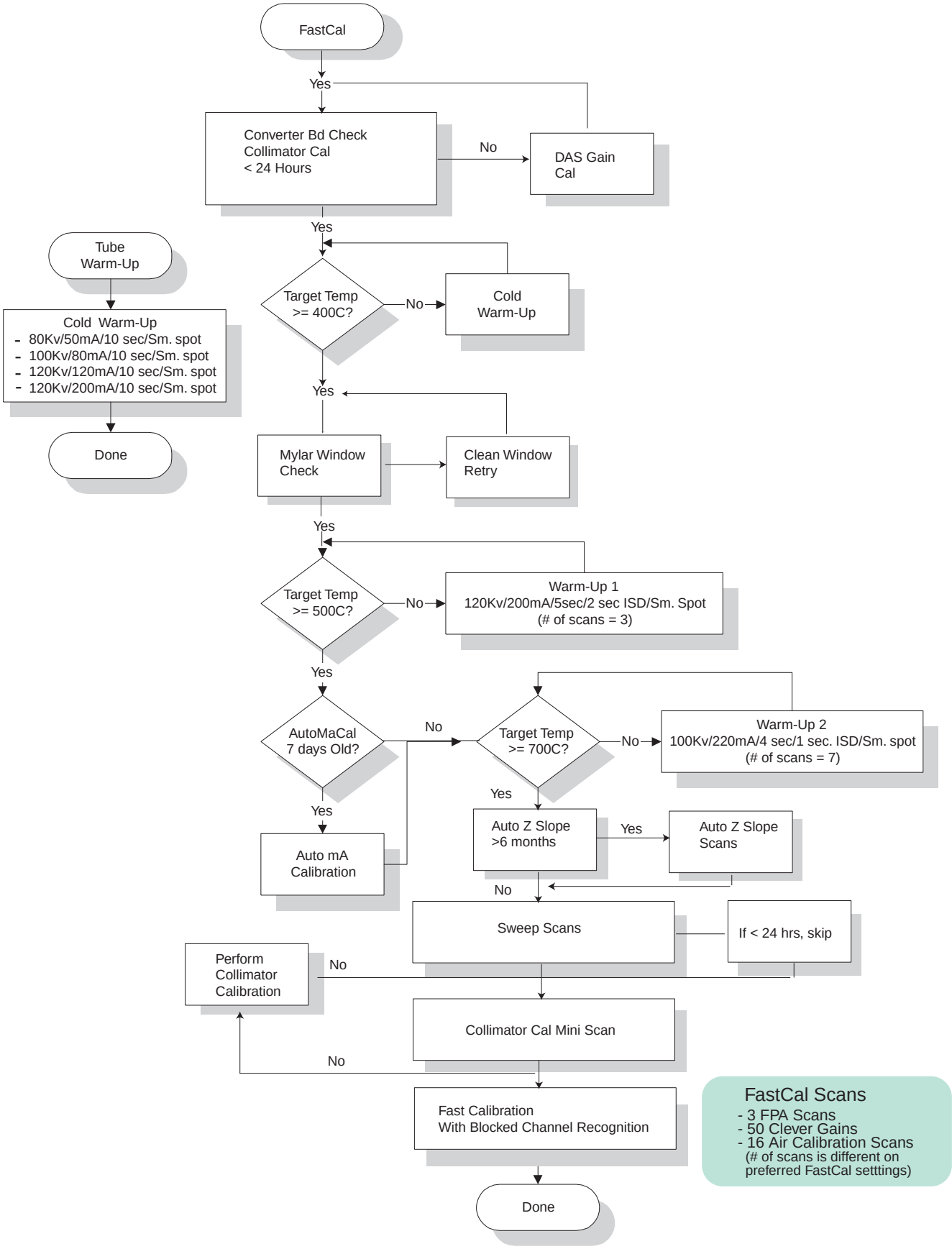


Figure 2-21 Tube Warmup and FastCal Flowchart

DAILY IQ CHECK

FastCal also performs Daily IQ Check, which compares the center 30 channels of today's FastCal vectors to yesterday's. This is done to determine whether there is any significant change that could lead to an image artifact. If the limit check fails, a message is posted to the log and to a pop-up box on the screen. The database is updated regardless of whether the check passes or fails.

The following are the two circumstances that will cause the failure:

1.) A hardware change, either after changing the detector or changing the center four DAS Converter cards will cause a failure message on the next FastCal.

A hardware change will cause a significant change in the calibration vectors and trip the limit check. In this case, the error message on the first FastCal after the change can generally be ignored, provided the images look good.

2.) A real change in the gain of the center channels, which could lead to an image artifact.

The possible causes are contamination on the copper filter, tube port or bowtie filter or DAS. Please refer to Section 3.0 - Tools and Diagnostics, for troubleshooting.

2.3 Preferred FastCal

The Preferred FastCal feature allows the site to tailor the total number of FastCal scans to what kV techniques they use when scanning patients. For example, if a site scans patients using two of the four available kVs, FastCal can be configured in **reconfig** to run with just those kV scans, thereby speeding up the total time to run FastCal by 50%.

To customize FastCal scans by kV, do the following:

1.) Shutdown applications:
   a.) If you are not already on the Service Desktop, select the SERVICE DESKTOP icon.
   b.) Select the UTILITIES icon.
   c.) Select APPLICATION SHUTDOWN.
2.) Open a UNIX SHELL from the toolchest menu on the desktop.
3.) **su - ENTER**
4.) Enter ***root password***
5.) **reconfig ENTER**
6.) Select PREFERENCES. Refer to Figure 2-22. Make kV choices in the "Selected Preferred FastCal kV" area.

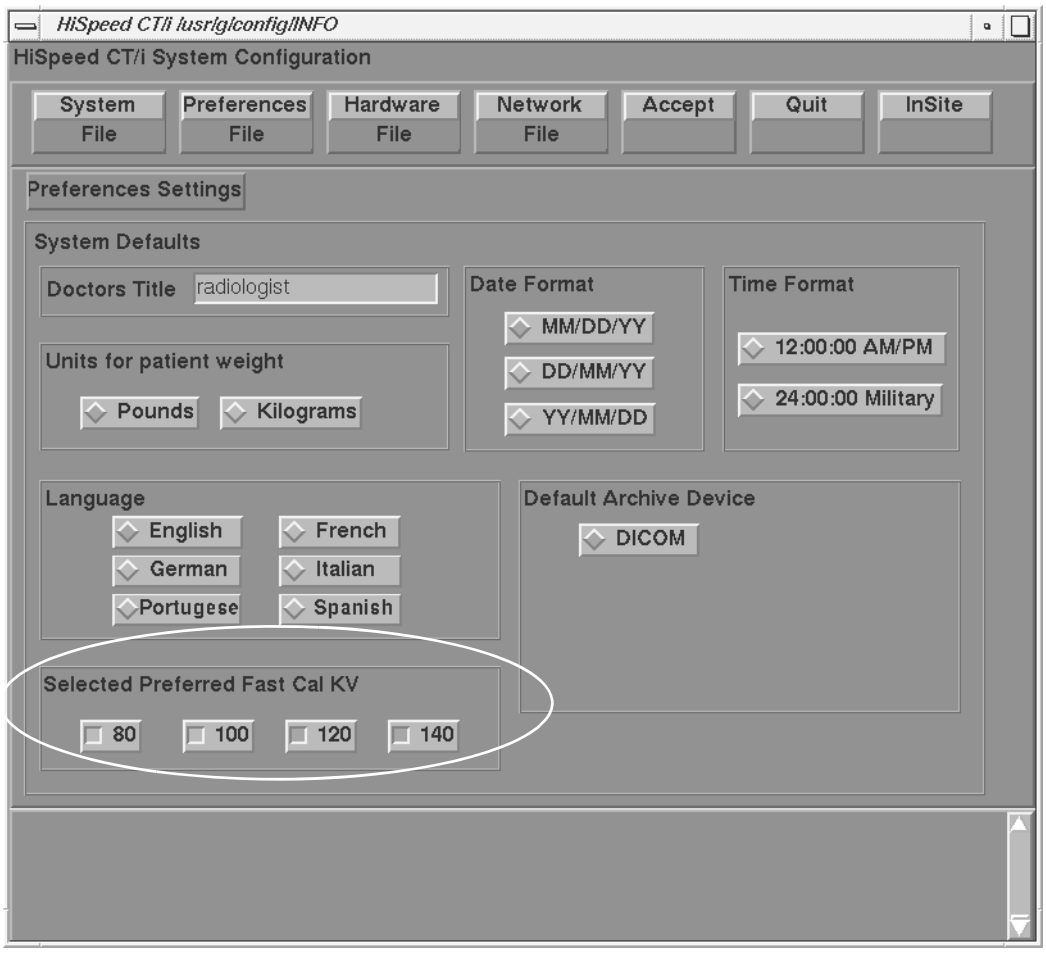


Figure 2-22 Preferences Setup Screen

A new configuration file for preferred FastCal will be created by reconfig in the /usr/g/config directory with file name PreferFastCal.cfg.

2.4 DAS Gain Calibration

1.) Enter DAS Gain Calibration through the Calibration menu on the Service Desktop. If you are not already on the Service Desktop, select the SERVICE DESKTOP icon.

2.) Select the CALIBRATION icon.

3.) Select DAS GAIN CALIBRATION.

4.) Before the DAS Gain scans are taken, a Mylar window check is done to ensure that the window is clean. Otherwise it can corrupt the tracking cals.

- If the check succeeds, the DAS Gain scans are taken, and the cal proceeds.
- If the check fails, a pop-up is posted asking the user to provide inputs on whether he/she wants to quit, continue, or retry the Mylar window check after cleaning the Mylar window.

The appropriate messages and pop-ups are discussed later in this section.

The Mylar window check and the corresponding state machine are also discussed in a separate section.

DAS Gain Calibration consists of 31 scans that are taken consecutively. The cal processing on the scan keys is done after all the scans are done.

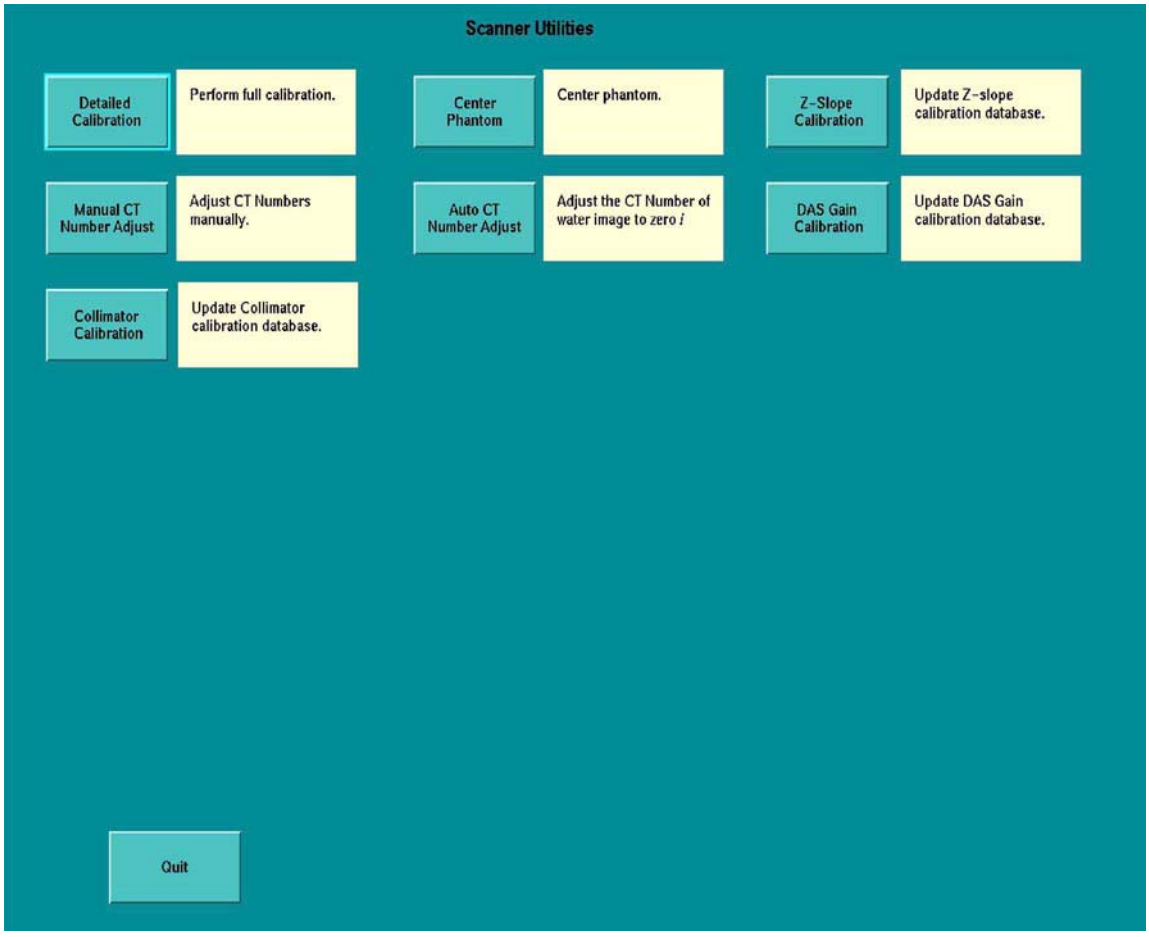


Figure 2-23 Scanner Utilities Screen

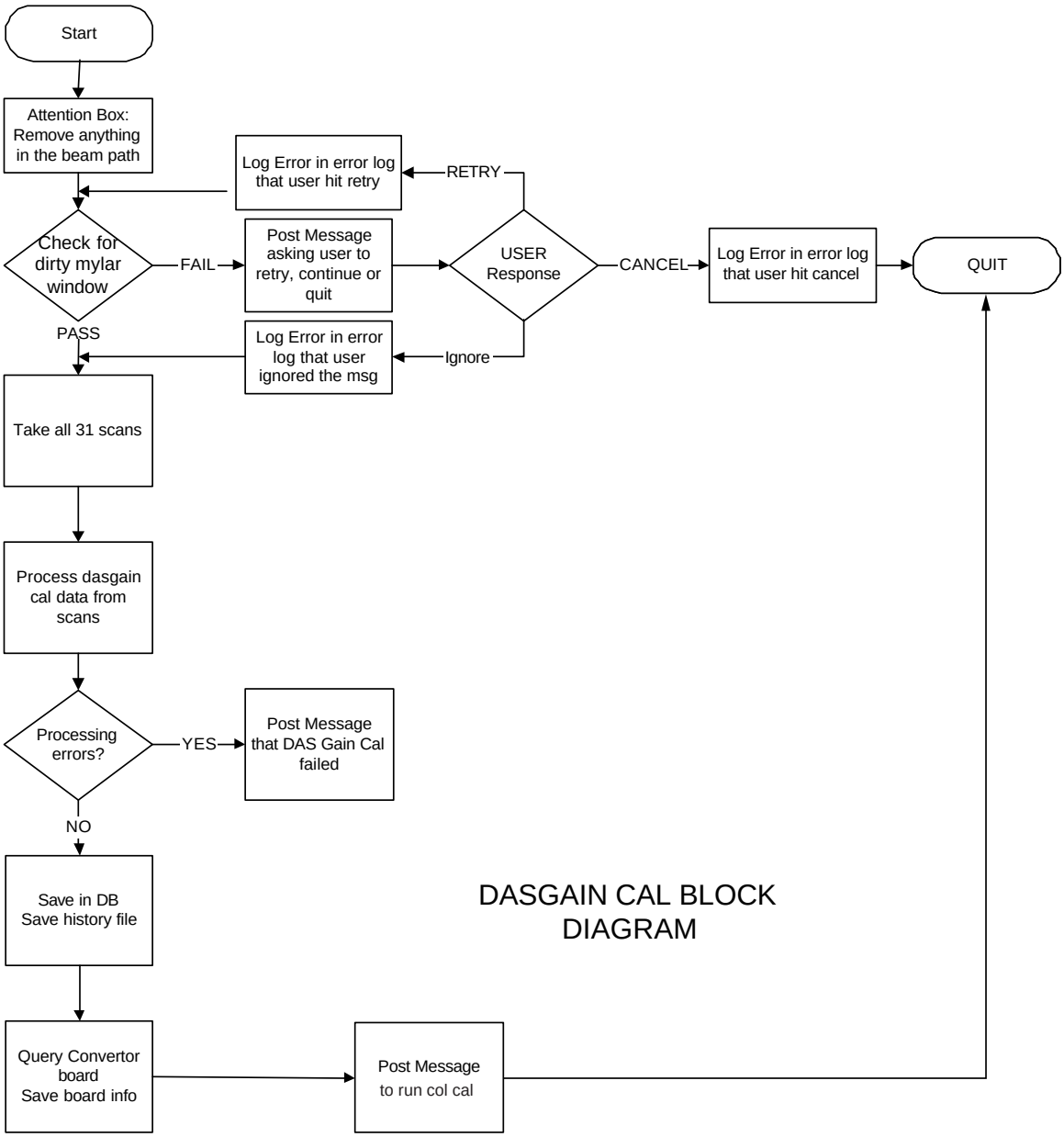


Figure 2-24 DAS Gain Cal Block Diagram

MESSAGES AND POP-UPS

Before DAS Gain or Collimator Cal come up, an attention box is posted asking the user to clear any obstruction in the path of the beam. Only when the user hits OK, will the cals proceed. Also after DAS Gain and Collimator Cals are done, each will post an attention box asking the user to run FastCal.

DAS GAIN CAL MESSAGES

Message 1: Please remove any obstruction in the path of the beam.

Message 2: The user retried Mylar window check.

Message 3: Please check Mylar window and clean if necessary to assure proper scanner operation.

Message 4: User quit the tracking cal after the Mylar window check failed.

Message 5: User ignored the Mylar window check failure and continued with the tracking cal.

Message 6: DAS Gain Cal was not completed.

MYLAR WINDOW CHECK

There is increased sensitivity with the tracking feature, if the Mylar window is dirty (refer to Figure 2-25). Therefore, a check of the Mylar window comprising four scans must be done to ensure that the Mylar window is indeed clean before the tracking cals (DAS Gain Cal and Collimator Cals) are performed. If the check fails and the window is found to be dirty, a message pop-up is posted that will require a user response. The user can choose to retry the Mylar window check after cleaning the window, quit, or carry on with the appropriate tracking cal anyway.

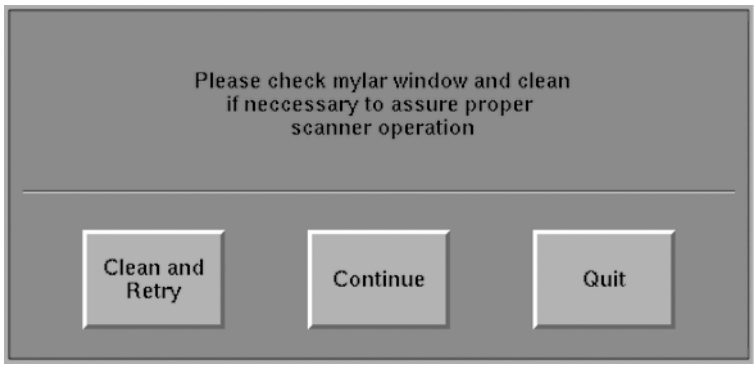


Figure 2-25 Mylar Window Check Screen

2.5 Collimator Calibration

1.) Enter Collimator Calibration through the Calibration menu on the Service Desktop. If you are not already on the Service Desktop, select the SERVICE DESKTOP icon.

2.) Select the CALIBRATION icon.

3.) Select COLLIMATOR CALIBRATION. The calibration will check for any converter boards changes for boards 47 and 48. If the board has been changed, Collimator Cal exits and posts a message informing the user to first run DAS Gain Cal.

4.) Collimator Cal also requires the Mylar window check before the cal can proceed to avoid corrupting the cal. If the check fails, the user can clean the Mylar window and retry or continue anyway. In either case, if the check succeeds or if the user ignores the failure and continue, the cal requires tube warm-up.

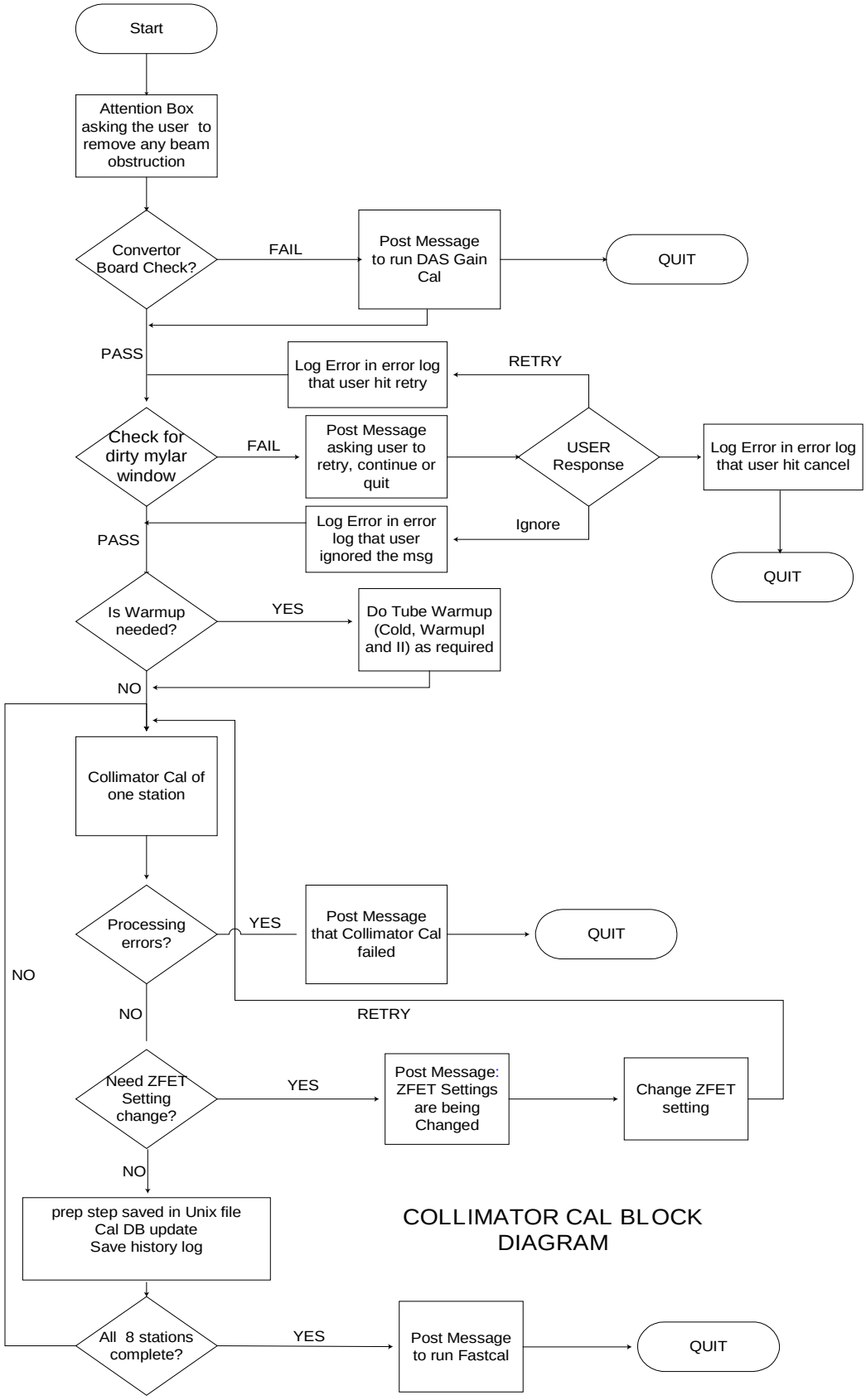


Figure 2-26 Collimator Cal Block Diagram

MESSAGES AND POP-UPS

Before DAS Gain or Collimator Cal come up, an attention box is posted asking the user to clear any obstruction in the path of the beam. Only when the user hits OK will the cals proceed forward. Also after DAS Gain and Collimator Cals are done, each will post an attention box asking the user to run FastCal.

COLLIMATOR CAL INFORMATIONAL MESSAGES

Message 1: Please remove any obstruction in the path of the beam.

Message 2: Converter boards have changed. Please first run DAS Gain Cal before running Collimator Cal.

Message 3: Please check Mylar window and clean if necessary to assure proper scanner operation.

Message 4: User quit the tracking cal after the Mylar window check failed.

Message 5 User ignored the Mylar window check failure and continued with the tracking cal.

Message 6: DAS Gain Cal was not completed.

Message 7: Collimator Cal was not completed.

Message 8: The Z-FET setting was changed for this scan.

COLLIMATOR CALIBRATION

A method has been devised of tracking the motion of the focal spot so that the collimator opening can be reduced, thus reducing dose.

With collimator tracking, the position of the collimator is no longer a fixed function of aperture and focal spot size. The two cams, which operate independently, form the sides of the collimator and must move with the motion of the focal spot. Information regarding the focal spot position is sensed through special channels called the z-channels. The information from the z-channels is translated into the position of the beam on the detector at the iso channel. The translation process depends on calibration polynomials and operating points, which are determined by the Collimator Calibration process.

DAS GAIN

This program computes the DAS Gain correction factors needed for the z-channel ratio (which determines the focal spot and beam position) and for channel 762 (which monitors blocking for tracking). The z-channel ratio correction is used in Collimator Calibration. There are two sets of correction factors—one for each cam.

CONVERTER BOARD CHECK

First, the ID's of the converter boards used by channel 762 and the z-channels (boards 47& 48) should be checked to see if they match the converter boards that were in place when the last DAS Gain Cal was performed. If there is no match, the user is directed to perform a DAS Gain Cal before doing Collimator Cal.

MYLAR WINDOW CHECK

Assuming the tube is warm when Collimator Cal is begun, the first scans should check if there is any contrast or other material on the Mylar window that will corrupt the calibrations. Four one-second rotating scans should be taken at 80 kvp, 20ma with aperture at 4x125, 4x250,4x375, and 4x500 respectively. If the 20 point filtered offset corrected channel 762 data vs views divided by the offset corrected view averaged value of channel 762 falls below 0.90 for any scan, for any row, a message will be displayed to the user and a response from the user is needed before continuing. The user should be allowed to go ahead without further action, clean the Mylar window and repeat the blockage scan, or quit the operation completely. The message should say:

> Please check Mylar window and clean if necessary to assure proper scanner operation. Indicate if you want to repeat the check scan or continue with the Collimator Cal, or abort Collimator Cal.

SWEEP SCAN

The information needed to perform calibration is obtained using sweep scans. The sweep scan is a stationary scan, with x-ray tube at 12 o'clock position, where the cam positions go through their entire range of motion in 37 incremental steps. At each step, which is a 100 views, the offset corrected view averaged data is collected for the data channels and the z-channels. This information with DAS, Gain is the basic information that is used to perform the calibration. Scans are only done at 120kv with the head bowtie. The time of these scans is 5.9 seconds, which allows for 37 steps at 100 views with time allowed to transition between the steps. The information from rows 2A and 1A are used to calibrate the cam on the A side while the cam on the B side uses the information from the B rows. The signals from side A should be monotonic, starting high and ending low, while the signals from side B are monotonic, starting low and ending high.

COLLIMATOR CALIBRATION

This is the major program that computes the calibration.

The outputs to the cal database are: mapping sides A & B, target position on iso channel, ratio range, and dose reduction. Some ID information that determines where the data goes is stored in the file with the other data: spot size, data channel fet, z channel fet, DAS Gain used, aperture size, and focal spot position. Also the ID numbers for the DAS Converter boards that are used by the z-channels and channel 762 need to be stored in the cal database. In measure mode, the channel positions the ratios, zratio, and dratio for both sides must be stored in addition to the other output.

The Collimator Cal needs to be done after a detector change or tube change. If a converter board change has been made, affecting the z channel or channel 762 (boards 47&48), or if the detector has been changed, the DAS Gain Cal should be done. Tube change does not require redoing the DAS Gain Cal. At the beginning of Collimator Cal, the serial numbers of the converter boards should be queried, and it should be determined if there has been a change since the last DAS Gain Cal was done. The software should force the user to leave collimator cal and perform DAS Gain Cal.

Section 3.0
Tools and Diagnostics

3.1 Log Viewer

3.1.1 Introduction

Log Viewer provides a common method to review various system files that may be useful in evaluating system performance and/or troubleshooting system problems. It replaces the System Browser at the CT application level of operation. The Log Viewer provides “one-stop” shopping by eliminating the need to remember complex directory structures and paths. The contents of important system files can be display using the browser’s functions and menus.

The Log Viewer is WEB based. It utilizes the Java language for much of its functionality and user interface. This allows for future expansion.

3.1.2 Log Viewer Startup (Applications Level)

Starting from the Service desktop Home Page Tab, select the Error Logs tab, and then select System Browser from the list of file options. See Figure 2-27. If the CT applications are not up, bring them up by typing **st** in the console window, and then select service desktop.

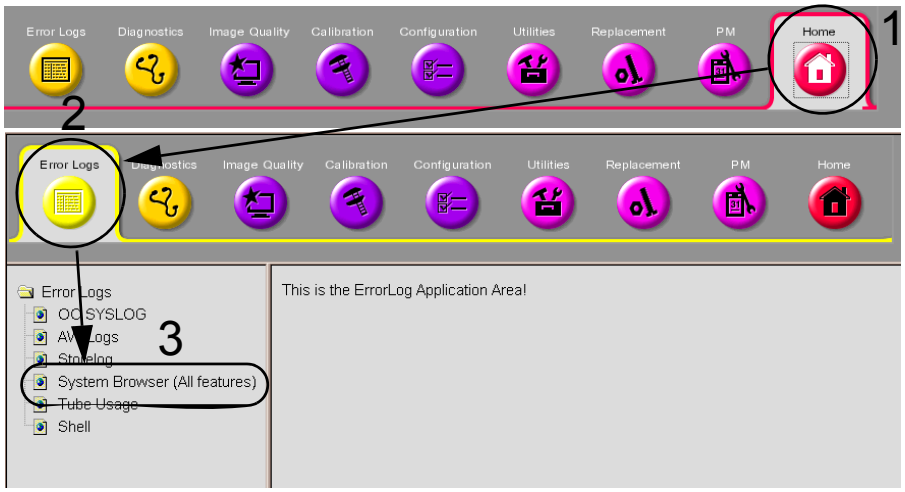


Figure 2-27 Browser Home and Error Log Tabs

Once the Log Viewer starts, a new window (HTML Page) is opened. By default, gesyslog should be selected and the logs for today should be displayed in tabular form in the display area. By default, the last messages in the gesyslog should be displayed

The viewer window is divided into two frames. Starting from top to bottom, they are the “selection area” and the “informational viewing area”. The selection area is used to select the log to be viewed. The informational viewing area is where the log is actually displayed.

3.1.3 Log Viewer Selections

In the browser's log selection area, the option to choose several different system logs for viewing is available.

To view a log, use the mouse, click the Log Select drop-down list box, and click on the log name you wish to view. Next click on SHOW LOG!. The log will be displayed in the viewing area.

The drop-down list gives you the following selections:

- **GE System Log** — gesyslog
- **SYSLOG OC** — The OC computer IRIX Operating System Log
- **IOS LOGS** — Application software logs for: Image Browser, Image Database Read Server, Image Database Write Server, Image Server, DICOM Server, Image Acquisition Server, Networking Server, Film Composer Log, Printer Server, Archive, Display, Filming.
- **Tube Usage** — Tube slice count and use information for the current and previous x-ray tubes.
- **OC Info**
- **Config Files** — OC Host Configuration File, OC Scan Hardware Configuration File
- **Scan Usage**
- **Motorola scan Corrections Computer, VxWorks Logs**

In addition to showing a log, Histogram VIEW and SEARCH are also available.

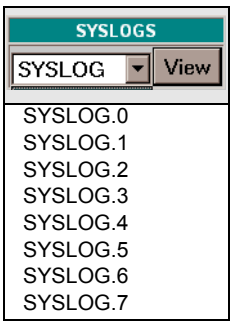
3.1.4 GE Message Log (gesyslog) Viewing

The entire gesyslog will be displayed, starting with the last page message first. There should be a hyperlink to the TOP of the page, when you scroll to the bottom. The PREV, FIRST and LAST links will be enabled (if the gesyslog is huge). Clicking on the TOP link displays the first few messages in log. If the PREV, FIRST, LAST links are displayed, click on them to view the next set of messages. Selecting PREV displays the previous records for the gesyslog file, if it exists. LAST takes you to the end of the log, where you should find the text "A New gesylog file is being created." You will find gesyslog located in the following pathname:

/usr/g/service/log/gesys_<suite name>_oc.log

3.1.5 SYSLOG OC

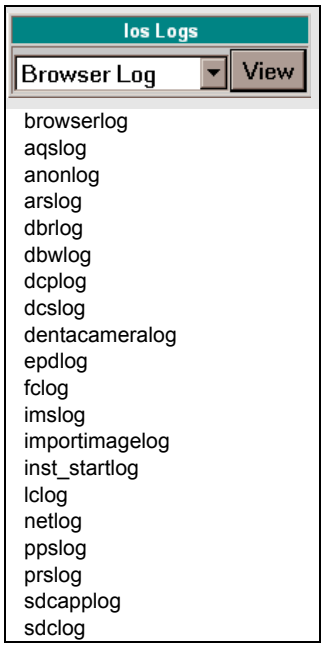
When you select SYSLOG OC and click SHOW LOG!, you can choose which specific SYSLOGS to view. Use the drop-down list box to make your selection and choose VIEW.



The SYSLOGS are found within the path /var/adm. If a log is present and is of size > 0 bytes, its contents will be displayed. Otherwise you will get an error message saying that the specified log-file has zero contents.

3.1.6 IOS Logs

When you select IOS LOGS and then SHOW LOG!, a new frame is opened. A pull-down in the frame lets you select which specific log file to display.



The IOS log files are created and updated by various scanner application software processes. The IOS Logs are normally found within the path /export/home/sdc/logfiles. If a log is present and is of size > 0 bytes, its contents will be displayed. Otherwise you will get an error message saying that the specified log-file has zero contents.

3.1.7 Tube Usage

When you select TUBE USAGE and then SHOW LOG!, a new frame is opened. Within the new frame is a list of tube usage files presently available for viewing. The tubes files are displayed from newest to oldest, top to bottom respectively. Three different views of information can be generated by following the hyperlink: Summary, Details, and Cumulative Statistics. See Figure 2-28.

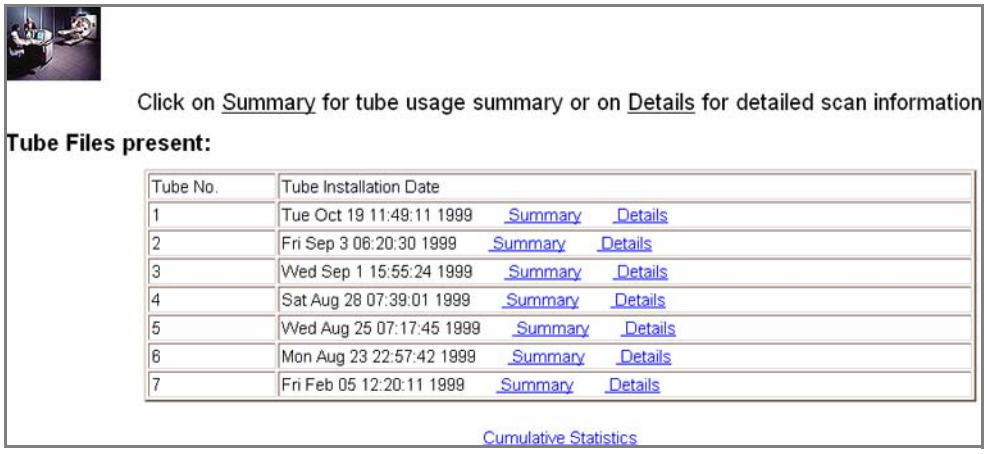


Figure 2-28 Tube Usage Screen - Example

For Tube Warranty purposes, “Warranty Effective Slices” is the correct number to report upon tube unit failure.

3.1.7.1 Tube Usage Details

The Tube Usage Details information provides identification, usage and scan information. Scan information lists the types and number of scans taken on unit being displayed. An example is provided in Figure 2-29.

HEADER INFORMATION:

Hospital Name: G.E. Medical Systems
Suite Name: CT09
Product Name: LightSpeed Plus
Tube serial no: 564GI5
Tube Name: 2120785
Housing serial no: 657GM7
Housing Name: 2137130-2
Installed on: Fri. Sep 3 06:20:30 1999
Last scan on: Fri. Nov 5 12:12:41 1999

TUBE USAGE

Scan Mode	Patient	Non-Patient
mAs	12898304	1188368
Number of Slices	476565	17095
Number KW Slices	811	266
KW Hours	4257.10	375.65
Scan Seconds	120150.3	9011.70000000001

SCAN INFORMATION:

KV	MAMP	Scan Time (sec)	Scan Mode	Focal Spot	Usage Mode	No. of Scans	No. of Slices
80	50	0.1	CINE	SMALL	Non Patient	90	0
100	80	0.1	CINE	SMALL	Non Patient	90	0
120	120	0.1	CINE	SMALL	Non Patient	89	0
120	200	0.1	CINE	SMALL	Non Patient	266	0
120	80	2	SCOUT	SMALL	Patient	148	148
140	180	1	AXIAL	LARGE	Patient	3	12
120	200	0.8	AXIAL	SMALL	Patient	2497	9988
120	200	1	AXIAL	SMALL	Patient	3336	13344
120	400	1	AXIAL	LARGE	Patient	98	392
120	80	4	SCOUT	SMALL	Patient	558	558
120	140	1	AXIAL	SMALL	Patient	59	236

Figure 2-29 Tube Usage Detail - Example

3.1.7.2 Tube Usage Cumulative Information

The Tube Usage Cumulative Information displays the totaled tube usage information for all tubes that have been installed on the system. Refer to Figure 2-30 for an example of the display.

CUMULATIVE STATISTICS

Hospital Name: G.E. Medical Systems
Suite Name: CT01
Product Name: LightSpeed

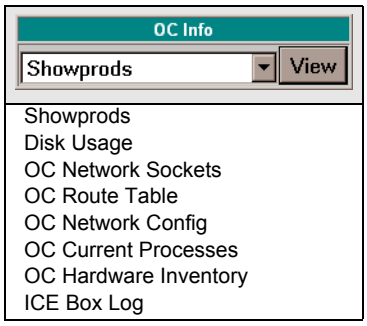
Scan Mode	Patient	Non-Patient
mAs	64183802	8620911.7
Number of Slices	2127256	92258
Number KW Slices	2932	1328
KW Hours	21341.91	2739.53
Scan Seconds	588763.5	53810.1999999999

Back to tube usage page.

Figure 2-30 Tube Usage Cumulative Statistics - Example

3.1.8 OC Info

When you select OC INFO and then SHOW LOG!, a new frame for OC Info is opened within the current window. "OC Info" executes basis IRIX commands to gather information used for display. To use, simply make a selection and select VIEW. The associated IRIX command is execute and the output is directed into the frame immediately below as HTML (See Table 2-1).



The command results available in this area are:

OC INFO LIST ITEM	ACTION (EQUIVALENT IRIX COMMAND)
Showprods (System Software Revisions)	**showprods**
Disk Usage:	**df**
OC Network Sockets:	**netstat -ian**
OC Route Table:	**netstat -r**
OC Network Conf	**ifconfig**
OC Current Processes	**ps -aef**
OC Hardware Inventory:	**hinv**
ICE Box Log	

Table 2-1 OC Info Commands

Refer to Figure 2-31 for an example of OC Network Sockets output.

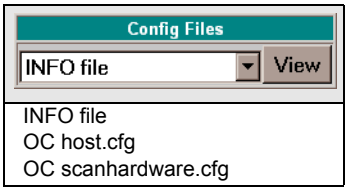
```
Name Mtu   Network     Address           Ipkts Ierrs   Opkts Oerrs  Coll
ef0  1500  192.9.220   192.9.220.1      104248     0   84909     0     0
                       224.0.0.1
                       08:00:69:13:50:11
ef1  1500  3.7.52      3.7.52.110        23636     0   20063     1  5899
                       224.0.0.1
                       08:00:69:0d:8f:1a
ppp0 1500  (pt-to-pt)  3.57.1.244         1432     1    1704     0     0
                       224.0.0.1
lo0  32992 127         127.0.0.1         253015     0  253015     0     0
```

Figure 2-31 OC Network Sockets - Example

3.1.9 Config Files

When you select CONFIG FILES and then SHOW LOG!, a new frame for Config Files is opened within the current window. “Config Files” executes basis IRIX commands to gather information used for display. To use, simply make a selection and select VIEW. The associated IRIX command (see Table 2-2) is execute and the output is directed into the frame immediately below as HTML.

The System Browser has the capability of viewing some of the routinely referenced scanner configuration files used in gathering data about the system.



Refer to Figure 2-32 for an example of the INFO file result.

CONFIG FILES LIST ITEM	ACTION (EQUIVALENT IRIX COMMAND)
OC host.cfg	**cat /usr/g/config/host.cfg**
OC scanhardware.cfg	**cat /usr/g/config/scanhardware.cfg**
INFO file	**cat /usr/g/config/INFO**

Table 2-2 OC Info Commands

```
TZ=CST6CDT
SERVER_DISTRIBUTOR=InSite Interactive Platform
IIP_USN=0000CTBAYA
INSITE_HOME=/usr/g/insite
PERL5LIB=/usr/g/insite/lib/perl5
IIP_ProductIP=172.28.64.1
IIP_LOCALE=en
PATH=/usr/g/insite/lib:/usr/g/insite/bin:/usr/g/insite/bin:/usr/sbin:/usr/bsd:/sbin:/usr/bin:/etc:/usr/etc:/usr/bin/X11:/usr/g/insite/
ProDiags/bin:.
ERMESDIR=/usr/g/db
DBDIR=/usr/g/db
LOGDIR=/usr/g/service/log
CONFIGDIR=/usr/g/config
DD_ROOT_DIR=/usr/g/service/dd
DD_MOD_DIR=/MOD
ACCS_TIMEOUT=300000
MSD_TIMEOUT=300000
AUXCHANNEL_TIMEOUT=8000
CALMODULE_TIMEOUT=4000
MAX_VIEW_RANGE=4000
ZAXISCHANNEL_TIMEOUT=10000
HTTP_ACCEPT=*/*
HTTP_REFERER=http://3.7.52.110/ctcgi-bin/show_config.cgi
HTTP_ACCEPT_LANGUAGE=en-us
CONTENT_TYPE=application/x-www-form-urlencoded
HTTP_ACCEPT_ENCODING=gzip, deflate
HTTP_USER_AGENT=Mozilla/4.0 (compatible; MSIE 5.5; Windows NT)
HTTP_HOST=3.7.52.110
CONTENT_LENGTH=27
HTTP_CONNECTION=Keep-Alive
SERVER_SOFTWARE=Apache/1.2.6
SERVER_NAME=3.7.52.110
SERVER_PORT=80
REMOTE_HOST=3.45.112.50
REMOTE_ADDR=3.45.112.50
DOCUMENT_ROOT=/usr/g/insite/server/htdocs
SERVER_ADMIN=ii-core@med.ge.com
SCRIPT_FILENAME=/usr/g/httpd/cgi-bin/show_config.cgi
REMOTE_PORT=2000
GATEWAY_INTERFACE=CGI/1.1
SERVER_PROTOCOL=HTTP/1.1
REQUEST_METHOD=POST
QUERY_STRING=
REQUEST_URI=/ctcgi-bin/show_config.cgi
SCRIPT_NAME=/ctcgi-bin/show_config.cgi
```

Figure 2-32 INFO File - Example

3.2 Flash Download Tool

3.2.1 The Need for FLASH Version Verification and Download Tool

The control boards in the system contain a new architecture for the CT environment that speeds up their initialization time. Application and characterization parameters are stored in the on-board FLASH memory of the DCB, CCB, ETC, STC, and OBC control boards, and must be the same as the files stored on disk. To ensure that these files are correct and current, a utility to validate the versions of the files (comparing Unique ID and CRC in FLASH with the files saved on the system disk) automatically runs silently when the scanner hardware is reset.

The CCB characterization file, which uses the device's serial number for a unique ID, is handled differently than other files. The CCB aperture char file is specific to its accompanying collimator and is NOT part of the load from cold. Therefore, in cases when the characterization file is not on the system disk or saved in the system state, the system must upload the file from FLASH to the disk. Once uploaded to the system disk, the file can be saved to system state and downloaded back to the device, in the event the CCB is swapped out or replaced.

In summary, the Flash Download Tool provides the mechanism for getting the correct files uploaded from FLASH or downloaded from the system disk to FLASH as required.

3.2.2 FLASH Download Tool

The FLASH Download Tool provides the user with the following functionality:

- Query the FLASH memory and system disk to determine correctness of FLASH files.
- Download and store files to the FLASH memory when control boards are replaced.
- Upload files to the system disk as required.

The tool is in several locations on the service desktop, including the UTILITY list under INSTALL.

3.2.2.1 FLASH Download Tool User Interface

After the tool is invoked from the Service Desktop Manager, the FLASH Download Tool screen appears (refer to Figure 2-33). By default, all five nodes are selected at startup. The user selects QUERY to simply query the nodes and selects UPDATE to query, update, and then re-query the nodes. The Node, File Name, and Status are then presented to the user in the Results window whenever a query is done. The Result and Status areas in the figure below show the result of a successful query.

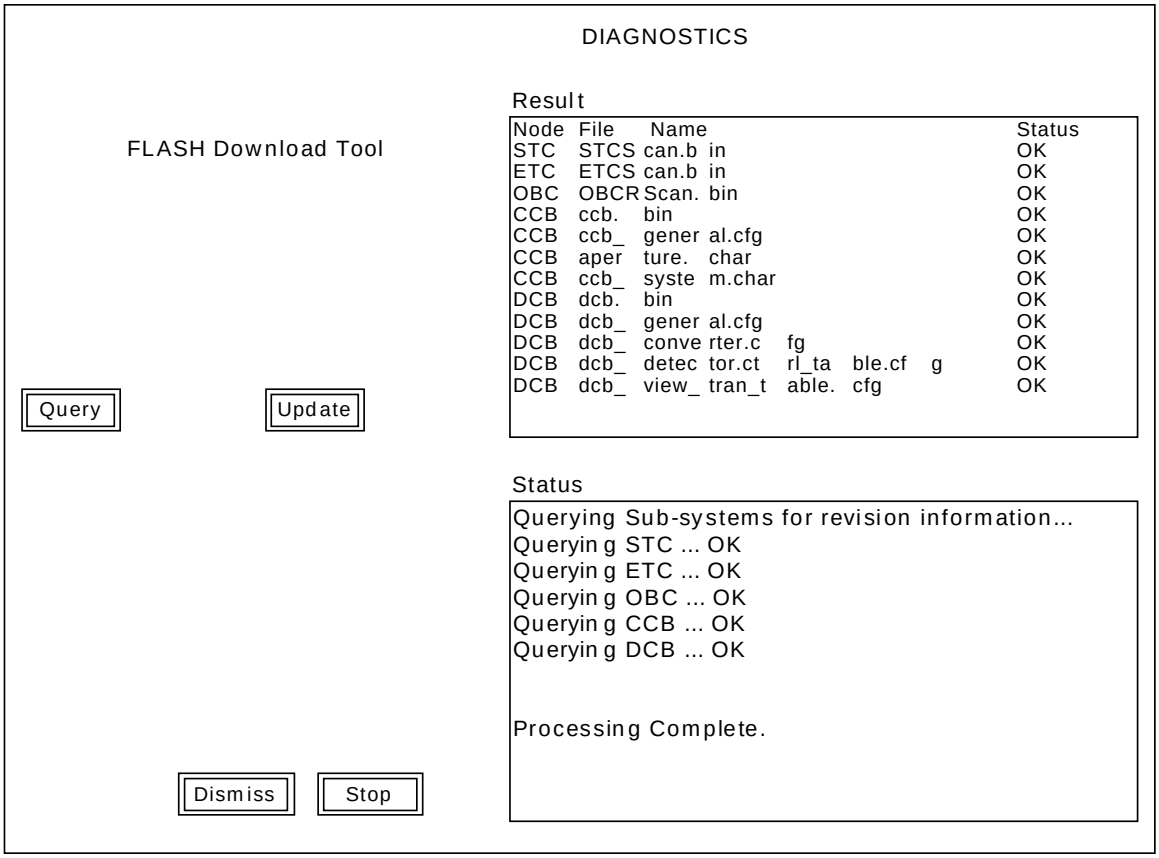


Figure 2-33 FLASH Download Tool User Interface

3.2.2.2 Button Processing

The buttons for the FLASH Download Tool shown in Figure 2-33 are described below. During a Query or an Update, all buttons are disabled except for the STOP button.

1.) Query/Update Options

- Pressing the QUERY button will cause the FLASH Download Tool to query the nodes.
- Pressing the UPDATE button will cause the FLASH Download Tool to update the nodes. The FLASH Download Tool will first perform a query, then update the nodes, then re-query the nodes. If the firmware is down or an ALM is updated, then the query/update

sequence may be repeated.

2.) Pressing DISMISS will exit from the FLASH Download Tool.

3.) Pressing STOP will terminate the current query or update as soon as reasonable.

4.) The Node column is the name of the node, either STC, ETC, OBC, CCB, or DCB. The File Name column is the actual name of the file obtained from the node. The Status column indicates the status of the file, with OK indicating that no update of the file is required.

3.2.3 Serial Number Input Cases

Each collimator has a unique aperture.char file with information for its cam movement and serial number of that collimator. If the collimator and CCB or the CCB only is replaced, the correct char file must be updated and stored on both the CCB and the system disk using the Flash Download Tool. When the CCB Board is replaced, or when the collimator with CCB is replaced, the following occurs:

1.) Starting up system, during hardware initialization, the gesyslog reports missing or invalid files and directs the user to run the Flash Download Tool.

2.) Enter Flash Download Tool and select UPDATE. The user is prompted to enter the serial number imprinted on the component for which the CHAR file is needed (refer to Figure 2-34).

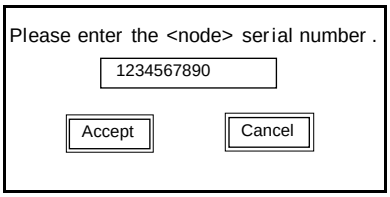


Figure 2-34 FLASH Download Tool Serial Number Window

3.) After entering the number, the FLASH Download Tool will compare the serial number entered by the user with the unique ID in the CHAR file on the system disk and on the CCB.

a.) **CCB Replacement Case** - The serial number entered will match the unique ID on the system disk, and the file will be downloaded to the CCB from the disk.

If a second pop-up to upload appears (see Figure 2-35), the number entered is not matching what is on the system Disk. There is likely a problem with the serial number that was entered. Select NO and recheck the number.

b.) **Collimator & CCB Replacement Case** - The serial number entered matches the unique ID on the collimator, (and therefore is a different ID than what is on the system disk), then an additional window (refer to Figure 2-35) appears, and the user would be informed that the serial number entered requires the *upload* of a file from the CCB to the system disk. The user would then be able to accept or refuse the file transfer.

An invalid serial number message is reported to the user in the Status window, if the number entered matches neither the unique ID on the node nor the system disk.

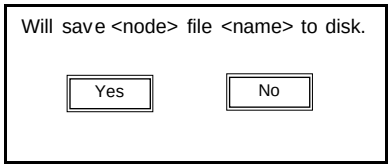


Figure 2-35 FLASH Download Tool Upload Window

After all possible uploads and downloads of files, processes similar to those in the FLASH Version Verification Utility would automatically be invoked to confirm the successful transfer of all necessary files. If the necessary files are still absent, or an error occurs, then the FLASH Download Tool Status

window would indicate an inoperable system condition. If successful, the tool will enable scanning capabilities for the system.

System resources will be taken during download and version verification to prevent scanning. The system will lock out the user, if the transfer of any file is refused by exiting the tool before completing all transfers.

3.2.4 FLASH Version Verification Error Handling

The FLASH Version Verification Utility is automatically activated after a node is reset or when the system is initialized. The operation of the utility itself is invisible to the user unless an error occurs. If an error is detected by the utility, then the window shown in Figure 2-36 will be displayed. An error will be logged and the system will be inhibited from scanning.

Figure 2-36 FLASH Version Verification Utility Window

The <attention-message> in the window shall be one of the following:

- One or more of the controllers(ETC/STC/OBC) or system disk contains missing or invalid files. Please run the FLASH Download Tool from the Service Desktop Manager to correct this problem.
- The collimator or system disk subsystem contains missing or invalid files. Please run the FLASH Download Tool from the Service Desktop Manager to correct this problem.
- The DAS subsystem or system disk contains missing or invalid files. Please run the FLASH Download Tool from the Service Desktop Manager to correct this problem.

3.2.5 Flash Download Tool Exception Handling

The error cases handled by the FLASH Download Tool are explained below in Table 2-3. Note that errors recorded by the FLASH Version Verification Utility will not be repeated in the error log. All errors will be recorded in the “GE system log”.

ERROR DESCRIPTION	ACTION
Missing or Invalid ALM (Application Load Module) file on the SBC disk. (The ALM file is the application executable file.)	An error message is reported to the error log indicating the message code of the missing file from the SRU. The FLASH Download Tool Status window reports a file error. The HOP or fwmgr lock the system scanning capabilities.
Missing or Invalid ALM file on the FLASH memory	An error message is reported to the error log indicating the message code of the missing file on the FLASH. The FLASH Download Tool Status window reports a file error. The FLASH Download Tool attempts to replace the file. If the file cannot be replaced, the HOP or fwmgr lock the system scanning capabilities.

Table 2-3 FLASH Download Tool Exception Handling

ERROR DESCRIPTION	ACTION
Missing or Invalid CHAR file on the SBC disk	An error message is reported to the error log indicating the message code of the missing file from the SRU. The FLASH Download Tool Status window reports a file error. The FLASH Download Tool continues to download the next required CHAR file(s) until all possible files have been recovered. The HOP or fwmgr locks the system scanning capabilities.
Missing or Invalid CHAR file on the FLASH memory	An error message is reported to the error log indicating the message code of the missing file on the FLASH. The FLASH Download Tool Status window reports a file error. The FLASH Download Tool attempts to replace the file. The FLASH Download Tool continues to download the next required CHAR file(s) until all possible files have been recovered. If the missing or invalid file could not be replaced, the HOP or fwmgr lock the system scanning capabilities.
Invalid CRC or Status received from the node	An error message is reported to the error log The HOP or fwmgr lock the system scanning capabilities.

Table 2-3 FLASH Download Tool Exception Handling (Continued)

3.3 Diagnostic Data Collection (DDC)

Diagnostic Data Collection is a tool that allows the user to scan and create scan files using user selectable scan types and parameters as an aid in troubleshooting and verifying the data integrity of the DAS/Detector subsystem.

HOW TO ACCESS DDC - GENERAL SERVICE

1.) Select DIAGNOSTICS.
2.) Select DIAGNOSTIC DATA COLLECTION.
   - Use DDC to collect DAS data with and without x-ray and/or rotation.
   - Use the Scan Analysis tool to examine collected data.

3.3.1 Scan Types and Parameters

The Diagnostic Data Collection (DDC) tool supports the following scan types:

1.) Static X-Ray Off.
2.) Static X-Ray On.
3.) Rotating X-Ray Off.
4.) Rotating X-Ray On.

Each scan type is presented as a selectable button on the left-hand side of the DDC screen. With each scan type is an associated set of scan parameters that the user will be allowed to select.

There are additional scan parameters displayed on the screen that the user will not be allowed to modify, presented as insensitive for the following reasons:

- The parameters are not required for the scan type selected.
- The parameters will not be functional until a future release.

The following table shows what scan parameters are available in each of the four scan types:

SCAN PARAMETER	STATIC X-RAY-ON	STATIC X-RAY OFF	ROTATING X-RAY-ON	ROTATING X-RAY-OFF
Run Description	X	X	X	X
Scan Time	X	X	X	X
No. of Scans	X	X	X	X
Inter Scan Delay	X	X	X	X
Trigger Rate	X	X	X	X
Calibration Vector	X	X	X	X
Rotor		X		X
kv	X		X	
mA	X		X	
DAS Gain	X		X	
Gantry Velocity			X	X
Xray On Position			X	
Initial Start Position				X
Modulation				
Phase				
X-ray Duration				
Dly Until Xray On				
Focal Spot	X		X	
Filter	X		X	
Slice Collimation	X		X	

Table 2-4 Scan Parameters vs. Scan Types

3.3.2 Options

For each of the scan types selected, the user may specify the following options, which are presented in the DDC GUI as buttons close to the bottom of the screen (refer to Figure 2-37):

1.) Auto Scan
2.) TXXT

3.3.2.1 Auto Scan

For each of the scan types selected the user may specify the auto scan option.

3.3.2.2 TXXT

TXXT (Trigger On, X-ray On, X-ray Off, Trigger Off) is an option for the Static X-Ray On and the Rotating X-Ray On scan type selections. This button will be insensitive when the Static X-Ray Off or Rotating X-Ray Off scan type is selected.

The TXXT button is associated with the following scan parameters:

- X-ray Duration
- Dly Until X-ray On

3.3.3 DDC Interface

The Diagnostic Data Collection Interface consists of three main areas (Figure 2-37, an example of Static X-Ray-Off).

1.) Command Area
2.) Work Area
3.) Status Message Area

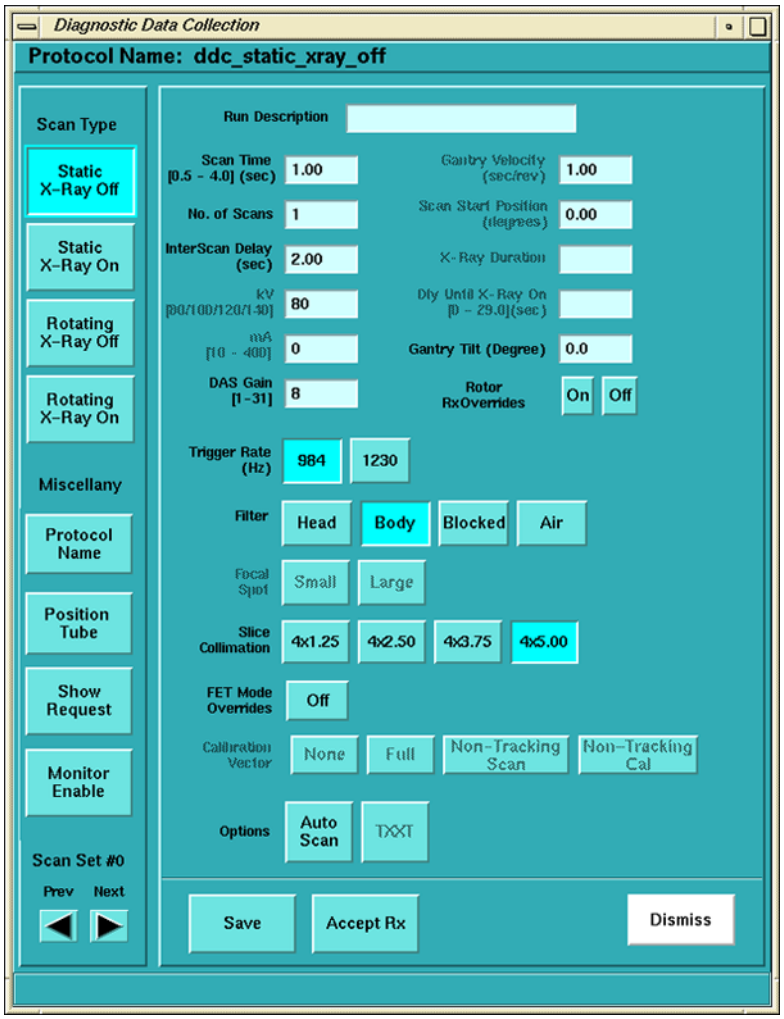


Figure 2-37 DDC Interface

3.3.3.1 Command Area

The Command Area consists of a vertical palette of push buttons located on the left hand side of the screen. These include the four scan type selection buttons and two miscellaneous buttons; the Protocol Name and the Position Tube buttons.

Scan Type Buttons

The four scan type buttons, described previously in Section 3.3.1, are provided to select the scan type indicated by the button label. On selection of a scan type, the corresponding scan parameters that the user will be allowed to modify will become sensitive, and the parameters that the user will not be able to modify will become insensitive.

Protocol Name Button

When this button is selected, the Protocol Selection List pop-up window (Figure 2-38) will appear. This list contains all the available protocols on the system. When the user selects a protocol for loading, the values of the scan parameters that were stored in the protocol file will be displayed in the appropriate areas of the screen.

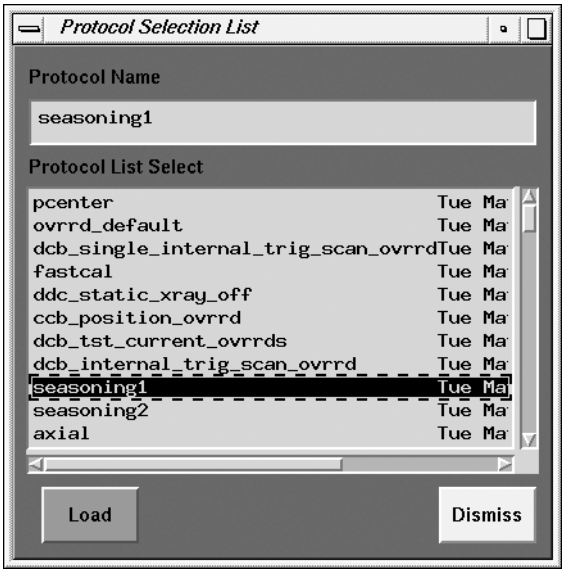


Figure 2-38 DDC Protocol List

Diagnostic Data Collection (DDC) Protocols are located in the following directory on the OC:

/usr/g/protocol/service/v1.1

Most of these protocols are used by tools and diagnostic scans. Depending on troubleshooting experience, these protocols can be selected from within DDC, and accepted “as is” or some of the parameters can changed for the current exam. Changes to the protocols cannot be changed and saved as well as new service protocols cannot be created.

PROTOCOL NAME	PROTOCOL USED FOR
prot.1set.scanr	For Engineering Use Only
prot.4sets.scanr	For Engineering Use Only
prot.TestDriver.scanr	For Engineering Use Only
prot.air_100.scanr	100KV Air Calibration Scans
prot.air_120.scanr	120KV Air Calibration Scans
prot.air_140.scanr	140KV Air Calibration Scans
prot.air_80.scanr	80KV Air Calibration Scans
prot.air_xtalk.scanr	Not Used
prot.aircal.scanr	Air Calibration
prot.axial.scanr	“Template” of simple Axial
prot.axial2.scanr	For Engineering Use Only
prot.bleedersetup.scanr	HV Bleeder set-up scans
prot.cal0.scanr	Z-Slope Cal Scans

Table 2-5 Diagnostic Data Collection (DDC) Protocols

PROTOCOL NAME	PROTOCOL USED FOR
prot.cal1.scanr	Z-Slope Cal Scans
prot.cal2.scanr	Z-Slope Cal Scans
prot.cal3.scanr	Z-Slope Cal Scans
prot.cal4.scanr	Z-Slope Cal Scans
prot.cal5.scanr	Z-Slope Cal Scans
prot.cal6.scanr	Z-Slope Cal Scans
prot.cal7.scanr	Z-Slope Cal Scans
prot.ccb_offset_ovrrd.scanr	For Engineering Use Only
prot.ccb_position_ovrrd.scanr	For Engineering Use Only
prot.ccb_test_all_ovrrds.scanr	For Engineering Use Only
prot.ccb_time_sweep_ovrrd.scanr	For Engineering Use Only
prot.ccb_trig_sweep_ovrrd.scanr	For Engineering Use Only
prot.ccb_tst_current_ovrrds.scanr	For Engineering Use Only
prot.cine.scanr	“Template” of simple Cine scan
prot.clever_gain_aircal.scanr	Clever Gain scans used during FastCal
prot.cold_warmup.scanr	Cold Tube warm-up during Calibration
prot.das_aux_channels.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_aux_channels2.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_aux_channels3.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_aux_channels4.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_dccal_absolute.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute10.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute11.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute12.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute13.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute14.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute15.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute2.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute3.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute4.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute5.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute6.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute7.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute8.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute9.scanr	Used for DCCAL Scanning in DASTools
prot.das_dcnoise.scanr	Used for DC Noise Scan in DASTools
prot.das_dcnoise_offsets.scanr	Used for DC Offset/Noise Scan in DASTools

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

PROTOCOL NAME	PROTOCOL USED FOR
prot.das_dcoffsets.scanr	Used for DC Offset Scan in DASTools
prot.das_drift.scanr	Used for Offset Drift Scan in DASTools
prot.das_interconnect.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect10.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect11.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect2.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect3.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect4.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect5.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect6.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect7.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect8.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect9.scanr	Used for Interconnect Test in DASTools
prot.das_popmicro.scanr	Used for Pop/Noise Scans in DASTools
prot.dcb_canned_cnv_pattern_ovrrd.scanr	Scan Data Path Diagnostic Scans
prot.dcb_canned_dcb_pattern_ovrrd.scanr	Scan Data Path Diagnostic Scans
prot.dcb_cnv_autocorr_disable_ovrrd.scanr	Eng. Use only, disables Converter Bd. Auto-correction
prot.dcb_detector_ctrl_ovrrd.scanr	Eng. Use Only, Controls FET over-ride settings
prot.dcb_internal_trig_scan_ovrrd.scanr	Currently not used, Internal Trigger over-rides
prot.dcb_single_internal_trig_scan_ovrrd.scanr	Currently not used, Single Trigger over-ride
prot.dcb_test_all_ovrrds.scanr	For Engineering Use Only
prot.dcb_tst_current_ovrrds.scanr	Converter Bd. Test voltage injection over-ride
prot.dcb_view_auto_zero_chan_ovrrd.scanr	Converter Bd. Auto-zero channel over-ride
prot.ddc_axial_xray_off.scanr	Default DDC Axial x-ray off
prot.ddc_axial_xray_on.scanr	Default DDC Axial x-ray on
prot.ddc_scout_xray_off.scanr	Default DDC Scout x-ray off
prot.ddc_scout_xray_on.scanr	Default DDC Scout x-ray on
prot.ddc_static_xray_off.scanr	Default DDC Stationary x-ray off
prot.ddc_static_xray_on.scanr	Default DDC Stationary x-ray on
prot.ductwarm.scanr	Ductility warm-up scans used in Auto mA scans
prot.fpa_check.scanr	FPA Test Scans used during FastCal
prot.grndleakage.scanr	Ground Leakage scans during HV integration
prot.helical.scanr	"Template" for simple Helical scan
prot.hhs_large_spot.scanr	HHS Scans
prot.hhs_large_sweep.scanr	Collimator Aperture Test
prot.hhs_small_spot.scanr	HHS Scans
prot.hhs_small_sweep.scanr	Collimator Aperture Test
prot.hot_iso.scanr	Hot ISO Data Scans
prot.hss.scanr	Heat Soak & Seasoning Scans

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

PROTOCOL NAME	PROTOCOL USED FOR
prot.hssquick.scanr	Heat Soak & Seasoning Quick Scans
prot.kvtest.scanr	Not Used
prot.large_cal.scanr	Phantom Calibration
prot.medium_cal.scanr	Phantom Calibration
prot.nbt_aircal.scanr	Non-Bowtie Air Calibration
prot.ovrrd_default.scanr	Not Used
prot.p12_xtalk.scanr	Not Used
prot.p35_100.scanr	Engineering IQTB Phantom Calibration
prot.p35_120.scanr	Engineering IQTB Phantom Calibration
prot.p35_140.scanr	Engineering IQTB Phantom Calibration
prot.p35_80.scanr	Engineering IQTB Phantom Calibration
prot.p48_100.scanr	Engineering IQTB Phantom Calibration
prot.p48_120.scanr	Engineering IQTB Phantom Calibration
prot.p48_140.scanr	Engineering IQTB Phantom Calibration
prot.p48_80.scanr	Engineering IQTB Phantom Calibration
prot.pcenter.scanr	Phantom Centering
prot.prescanma.scanr	Auto mA Calibration
prot.risefall.scanr	HV Integration Rise / Fall Scans
prot.rx_test_all_ovrrds.scanr	Not Used
prot.sanity_1.scanr	Internal S/W sanity testing scans
prot.sanity_2.scanr	Internal S/W sanity testing scans
prot.sanity_3.scanr	Internal S/W sanity testing scans
prot.sanity_4.scanr	Internal S/W sanity testing scans
prot.sanity_5.scanr	Internal S/W sanity testing scans
prot.sanity_6.scanr	Internal S/W sanity testing scans
prot.sanity_7.scanr	Internal S/W sanity testing scans
prot.scandp.scanr	Scan Datapath Diagnostic
prot.scantimer.scanr	Scan Timer scan
prot.scout.scanr	"Template" for simple Scout scan
prot.seasoning1.scanr	Heat Soak & Seasoning scans
prot.seasoning2.scanr	Heat Soak & Seasoning scans
prot.small_cal.scanr	Small Phantom Cal
prot.static.scanr	"Template" for simple static scan
prot.sweep.scanr	For Engineering Use Only
prot.ta_bow.scanr	Beam On Window (BOW) Alignment Scan
prot.ta_cbf.scanr	Center Bowtie Filter (CBF) Alignment scan
prot.ta_iso.scanr	ISO (cold) Alignment Air scan
prot.ta_iso_lrg.scanr	ISO (Large Spot) Alignment scan
prot.ta_iso_sml.scanr	ISO (Small Spot) Alignment scan
prot.ta_por.scanr	Plane of Rotation (POR) Alignment scan

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

PROTOCOL NAME	PROTOCOL USED FOR
prot.ta_snr.scanr	Not Used
prot.tst_all_current_ovrrds.scanr	For Engineering Use Only
prot.tst_all_ovrrds.scanr	For Engineering Use Only
prot.w20_100.scanr	Engineering IQTB Phantom Calibration
prot.w20_120.scanr	Engineering IQTB Phantom Calibration
prot.w20_140.scanr	Engineering IQTB Phantom Calibration
prot.w20_80.scanr	Engineering IQTB Phantom Calibration
prot.warmup1.scanr	Tube warm-up 1 scans during calibration
prot.warmup2.scanr	Tube warm-up 2 scans during calibration
prot.water_cal.scanr	Auto CT Number scans
prot.water_numbers_kv100.scanr	Manual CT Number Scans (100KV)
prot.water_numbers_kv120.scanr	Manual CT Number Scans (120KV)
prot.water_numbers_kv140.scanr	Manual CT Number Scans (140KV)
prot.water_numbers_kv80.scanr	Manual CT Number Scans (80KV)
prot.xrayverif_4x125.scanr	Used for X-Ray verification Scans in DAS Integration
prot.xrayverif_cal2.scanr	Used for X-Ray verification Scans in DAS Integration
prot.xrayverif_cal4.scanr	Used for X-Ray verification Scans in DAS Integration
prot.xrayverif_cal6.scanr	Used for X-Ray verification Scans in DAS Integration
prot.zscal.scanr	Not Used

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

Position Tube Button

When this button is selected, the Tube Position pop-up window (Figure 2-39) will appear. The tube positioning function allows the user to position the tube between 0 and 360 degrees of the rotation.

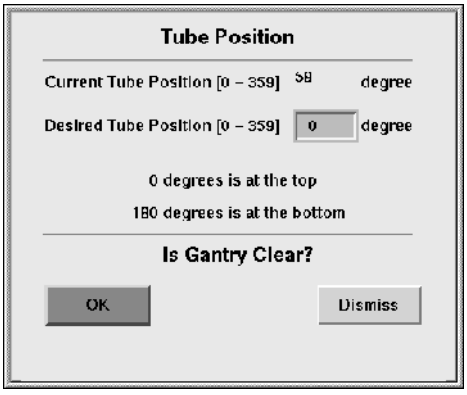


Figure 2-39 Position Tube Pop-Up Window

3.3.3.2 Work Area

All scan parameters in the fields to the right of the Command Area that may be modified, depending on the scan type and protocol selected, are displayed in the Work Area. Each scan parameter value is presented in a text field or indicated by a toggle button in a depressed state. When a value is displayed and is sensitive in a text field, a new value can be entered directly to replace the old value.

3.3.3.3 Status Message Area

Status messages will be displayed in this area at the very bottom of the GUI screen. The messages displayed in this area are not persistent and will disappear after a few seconds.

3.3.4 Reconstruct DDC Images

Use ReconRx screens to list/select the DDC-acquired data. Use ReconRx to reconstruct the DDC-acquired data into images.

DDC scans appear in Recon Rx List/Select when they consist of:

- Rotating X-Ray On scans
- Full rotation scans consisting of 984 views
- Scans that have a corresponding cal file

3.3.5 DDC With Tracking Off

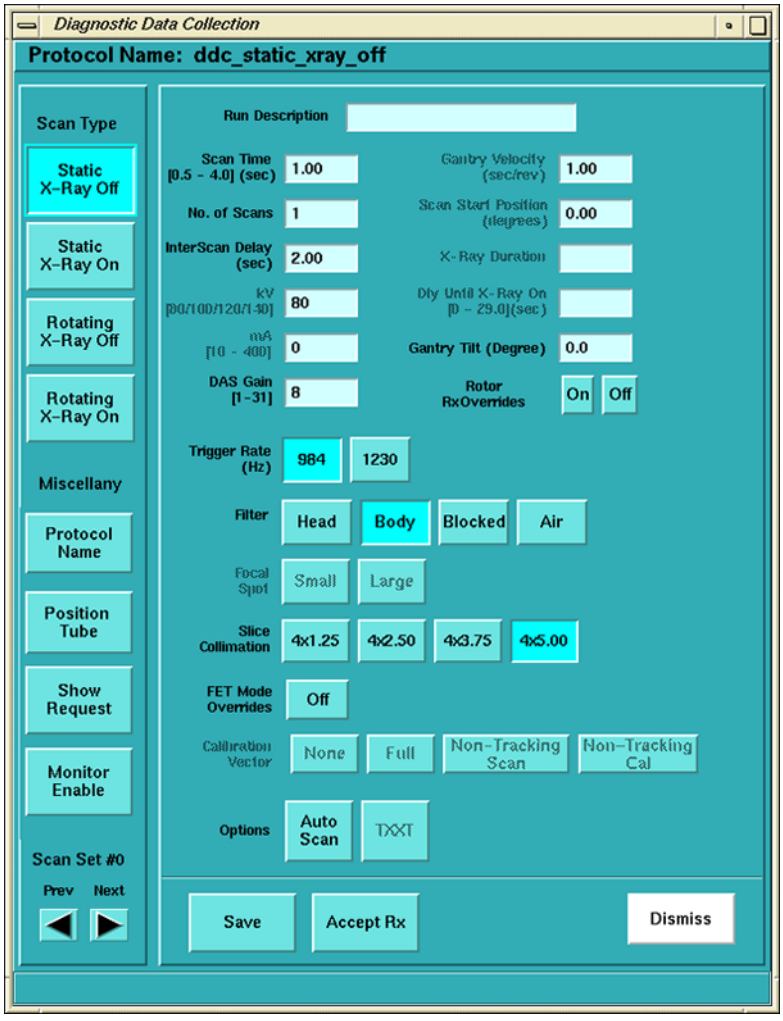


Figure 2-40 Diagnostic Data Collection Screen

To produce an image without tracking:

1.) Using DDC, create a non-tracking air cal. Use KV, mA, Filter, Focal Spot, and Aperture to duplicate patient scanning.
2.) Nothing should be in the beam.
3.) Select Calibration Vector Option Non-Tracking Cal. This will produce a temporary file that will be used for the air cal portion of data reconstruction.
4.) Scan.
5.) Place the phantom that you want scanned and reconstructed center in the beam.
6.) Select the exact same parameters that was used for the temporary Aircal, except for Calibration Vector option, select Non-Tracking Scan.
7.) Scan and record the exam number.
8.) Retro-Recon this exam number using Application ReCon menu options. Be sure to adjust the Field Of View (FOV) that matches the phantom size of FOV that your interested in viewing.
9.) View the images view the browser.

3.3.6 FET Mode Selection

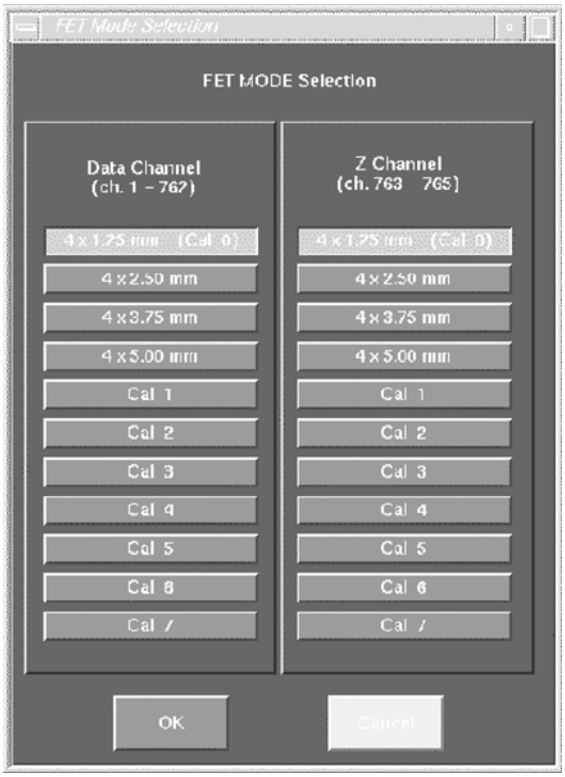


Figure 2-41 FET Mode Selection

Refer to Collimator Tracking Theory in section 4.3.18, on page 784, in Chapter 9 - X-Ray Generation, to understand FET Mode use with tracking.

3.4 Scan Data Analysis Tools (SCAN, Tracking dd, CAL)

The scan analysis feature allows users to have interactive access to scan files collected on the scanner. Scan data to be viewed can come from either patient scanning or from service mode tools such as Diagnostic Data Collection or Calibration.

Analysis is divided into three major areas of: SCAN ANALYSIS, dd FILE ANALYSIS, and CAL FILE ANALYSIS. CAL File analysis is not yet available for the Plus System. Each major section provides a file list select interface similar to the Image Works List Select, Image Browser. Analysis List Select allows you to select the appropriate file of interest.

Any of the normal scan files may be selected for processing within Scan Analysis including Axial, Helical, and Scout scans. Once the scan data of interest is selected you can select one of several processing options, which include: Update, Scan Header, Cal Vectors, Aux Channels, Create MSD dd File, Plot MSD, Plot VVC, and Save Scan.

3.4.1 Definitions within Scan Analysis

dd File (Diagnostic Data File): dd files are a result file from some type of operation on the scan data file. dd files are typically some form of view summed file that may have had some specific type of processing applied to it. For example, the processing applied to the raw data to calculate the position of the pin in ISO alignment results in a temporary file that is a view summed result that could be saved as a dd file. As long as two dd files have the same number of data elements in them, the two files may be added, subtracted, multiplied, or divided with each other.

Detector Macro Row: One detector output row for each of the four 4x1.25, 4x2.5, 4x3.75, or 4x5 acquisition mode combinations for the detector. For most of the analysis functions, this provides either four selections for the detector row to be examined, or four sets of data results that correspond to the detector rows 2A, 1A, 1B, 2B. Refer to the DAS Architecture (section 1.1, on page 483, in Chapter 7 - Detector and DAS) for further information.

Means and Standard Deviation File (MSD): This is usually the result of combining two or more views mathematically, which results in mean values for each channel in the views and an associated standard deviation for each channel in the views. In essence all of the user selected views in a scan file are summed together, resulting in a single “master view” that contains the averaged data from all of the views. The mean values represent the average data value from the channels, and the standard deviation values represent the amount of variability for that channel’s data values across all of the views. The higher the standard deviation, the more the channel output varied from view to view.

Scan Header: This is the information contained within the scan file that identifies the specific settings in effect when that scan file was created. The scan header includes information at several levels, including: Exam, Series, and Scan. Information identifying the technique selections, scan time, acquisition mode, and many others may be found in the scan header.

Cal Vectors: Within scan analysis, the cal vectors are only those vectors contained within the scan data file at the time that the scan was taken.

Aux Channels: The auxiliary channels are data sampling “channels” in the S-DAS that provide a way to place other data into the view besides the patient information coming from the detector. These include: Power Supply, Temperature, kV, mA, and other analog data values. These analog signals are sampled at the same rate as the patient image data and are a snapshot of those values at each view sample time.

Z-Axis Channels: These are some special purpose channels built into the detector that are used for several different special operations related to determining the x-ray beam position on the detector.

VVC (Views vs Channels): This is a way to graphically represent the data values from each channel for each view of data from the S-DAS as a shade of grey. The display will have the views stacked vertically and the channels arranged across the display horizontally.

3.4.2 Starting Scan Analysis

Scan Analysis may be started from any of several menu locations, including: UTILITIES, TOOLS and IMAGE QUALITY.

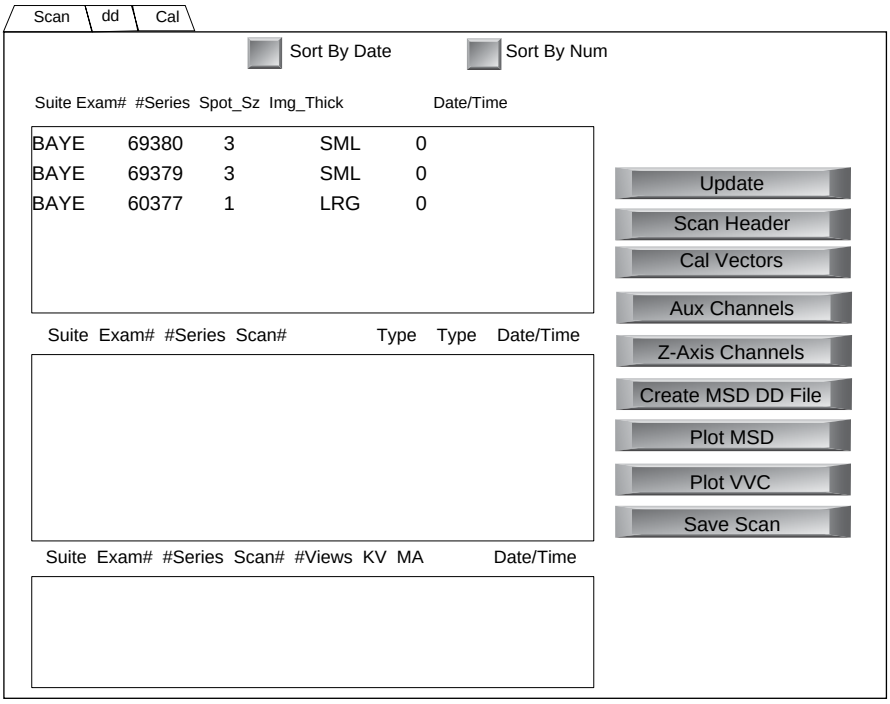


Figure 2-42 Initial Scan Analysis Screen

3.4.3 Selections in Scan Analysis

Upon starting the Scan List Select window, you can highlight an EXAM > SERIES > SCAN, and perform the desired analysis feature by pressing any of the following buttons:

3.4.3.1 UPDATE

The UPDATE selection will refresh the List Select display if new scan files have been created since the Scan Analysis Tool was started.

3.4.3.2 SCAN HEADER

The SCAN HEADER selection will open a scrolling text window that contains the header text information contained in select scan file.

3.4.3.3 CAL VETORS

The CAL VETORS selection will open a window allowing you to select the calibration vectors *in the selected scan file* that you wish to view. After the selections are made, OK will process the data requests and display the results.

The resultant plots will be auto-scaled, and in some cases, the range of data displayed will be set automatically. This is to provide a reasonable initial view of the data. Always check the scale on the left-hand side of the plot displays. Cursor reporting of data value and channel numbers is provided.

The default selections are underlined in Table 2-6.

SCAN FILE CAL VECTORS		
Cal Header	Sin	Cos
B1	B2	B3
PCal	Acal	Misc.
XTalk	Matrix decon	ZSlope

Table 2-6 Scan File Calibration Vector Selections

3.4.3.4 AUX CHANNELS

This selection will open a window that allows you to select which of the auxiliary channels in the scan file you wish to look at, as well as the start and ending views to display. After the selections are made, OK will process the data requests and display the results.

The resultant plots will be auto-scaled, and in some cases the range of data displayed will be set automatically. This is to provide a reasonable initial view of the data. Always check the scale on the left-hand side of the plot displays. Cursor reporting of data value and view numbers is provided.

The default selections are underlined inTable 2-7.

SCAN FILE AUXILIARY CHANNELS	
Detector Heater Temperature	Negative 5 Volt Reference
MA	5 Volt Dc Power Supply
KV	Positive 5 Volt Converter
Positive 12 Volt	Digital Ground
Negative 12 Volts	Analog Ground 11
Positive 5 Volt Analog	Analog Ground 12
Negative 5 Volt Analog	Analog Ground 15
Positive 5 Volt Test Reference	Analog Ground 16

Table 2-7 Scan File Auxiliary Channel Selections

3.4.3.5 Z AXIS CHANNELS

This selection allows you to select the start and end views to display for the Z Axis Channel data. After the selections are made, OK will process the data and display the results.

3.4.3.6 CREATE MSD DD FILE

This will calculate a view averaged “super view” for the selected views and store the results in a separate file on the systems disk. The display will report the path and filename of the file just created. Once created, dd File can be viewed or compared with other files to check for specific operating characteristics.

3.4.3.7 PLOT MSD

Provides a set of view summed means and standard deviation plots of a scan file. The plotter is started to display the means vectors and the standard deviation vectors, computed across the entire scan for each detector macro row. There will be four mean and standard deviation plot sets in the display window.

After Plot MSD is started, a window will allow you to select:

- Start View and EndView
- View Compression: Automatic, 2 to 1, 4 to 1

- Processing steps:
  1.) Offset Correction: This processing step removes the signal bias introduced by the acquisition electronics from the scan data. This operation is performed on a channel-by-channel basis for each view.
  2.) Primary Speed Correction (afterglow): This processing applies a correction value to each channel value to reduce the effect of scintillator afterglow from the detector cells.
  3.) Reference Normalization: Makes use of unobstructed (not blocked by the patient) detector cells at the end of the detector to adjust for fluctuations in the x-ray beam and effects of aperture size and mA. In the case where the reference channels are blocked, the system uses an estimated value for the processing. The steps for reference normalizing the scan data involve:
     A.) Offset correction for the reference channels.
     B.) Dividing the offset corrected scan data by the averaged reference channels for each view.
  4.) Convolved Data: This processing step mathematically filters the channel data to remove blurring effects that would occur when the views are back-projected. The effect is to "sharpen" each channel's data value within the view. Without the convolution step, some of the x-ray attenuation data for a particular channel ends up in the channels on either side of that particular channel. Convolution puts that adjacent channel contribution back into the channel data that it should have been in to begin with.

Cursor reporting of data value and channel numbers is provided.

3.4.3.8 PLOT VVC

The PLOT VVC selection provides Views-vs-Channels display of a grey scale representation for the selected scan file. Each view of data (or summed, compressed view) is represented on the display as a horizontal line. Each pixel in the line represents the data value for a particular channel from the DAS.

After VVC is activated, a window will allow you to select:

- Row (macro row) One of: 2A, 1A, 1B, 2B
- Start View and EndView
- Start Channel and End Channel
- View Compression: Automatic, 2 to 1, 4 to 1
- Processing steps:
  1.) Offset Correction: This processing step removes from the scan data, the signal bias introduced by the acquisition electronics. This operation is performed on a channel-by-channel basis for each view.
  2.) Primary Speed Correction (afterglow): This processing applies a correction value to each channel value to reduce the effect of scintillator afterglow from the detector cells.
  3.) Reference Normalization: Makes use of unobstructed (not blocked by the patient) detector cells at the end of the detector to adjust for fluctuations in the x-ray beam and effects of aperture size and mA. In the case where the reference channels are blocked, the system uses an estimated value for the processing. The steps for reference normalizing the scan data involve:
     A.) Offset correction for the reference channels.
     B.) Dividing the offset corrected scan data by the averaged reference channels for each view.
  4.) Convolved Data: This processing step mathematically filters the channel data to remove blurring effects that would occur when the views are back-projected. The effect is to "sharpen" each channel's data value within the view. Without the convolution step, some of the x-ray attenuation data for a particular channel ends up in the channels on either

side of that particular channel. Convolution puts that adjacent channel contribution back into the channel data that it should have been in to begin with.

Once displayed, the window and level for the displayed data can be changed to better see variations in the data.

CURSOR BEHAVIOR IN VVC

Cross hair cursor reporting is provided for: Data Value, DAS Channel, Detector Channel, and View number. The cursor is moved across the display using the mouse.

A selection box on the display allows selection of line cursors and box cursors, which allow the selection of a channel, view, or group of channels and views for plotting.

The line and box cursors can be moved around the screen to view specific areas of interest. When the mouse pointer cursor is moved over a line cursor the mouse cursor will change to a four pointer arrow. Pressing the left mouse button allows you to 'drag' the cursor across the display.

For the box cursors, the box may be dragged using the left mouse button with the mouse cursor positioned over the box. The size and shape of the box can be changed by moving the mouse cursor over the *Bottom* or *Right* edges of the box. When over the *Bottom* or *Right* edges of the box you can press the left mouse button to drag the box edge up and down or left and right.

With the channel and view cursors, the plotted data will represent all channels for a selected view or all views for a selected channel.

With the box cursors, the resulting plot will be a view summed means and standard deviation plot for the selected views and channels.

3.4.3.9 SAVE SCAN

This will save the selected scan file to a temporary disk location so that it can moved to MOD or transferred via ftp to another location.

3.4.4 dd File List Select Overview

dd math is a means for the user to apply mathematical operations: add, subtract, multiply, and divide to dd files, and calculate the channel-to-channel difference or ratio of means vs. standard deviation vectors of a dd file. It allows the user to specify the scaling factor for the output vector, and provides three output modes: dd file, plot, and view numbers.

dd math is part of the dd analysis user interface. Scan Analysis is used to generate dd files that may then be manipulated or examined using dd File Analysis.

3.4.4.1 dd Files Generation

There are 18 different dd file types of six orientations. The orientations are View, Channel, RTS, CAL, Elements, and Header.

Channel oriented means and standard deviation type dd files *are the only type* that can be created from scan data files in the Scan Analysis application.

3.4.4.2 dd Math Functions

dd math consists of the following functions:

- Add
- Subtract
- Multiply
- Divide
- Channel to Channel difference
- Ratio of means vs. standard deviation

3.4.4.3 Add, Subtract, Multiply, Divide

Applies add, subtract, multiply, and divide between vectors in two dd files. The output file is a dd file with one of the following suffixes:

- .add
- .dif
- .mul
- .rat

Operations can be performed on dd files in View orientation, Channel orientation, RTS orientation, and Cal orientation.

Currently, no dd type restrictions are applied to operations between dd files, as long as the dd vectors have the same number of elements. If one file has a single vector and the other file has multiple vectors, the mathematical operation will be applied multiple times using the single vector. Otherwise, the mathematical operation will be applied component-wise for the number of vectors in each file.

3.4.4.4 Channel to Channel Difference

Applies the following calculation to the data from the data set(s) in the dd files for View, RTS or Cal orientation:

(X2-X1), (X3-X2), (X4-X3),...,(Xn-Xn-1)

where X is the data value for each channel.

The output is channel to channel dd file with extension: .c2c

3.4.4.5 Ratio of Means vs. Standard Deviation

Takes a MSD (means and standard deviation) or RTS (real time statistics) type of dd file, calculates the ratio of data in the means vector (1st set) to data in standard deviation vector (2nd set). The output file is a ratio type of dd file with the extension: .rat

3.4.4.6 dd Math Output Mode

Three output modes are supported in dd math:

- **Plot** - Will plot the output dd vector using an on-screen vector display.
- **dd File** - Allows the user to specify the output dd file name with a full path or the file basename. If only base name is provided, the program will use the default prefix and suffix for the output file. The created dd file will be shown in the dd file list.
- **View Numbers** - View Numbers will display the dd vector numerical values on the screen, and the user can perform numerical searches in the window.

3.4.4.7 dd Analysis User Interfaces

The dd math operation panel and a set of the dd math operation buttons are part of the ddLS screen.

3.4.4.8 Functions in ddLS User Interface

The ddLS supports the following functions for various file types.

- Update
- Plot
- Save to MOD
- Restore From MOD
- dd math operations: +, -, x, /, ch2ch, Ratio
- Sort By Date or Sort by Type

The user can perform these functions, except dd math operations, by simply selecting one or more files in the list select window, and clicking the function button. The following file types are supported in the ddLS user interface.

- dd File
- Cal File
- Data File

3.4.4.9 File Operations

- **dd Math Operations** - Perform: add, subtract, multiply, divide, and channel to channel difference operations on dd files. These operations are only available for dd file types.
- **Plot** - Plots the vector(s) of the selected files in the display window for the following file types: dd Files and Cal Files
- **View #** - Prints the numerical data of the dd vector(s) to the display window(s). For image file types and scan file types, it will display the VVC plots of the selected files.
- **Save/Restore to/from MOD** - Saves the selected files to the MOD and restores all the dd files from /MOD/ddfiles to /data directory.
- **Update** - Refreshes the display in the ddLS user interface.

3.4.4.10 dd Math Operations in ddLS

The dd math operation buttons will be insensitive if no files are selected into the dd math operation panel.

The user may start dd math operation(s) by selecting the file(s) and putting them into the selection field by clicking the button FILE #1 or FILE #2. If the selected file is not a dd file, the application will not put it into the dd math operation field. A message window will pop up and ask user to select a dd file.

If only one file is selected and it is of the file type RTS dd file or MSD dd file, both CHANNEL TO CHANNEL and RATIO OF MEANS VS. STDV will become sensitive. If the selected file is not of the type MSD or RTS, only CHANNEL TO CHANNEL will become sensitive. When two dd files are selected, ADD, SUBTRACT, MULTIPLY, and DIVIDE become sensitive and CHANNEL TO CHANNEL and RATIO OF MEANS VS. STDV will be insensitive.

The user can specify the output file name when the dd file output mode is set. Otherwise a default dd file name will be provided.

The default output scaling factor is 1.0. The user can set the scaling factor to any real number.

When the dd math operation buttons are sensitive, the user can select the desired button to start the dd math operation.

3.4.5 Z-Axis Tracking

The Z-AXIS TRACKING tool is a new TAB, located within the Analysis Tool. The tool can be used to plot various tracking functions, using a Scan Data Set. For a scan data set, the analysis package can plot different data versus views in UN-FILTERED (the default) or FILTERED (20 pt. Boxcar) formats. Numerical information (“Max”, “Min”, “Mean”, and “Std. Dev.”) is also provided. In some plots, the numerical information provided can be used for further analysis by comparing it to a “specification” value, as an indication of a pass/fail condition. Whereas other plots are more general, and in some cases may be useful, they are typically only used for troubleshooting.

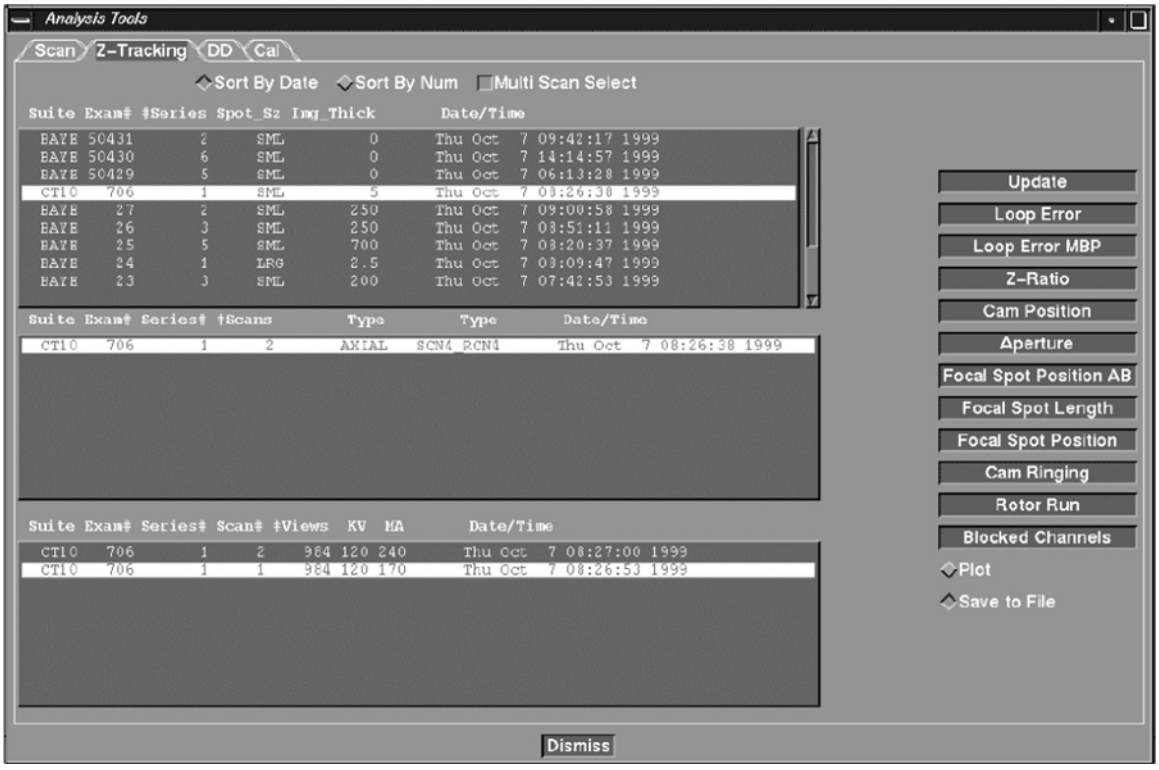


Figure 2-43 Top Level Tracking Menu

In the figures that follow, examples of “known” tracking plots are shown. Since plots vary from system to system, the examples shown should be used only as guides. Compare your system’s plots and analyze them relative to the specification shown in each figure. The plots shown are UN-FILTERED views, which is the default option when they are plotted. A 20 point boxcar filter takes the 20 view average and then plots the data.

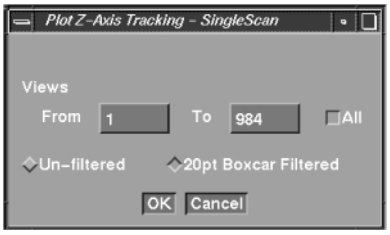


Figure 2-44 Single Scan Pop-Up Menu

A value is not considered to be out of specification unless the limit is exceeded for a sustained interval of 100 views or more. In the cases where specifications are not given, consider plots informational only.

3.4.5.1 LOOP ERROR

A LOOP ERROR is the difference between the calculated position of the beam minus the desired target's position (operating point) obtained during Collimator Calibration.

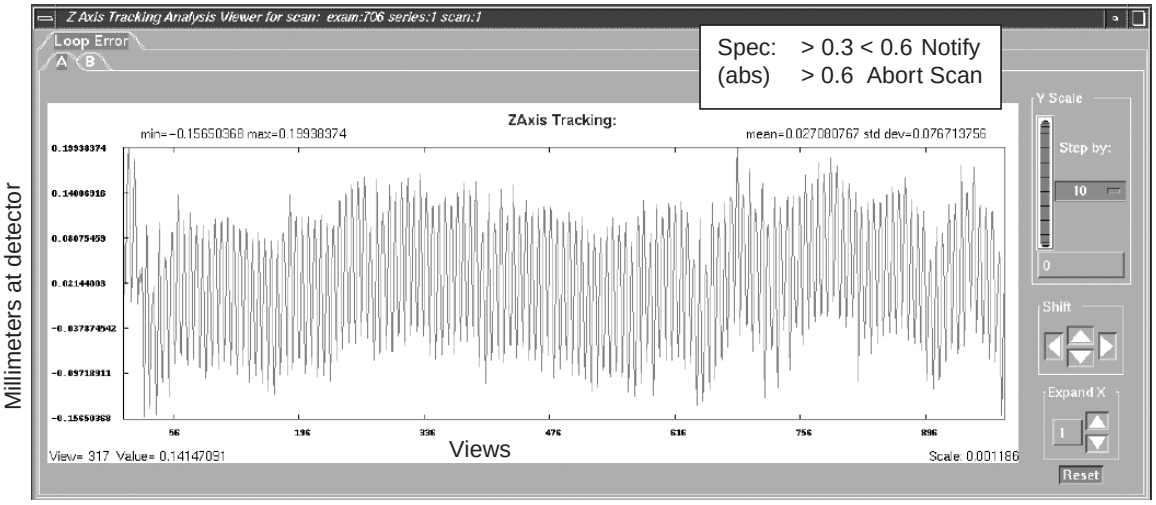


Figure 2-45 Loop Error Plot

3.4.5.2 LOOP ERROR (MBP)

A LOOP ERROR MBP (Mean Beam Position) plot is the same as the loop error plot, except that the display represents the loop error relative to the mean beam position during FASTCAL. The FASTCAL beam position is stored in the calibration database.

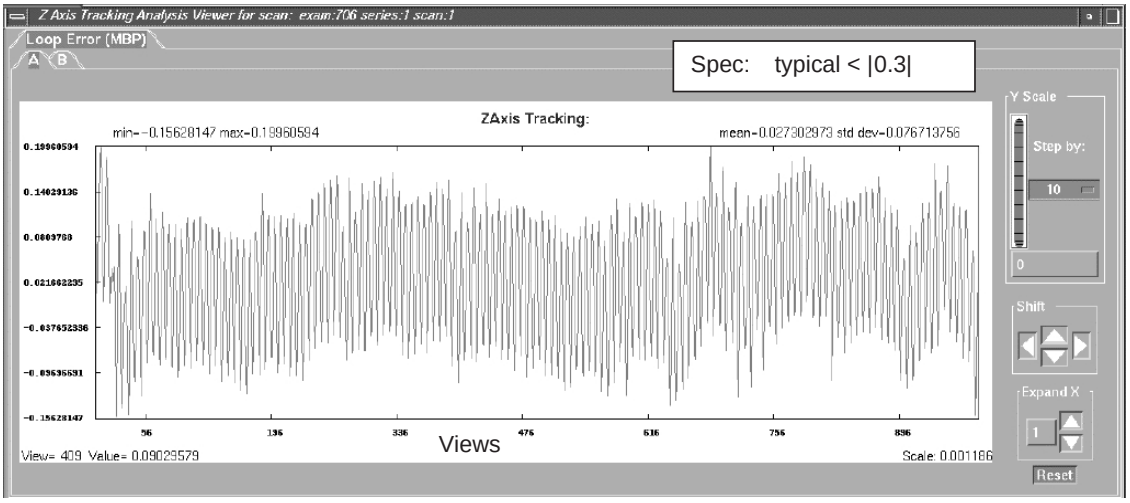
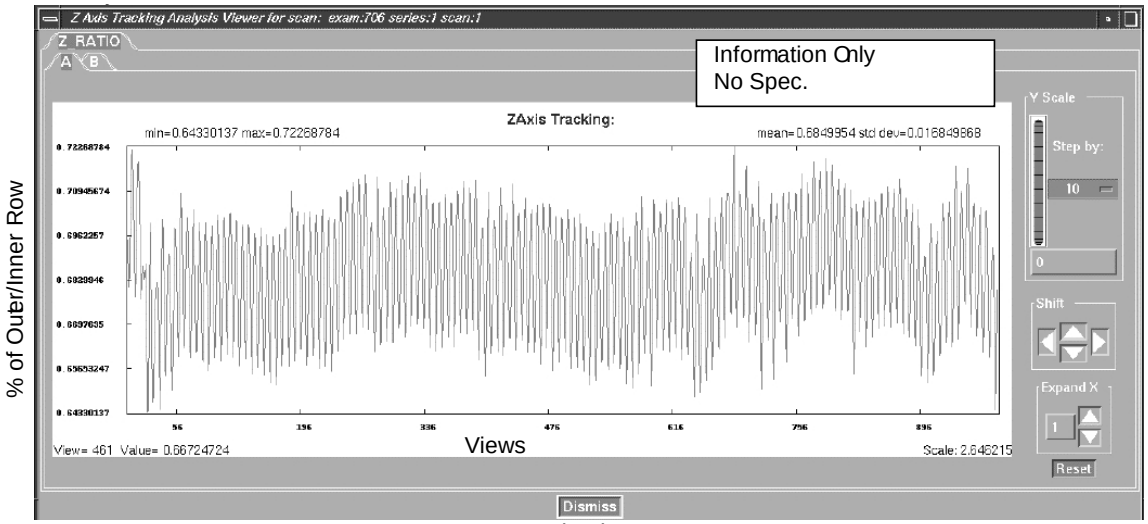


Figure 2-46 Loop Error (MBP) Plot

3.4.5.3 Z RATIO

Z-RATIO Plot computes the ratio of outer row Z-channels (Channels 763, 764, & 765 averaged) to inner row Z-channels. This is done for both the “A” and “B” sides.

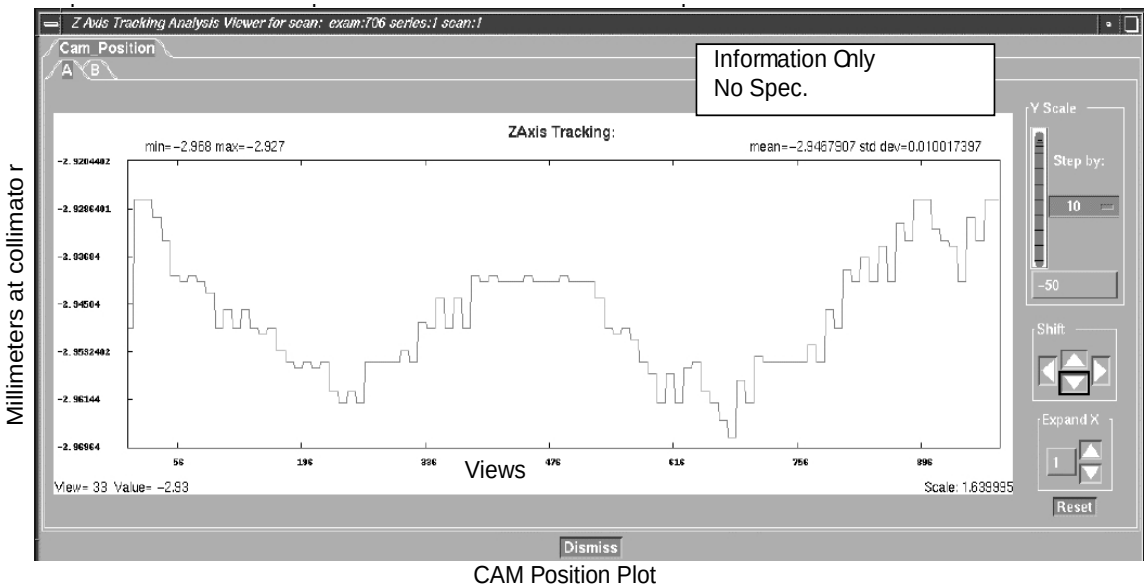


Z Ratio Plot

Figure 2-47 Z Ratio Plot

3.4.5.4 CAM POSITION

The CAM POSITION plot shows the CAM position during a scan from collimator opening (center-line). The absolute value of A side plus B side is the total aperture size at the collimator. Cam positions are stored in the scan file.

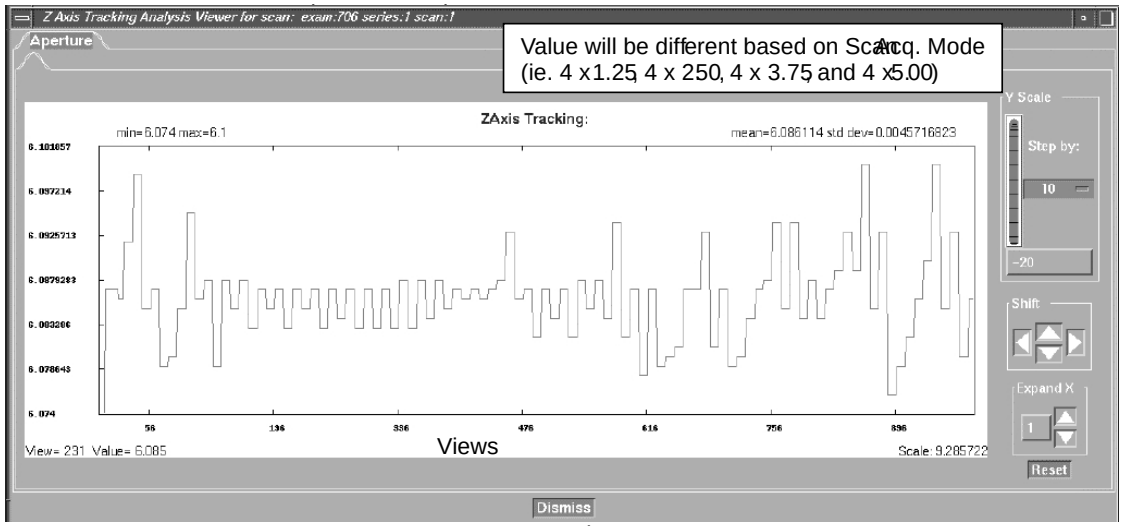


CAM Position Plot

Figure 2-48 CAM Position Plot

3.4.5.5 APERTURE

APERTURE plot indicates the width of the Collimator Cam aperture in millimeters. Due to the distance magnification factor, the width at the collimator is smaller than prescribed acquisition mode, or width of the beam at the detector window.

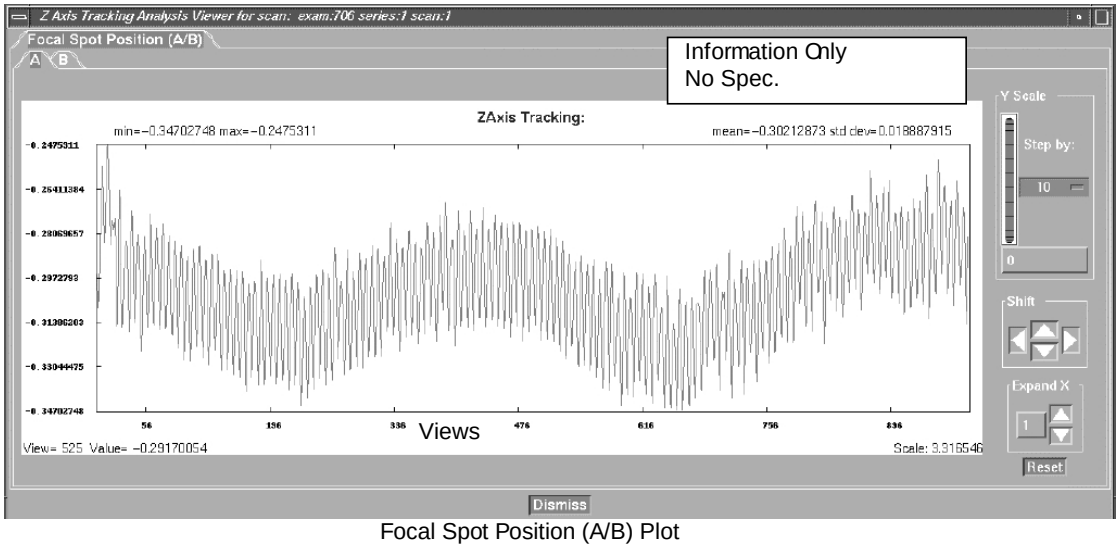


Aperture Plot

Figure 2-49 Aperture Plot

3.4.5.6 FOCAL SPOT POSITION (A/B)

FOCAL SPOT POSITION plot shows the calculated focal spot position from the centerline of either the A or B side. The vertical scale (in millimeter) represents that portion of the focal spot length. The absolute value of the A side plus the B side should equal the focal spot length (Small Spot = 0.7mm, Large Spot = 1.2mm).

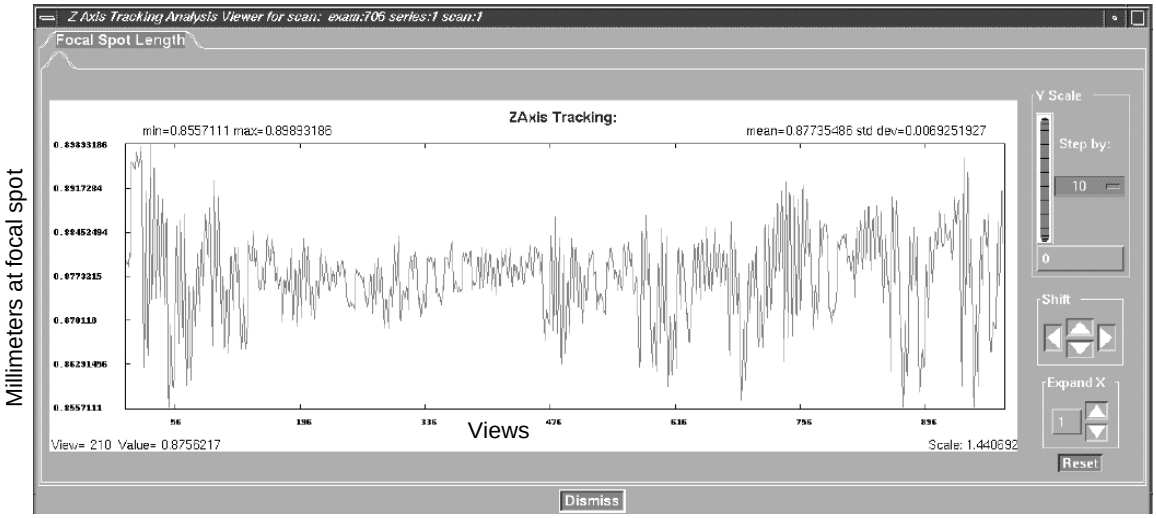


Focal Spot Position (A/B) Plot

Figure 2-50 Focal Spot Position (A/B) Plot

3.4.5.7 FOCAL SPOT LENGTH

FOCAL SPOT LENGTH plot shows the calculated focal spot length. The length may change slightly due to mA, rotor wobble or gantry rotation wobble. Length is also based on the calculations, which use values from the Z-channels. Typically the small spot size is 0.7mm, and the large spot size is 1.2mm.

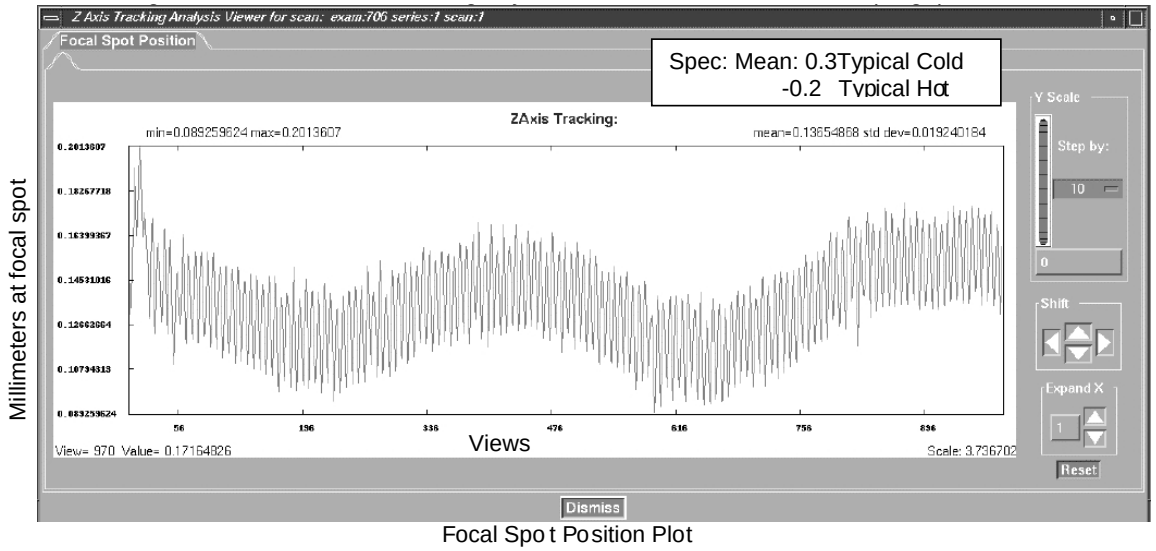


Focal Spot Length Plot

Figure 2-51 Focal Spot Length Plot

3.4.5.8 FOCAL SPOT POSITION

FOCAL SPOT POSITION plot indicates the calculated focal spot position relative to the centerline, with the center position being 0. The focal spot moves during a scan due to mA, rotor wobble, gantry rotation wobble, and because of tube (target) heat.

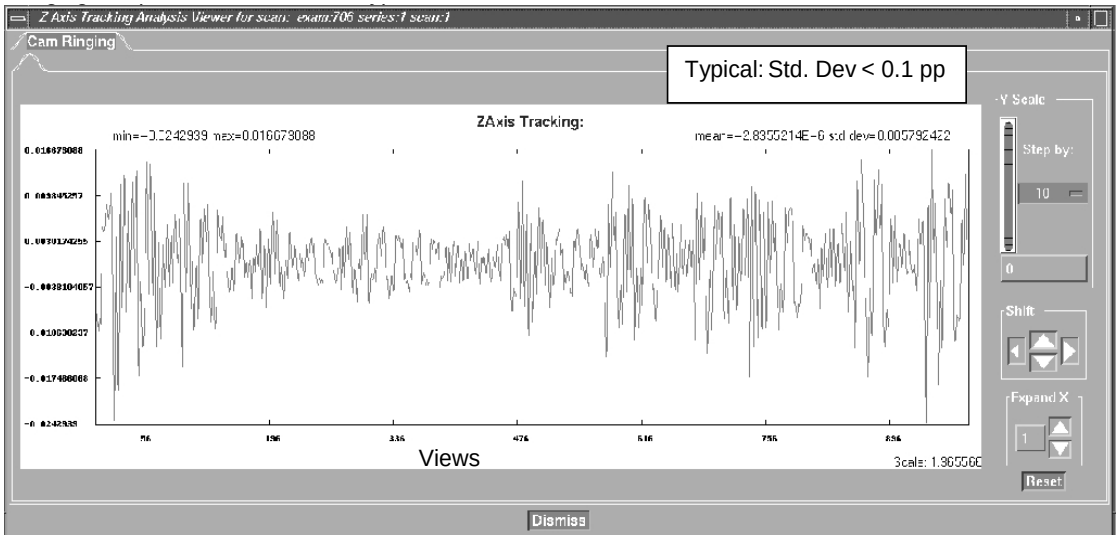


Focal Spo t Position Plot

Figure 2-52 Focal Spot Position Plot

3.4.5.9 CAM RINGING

CAM RINGING provides a plot of high frequency variations, such as variations that are 180 degrees out of phase, like typical CAM ringing. A specification is not available, but typical values are less than 0.1 counts.

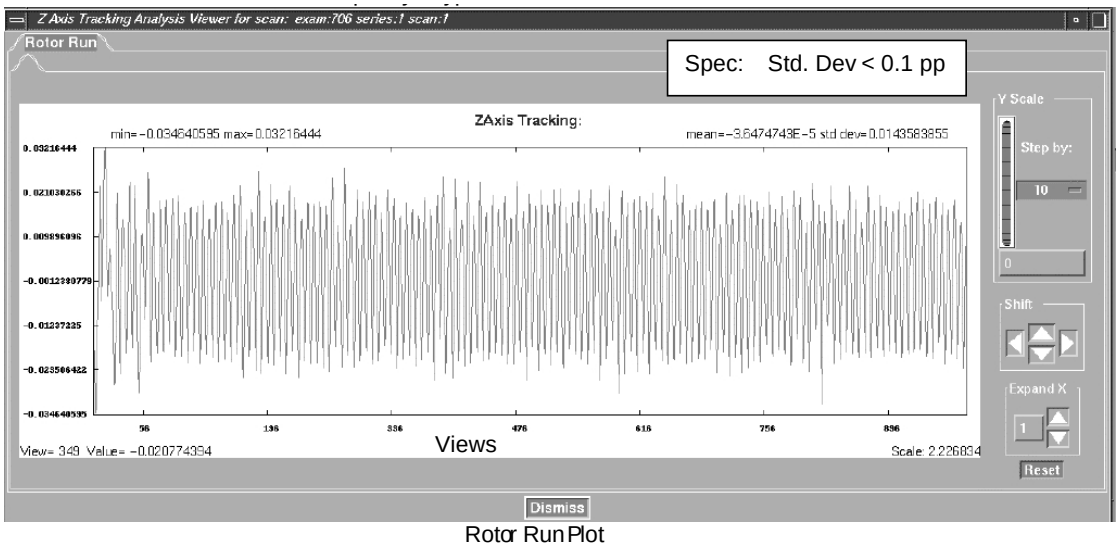


CAM Ringing Plot

Figure 2-53 CAM Ringing Plot

3.4.5.10 ROTOR RUN

ROTOR RUN provides a plot of high frequency variations that are IN phase, such as the small periodic movement of the anode at the rotor run frequency. Typical values are less than 0.1 count values.



Rotor Run Plot

Figure 2-54 Rotor Run Plot

3.4.5.11 BLOCKED CHANNEL

A BLOCKED CHANNEL indicates that the value for DAS Channel 762 falls below the 10% threshold. Indicating that the channel is blocked and tracking (CAM positions) remains constant at the last known good position. This plot indicates a normal unblocked scan. Unblocked condition is indicated by a numeric value of 0. Blocked view condition is indicated by a numeric value of 1.

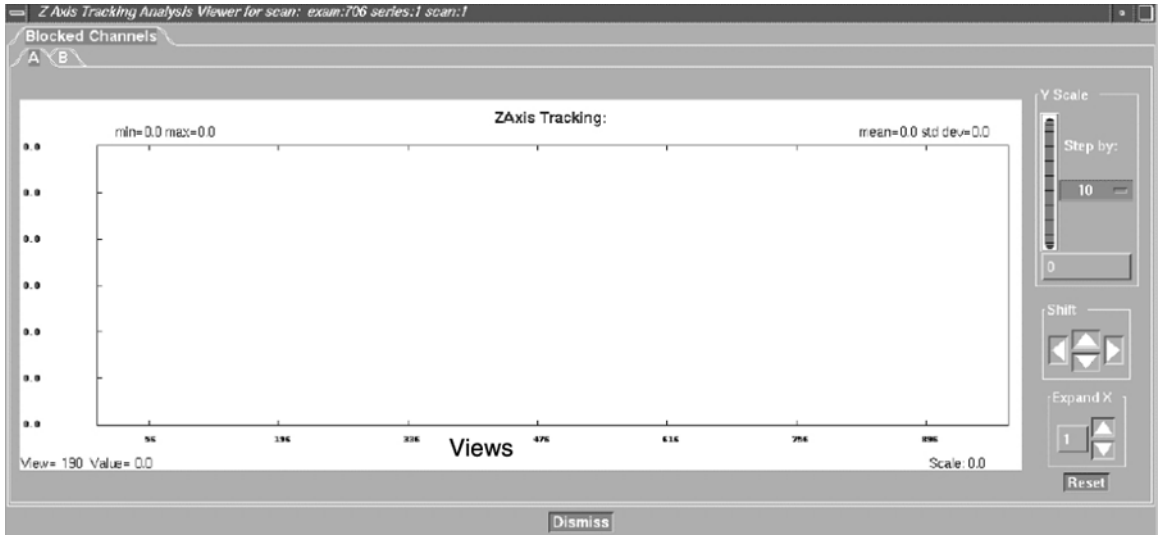


Figure 2-55 Blocked Channel Menu

3.4.5.12 MULTI-SCAN SELECT

The MULTI-SCAN SELECT option allows the user to calculate and view multiple scans. Select the MULTI-SCAN SELECT button, and then select the exams, series, or multiple scans. Once scans are selected, then select the plot that you are interested in. Due to the time it may take, based on the number of scans selected, a pop-up window may appear, to indicate the number of scans selected and the approximate time to calculate. If the time is too long, or wrong scans are selected, hit CANCEL. Once the OK button is selected, you cannot cancel processing.

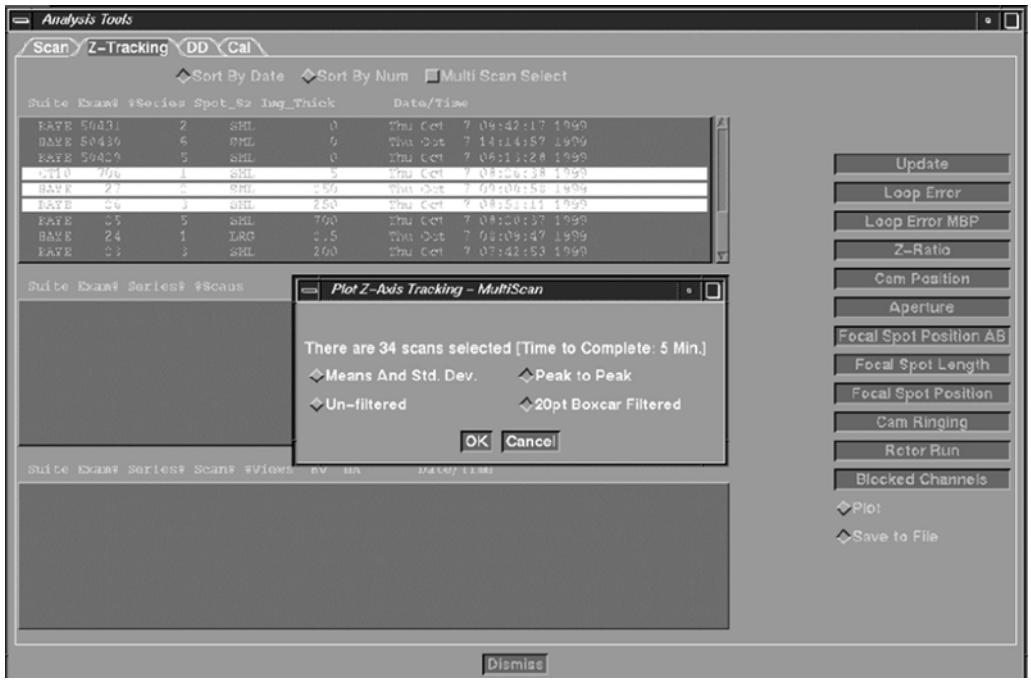


Figure 2-56 Multi-Scan Select Menu

3.4.6 Tube Spit Data Correlation Example

By using a combination of capabilities within Scan Analysis, some things just got easier.

In the past, tube spits as a source of image artifacts were frequently done by implication. The tube has been spitting lately, so the problem might be that.

With some of the new system and software capabilities, it is much easier to confirm some of these diagnosis. For example:

- VVC data for scan (refer to Figure 2-57). Dark horizontal lines are views with data values lower than the views immediately before and after.
- Select Channel Cursor and Plot Now (refer to Figure 2-58). Notice how the dip in the channel data corresponds to the views around 615. Next take a look at the kV and mA data.

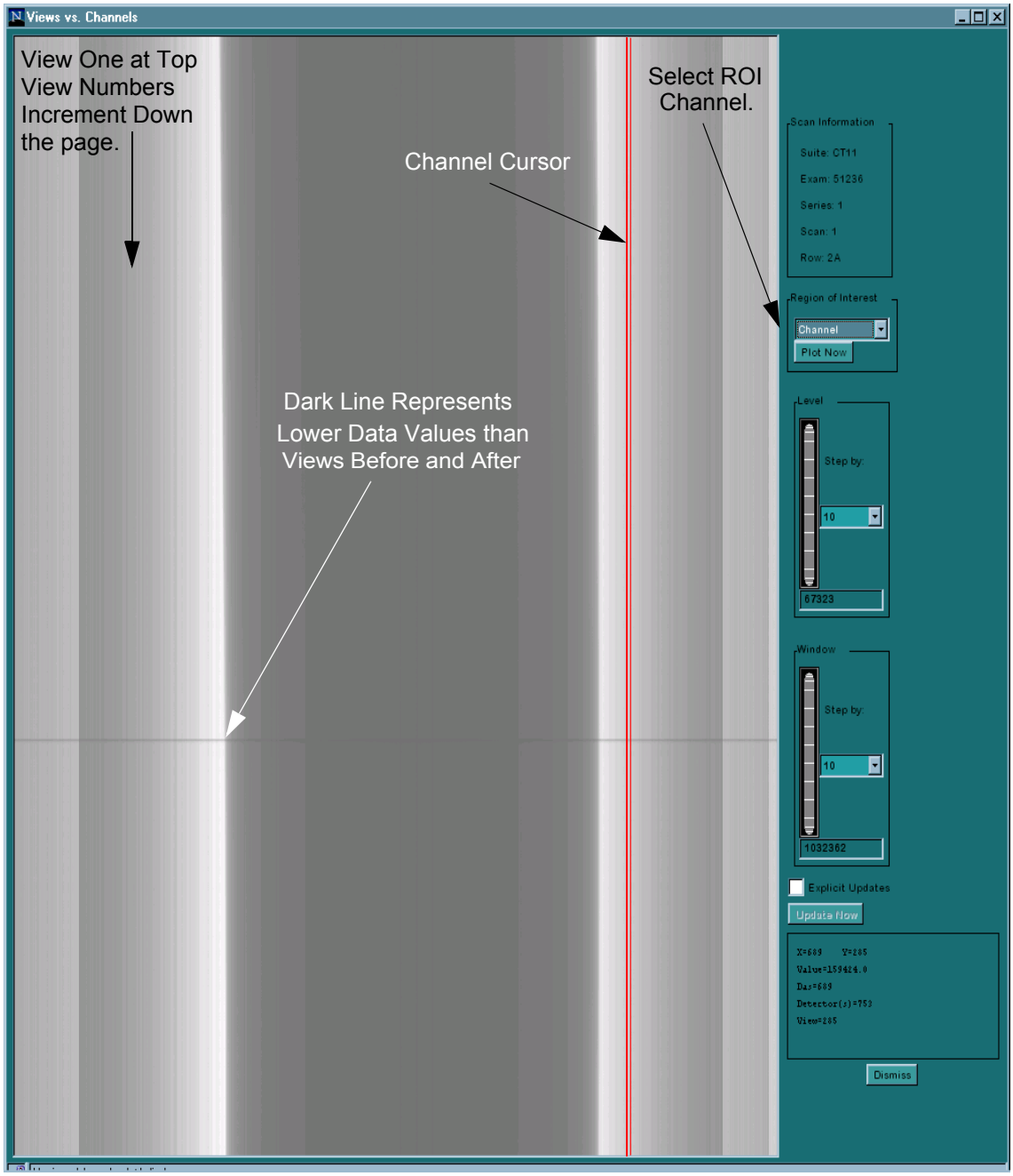


Figure 2-57 VVC Tube Spit Data Example

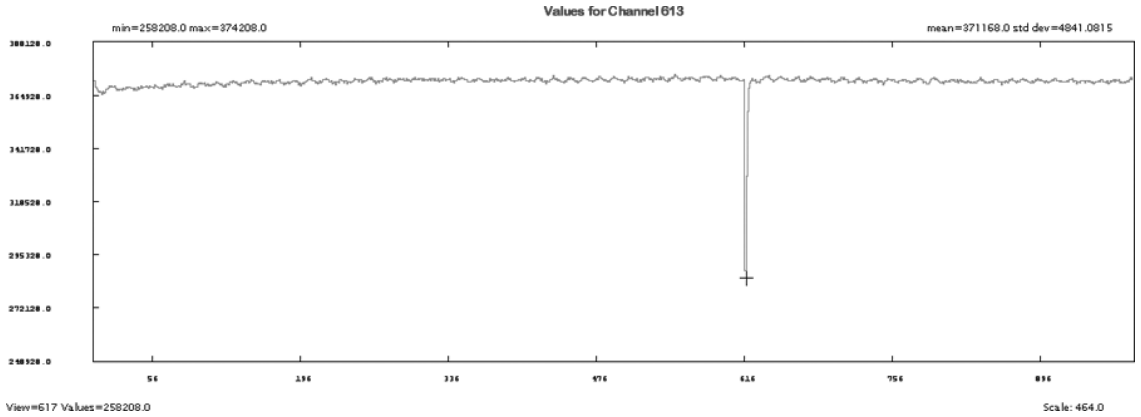


Figure 2-58 All View for one channel KV Spit Data Example

Once again the dip in the KV values reported in the view data corresponds to views around 615.

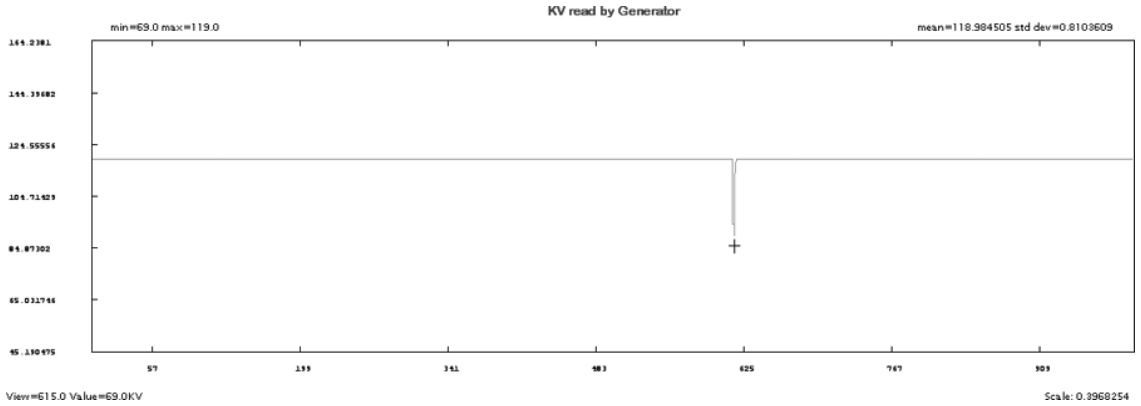


Figure 2-59 - Tube Spit Auxiliary Channel data for kV

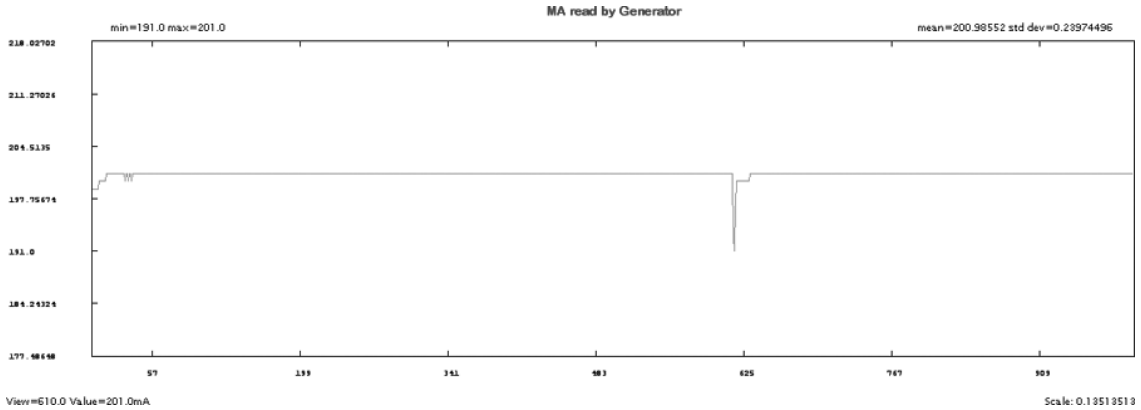


Figure 2-60 - Tube Spit Auxiliary Channel data for mA

From the previous examples, it is easy to correlate the views with suspect data from the VVC Display with the view by view plots for kV, mA, and Channels.

Specific information to look for on the examples:

- The Min, Max, and average values for kV, mA, and channel data. This information provides a quick way to determine the scale of the information that you are viewing.
- The cursor report information provides a continuous update, depending upon the type of data that is being displayed: data values, view number, channel number.

3.4.7 Typical Examples of CAL Plots with Scan Analysis

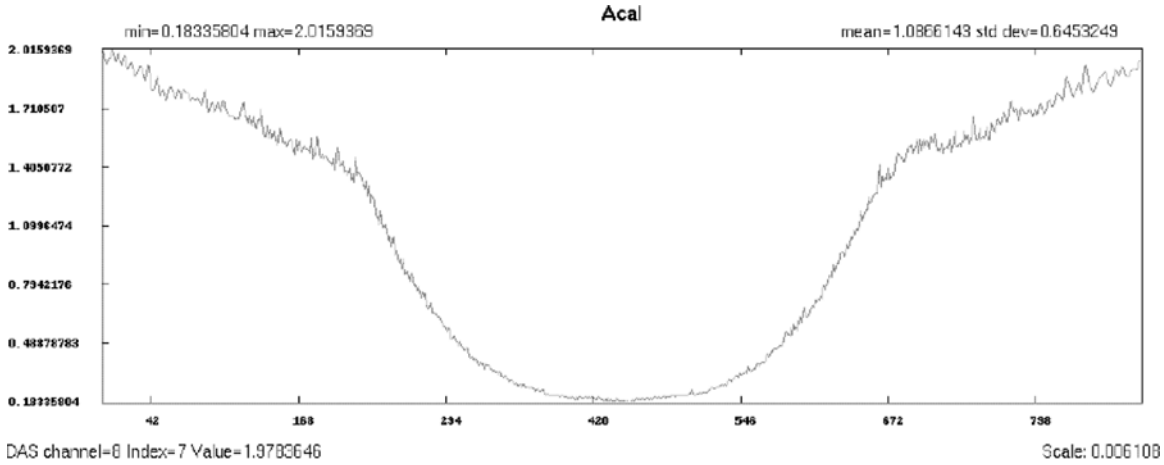


Figure 2-61 Calibration Vector Acal / Head Filter

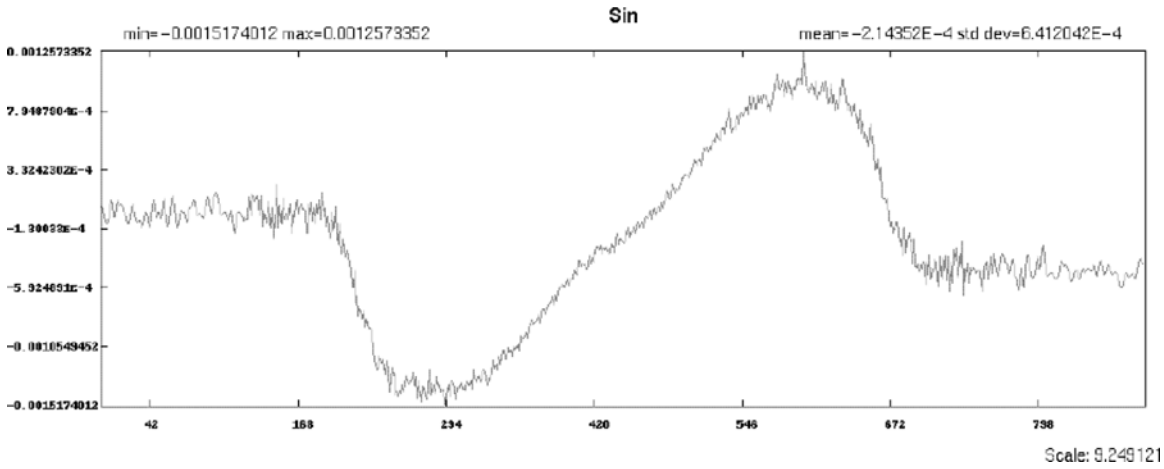


Figure 2-62 Calibration Vector Sin / Head Filter

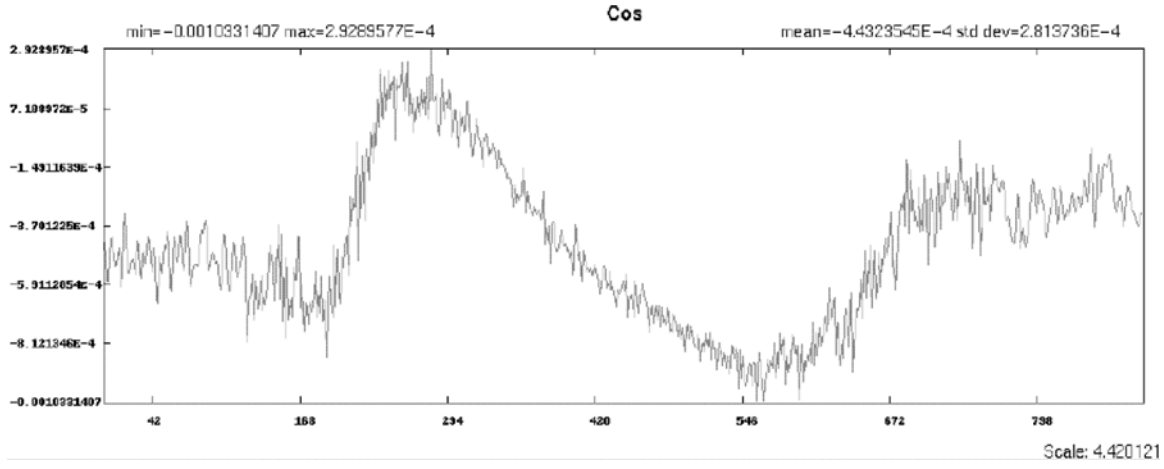


Figure 2-63 Calibration Vector Cosine / Head Filter

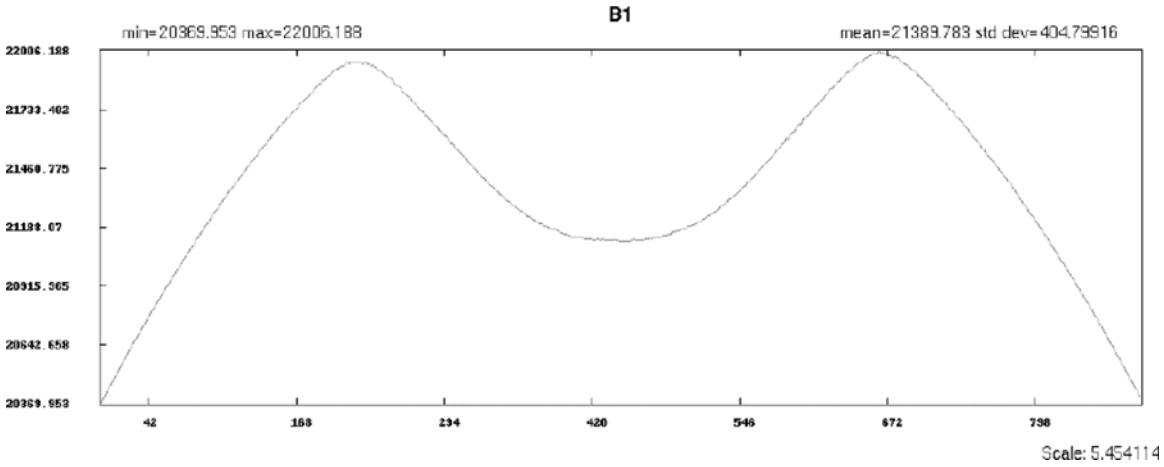


Figure 2-64 Calibration Vector "B1" / Head Filter

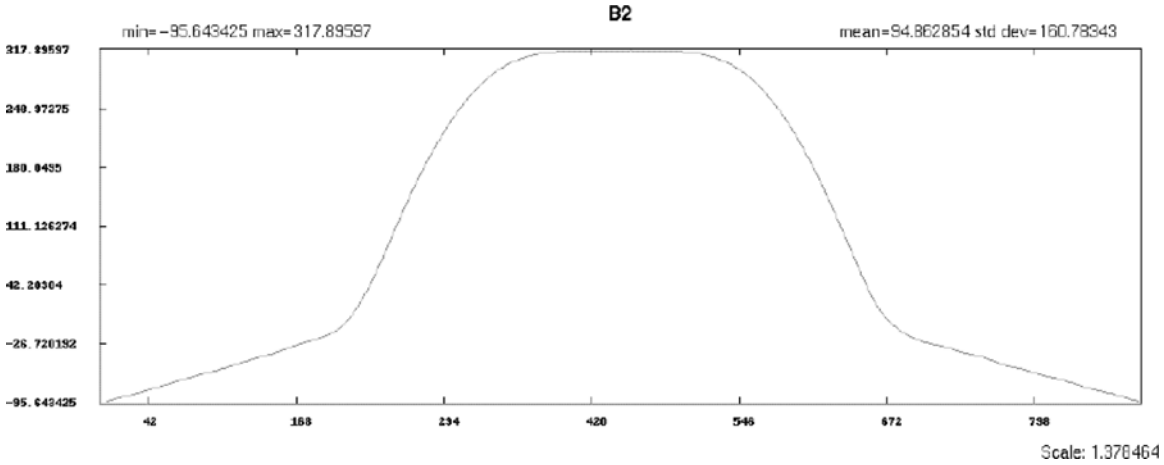


Figure 2-65 Calibration Vector "B2" / Head Filter

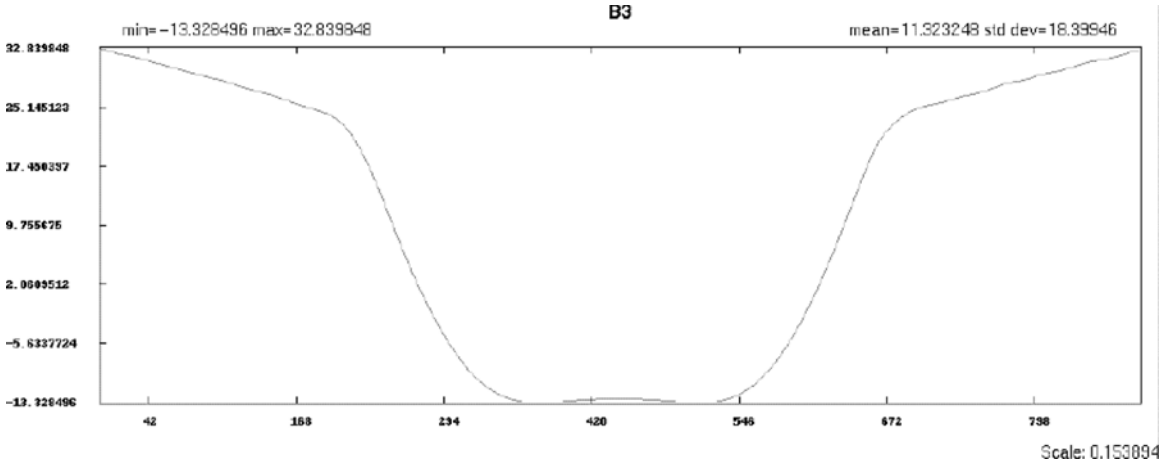


Figure 2-66 Calibration Vector "B3" / Head Filter

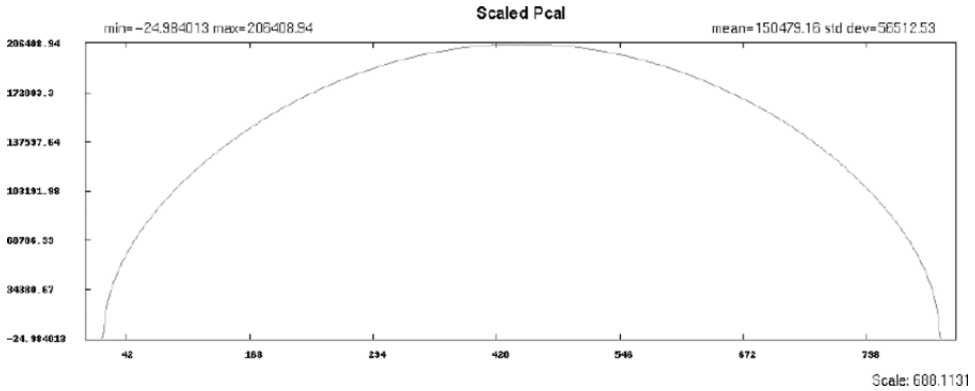


Figure 2-67 Scaled P-Cal - Head Filter

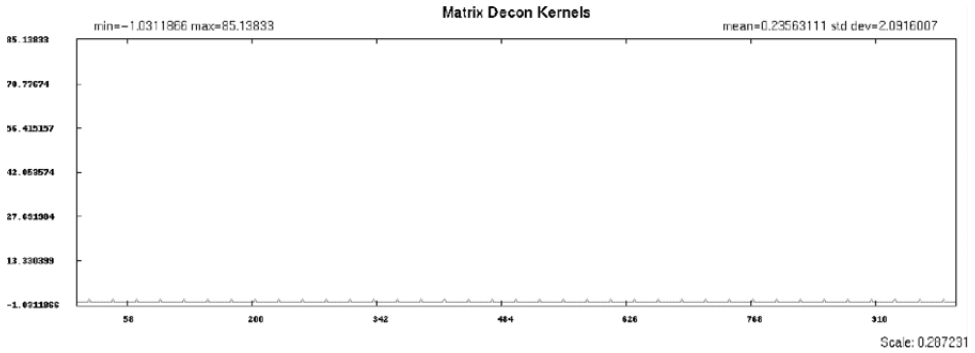


Figure 2-68 Matrix DeCon Kernels

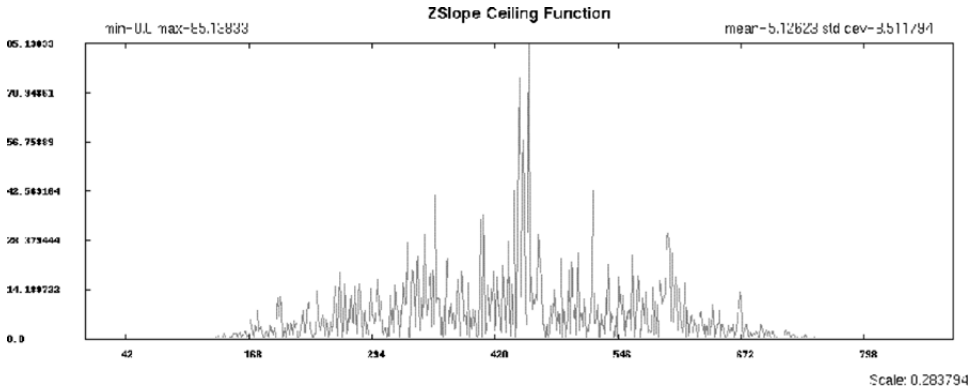


Figure 2-69 Z-Slope Cal / Ceiling Function

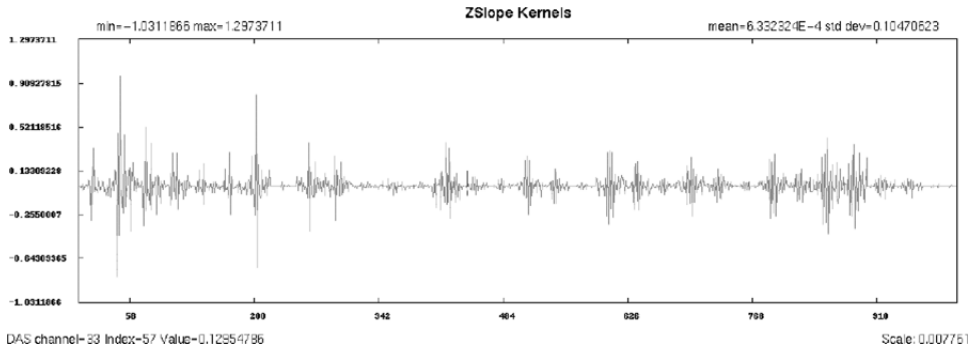


Figure 2-70 Z-Slope Cal / Z-Slope Kernels

3.4.8 DAS Tools

DASTool is both a tool and diagnostic used to test or exercise most or all functions of the SDAS, to verify their performance in both a manufacturing and field service environment. There are several sub-tests within DASTools that are specifically used during system install/integration, while other tests are used for diagnostic purposes. There is also a section called “viewers,” which allows the user to view the DAS architecture relative to DAS to Detector channel mapping, View error log, and view the test specification limits for each test.

Figure 2-71 shows the top level menu for DASTools. Access is through a Graphical User Interface (GUI) from the Service Desktop.

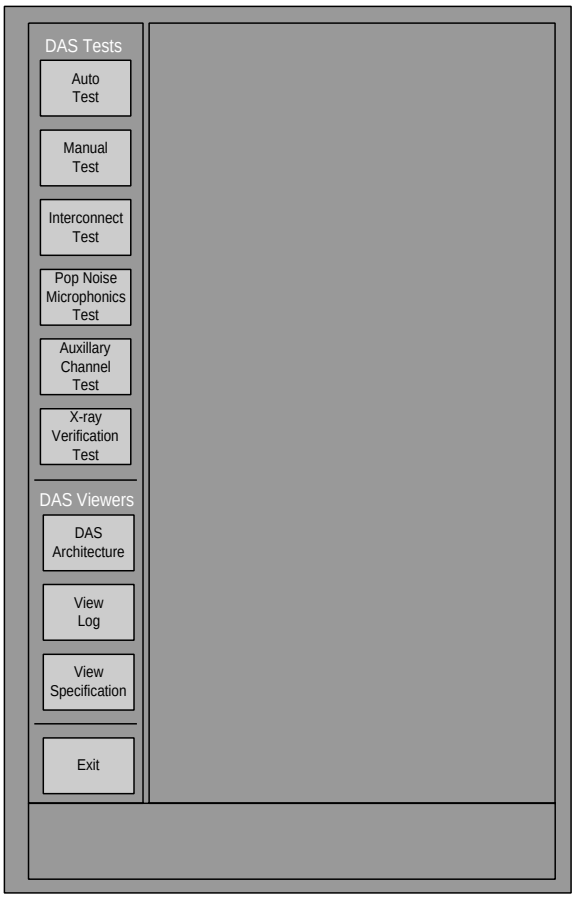


Figure 2-71 Main DASTools Menu

For most of the scanning in DASTools, DDC protocols are used, and the scan data is stored in standard scan data files that can be used for further review in Scan Analysis. During the scanning portion of the test, the exam, series, and scan number are displayed on the screen, as well as in the error log, if the analyzed scan data falls outside the expected values.

3.4.9 Auto Test / Manual Test

The difference between auto test and manual test is that the auto test feature runs a default number of iterations of each of the sub-tests, while the manual mode allows the user to specifically select a sub-test(s) and the number of iterations for that selection of test(s).

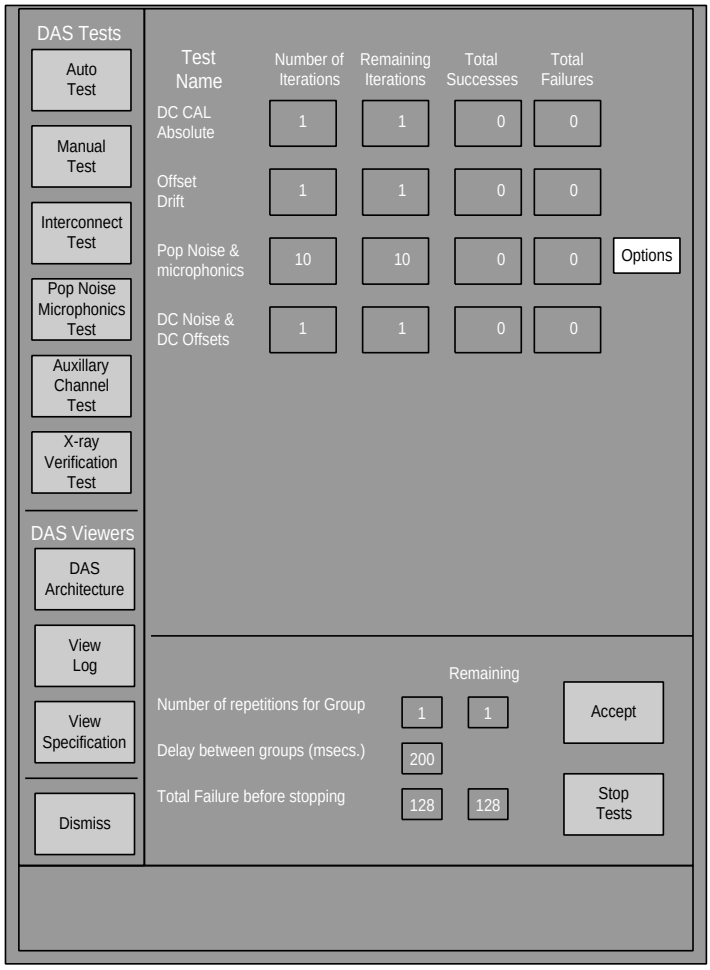


Figure 2-72 Auto Test / Manual Test

The following tests are executed during auto test:

1.) **DC CAL:** This test is performed to check the absolute linearity and absolute counts of the DAS using DC CAL modes using various levels, Pre-Amp gains, and FPGA gains. There are 15 stationary DAS scans taken, without x-ray. Each scan is analyzed for its absolute means count. This count range is different for each scan dependent on the injected dc signal. Then the ratio of the highest count scan to each of the other scans are performed and are analyzed to a specific count range to determine the linearity of the FPG amplifier.

- If DC Cal fails and the failing channels are all on one board, then most likely that particular board is suspected bad. The suggestion is to swap the board with a known good board and repeat the test.
- If the failing channels are random and occur across many boards, then the problem may be a DAS Control Board (DCB) fault, or more likely, noise getting into the DAS. To correct for noise, be sure that the DAS air plenum is securely in place and the fans are correctly mounted and orientated on the plenum. Also, check board seating, power supply noise, and cable seating on all DAS chassis.
- It is also possible that the diagnostic feature of this test may be bad on the board. The charging capacitors on the converter board used to input the correct diagnostic signal into

the front-end of the converter board may go bad. In this case, even if the diagnostic fails, there would be no adverse effect during patient or DDC scanning.

SCAN #	DAS GAIN	PROTOCOL	DESCRIPTION
1	31	DCCAL 0	Used for Offset correction on all Gain 31 scans
2	31	DCCAL 8	Tests FPGA = 1
3	31	DCCAL 1	Tests FPGA = 1
4	31	DCCAL 2	Tests FPGA =8
5	31	DCCAL 3	Tests FPGA =8
6	31	DCCAL 4	Tests FPGA =32
7	31	DCCAL 5	Tests FPGA =32
8	31	DCCAL 6	Tests FPGA =128
9	31	DCCAL 7	Tests FPGA =128
10	16	DCCAL 0	Used for Offset correction on Gain 16 Scan
11	16	DCCAL 1	Tests Pre-amp Gain capacitor
12	15	DCCAL 0	Used for Offset correction on Gain 15 Scan
13	15	DCCAL 1	Tests Pre-amp Gain capacitor
14	3	DCCAL 0	Used for Offset correction on Gain 3 Scan
15	3	DCCAL 1	Tests Pre-amp Gain capacitor

Table 2-8 DC Cal Test

2.) **Offset Drift:** A series of data collection scans, over a course of 120 seconds, and the offset means values are analyzed to measure the amount of variance over 1200 seconds of scanning. There are 3 scans taken in a 4 x 5.00mm mode / Gain 31 and 3 scans in a 4 x 1.25mm mode / Gain 10 with a delay of 60 seconds between each scan. The absolute value of the Means are taken and compared.

There should be very little or no drift between the first scan of each scan mode and the scan taken 120 seconds later. The spec is ±3 counts for each channel across a 120 seconds time.

SCAN #	DAS GAIN	SCAN MODE	DESCRIPTION
1	31	4 x 5.00mm	Initial Offsets scan at specific technique
2	31	4 x 5.00mm	Offset scan after 60 second interscan
3	31	4 x 5.00mm	Offset scan after another 60 second interscan
4	10	4 x 1.25mm	Initial Offsets scan at specific technique
5	10	4 x 1.25mm	Offset scan after 60 second interscan
6	10	4 x 1.25mm	Offset scan after another 60 second interscan

Table 2-9 Offset Drift Test

Therefore, from Table 2-9 above, the difference in counts between scans 1 & 3 must be within 2 counts per channel and also the difference in counts between scans 4 & 6. Failure analysis of the drift test may be a bad converter board, but also considerations need to be taken on account of room temperature fluctuations and DAS warm-up time. It may be normal for this test to fail if it is executed immediately after turning on the DAS.

3.) **Pop/Noise & Microphonics:** A series of predefined rotating scans, w/o x-ray, and the scan data saved on disk for analysis. The scan data is then viewed averaged and the standard deviations are measured against a spec limit.

This test takes a series of three scans. In the auto-mode, it takes ten iterations of the series. Failure analysis of this test is dependent on test results. Pop/Noise and microphonics issues can be caused by many system related conditions. Some of the most common could be the DAS/Detector interface (such as elastomer connection caused by dirt, oil, debris), flex top cover clamp torque incorrect, air plenum not installed, fan orientation not correct, power supply noise, electrical connections, gantry rotation/mechanical issues, and external influences.

It is very important to look at patterns relative to DAS/Detector architecture, gantry rotation (azimuth position as well as velocity), and high voltage (with or without x-ray, rotor on/off).

Scan #	Gantry Rotation	X-Ray	Rotor	Acquisition Mode	DAS Gain	Scan Time/ VPS	Scan Data Saved
1	Rotating	No X-Ray	On	4 X 5.00	31	1 / 984	Raw
2	Rotating	No X-Ray	On	4 X 1.25	5	1 / 984	Raw
3	Rotating	No X-Ray	On	4 X 1.25	5	0.8 / 1230	Raw

Table 2-10 Microphonic Noise Scans

Scan #	Acquisition Mode	DAS Gain	Channel Zones / Maximum DAS Counts Spec Limits				
			1 - 64 705 - 750	65 - 224 561 - 704	225 - 560	751 - 762	763 - 765
1	4 X 5.00	31	18.0	13.0	10.0	22.0	16.0
2	4 X 1.25	5	51.0	35.0	27.0	61.0	74.0
3	4 X 1.25	5	51.0	35.0	27.0	61.0	74.0

Table 2-11 Microphonic Noise Spec Limits

4.) **DC Offset & Noise:** This test collects DAS data with zero input current (no x-ray) and the mean value of each output channel is compared to spec. Also, the standard deviation is measured against a noise spec. It involves two scans, the first in a 4 x 5.00mm mode, gain of 31 and the other in a 4 x 1.25mm mode, gain 5.

Failure analysis is similar to that of DC Cal, with the exception that there is no input test voltage applied. Depending on failed pattern, based on DAS/Detector architecture, the fault may be a converter board, DAS/Detector interface, or power supply.

Scan #	Gantry Rotation	X-Ray	Rotor	Acquisition Mode	DAS Gain	Scan Time/ VPS	Scan Data Saved
1	Stationary 0° Deg.	No X-Ray	Off	4 X 5.00	31	1 / 984	Raw
2	Stationary 0° Deg.	No X-Ray	Off	4 X 3.75	29	1 / 984	Raw
3	Stationary 0° Deg.	No X-Ray	Off	4 X 2.50	9	1 / 984	Raw
4	Stationary 0° Deg.	No X-Ray	Off	4 X 1.25	5	1 / 984	Raw

Table 2-12 DC Offset and Noise Scans

Scan #	Acquisition Mode	DAS Gain	Channel Zones / Maximum DAS Counts Spec Limits			
			1 - 64 705 - 750	65 - 704	751 - 762	763 - 765
1	4 X 5.00	31	2100 +1000, -500	2100 +1000, -500	2100 +1000, -500	2100 +1000, -500
2	4 X 3.75	29				
3	4 X 2.50	9				
4	4 X 1.25	5	2300 +2000, -1000	2300 +2000, -1000	2300 +2000, -1000	2300 +2000, -1000

Table 2-13 DC Offset value - Analyze “Means - Raw”

Scan #	Acquisition Mode	DAS Gain	Channel Zones / Maximum DAS Counts Spec Limits			
			1 - 64 705 - 750	65 - 704	751 - 762	763 - 765
1	4 X 5.00	31	8.0	7.0	10.0	7.0
2	4 X 3.75	29				
3	4 X 2.50	9				
4	4 X 1.25	5	23.0	19.0	27.0	33.0

Table 2-14 DC Noise value - Analyze “Standard Deviations - Raw”

3.4.10 Interconnect Test

The Interconnect Test (Figure 2-73) is an automatic data collection mode to logically sequence through each switchable FET configuration, and the results compared to a known spec for each DAS channel. All the different FET configurations are defined with corresponding expected output values. The function of this diagnostic is to verify detector output across each row and combination of rows in respect to application slice modes. It will also help in determining if a detector is bad before removing it as a replacement.

This test will need to enable x-ray with a large aperture as to flood across all rows of the detector. Because of x-ray and optional rotation, the initiating of x-ray or mechanical movement cannot be started by InSite. The scan parameters are defined for each scan using a DDC protocol. There are 11 various modes across both Side A and Side B of the detector:

The output from each “scan” will be compared to each other for relative equal outputs (with some margin for cell output differences). The comparison will be each cell output for each channel to determine if a cell has no output (FET did not select) or more than expected output (FET combined more cells together than requested).

The means are to be processed and compared to specification for each row of each slice. The data is processed OFFSET CORRECTED and compared to spec for channel-to-channel spec as well as channel means. The table below indicates 8 of the 11 scans and the rows used during scanning and analysis. The remaining three scans are standard row combinations modes (4 x 2.50, 4 x 3.75, and 4 x 5.00mm).

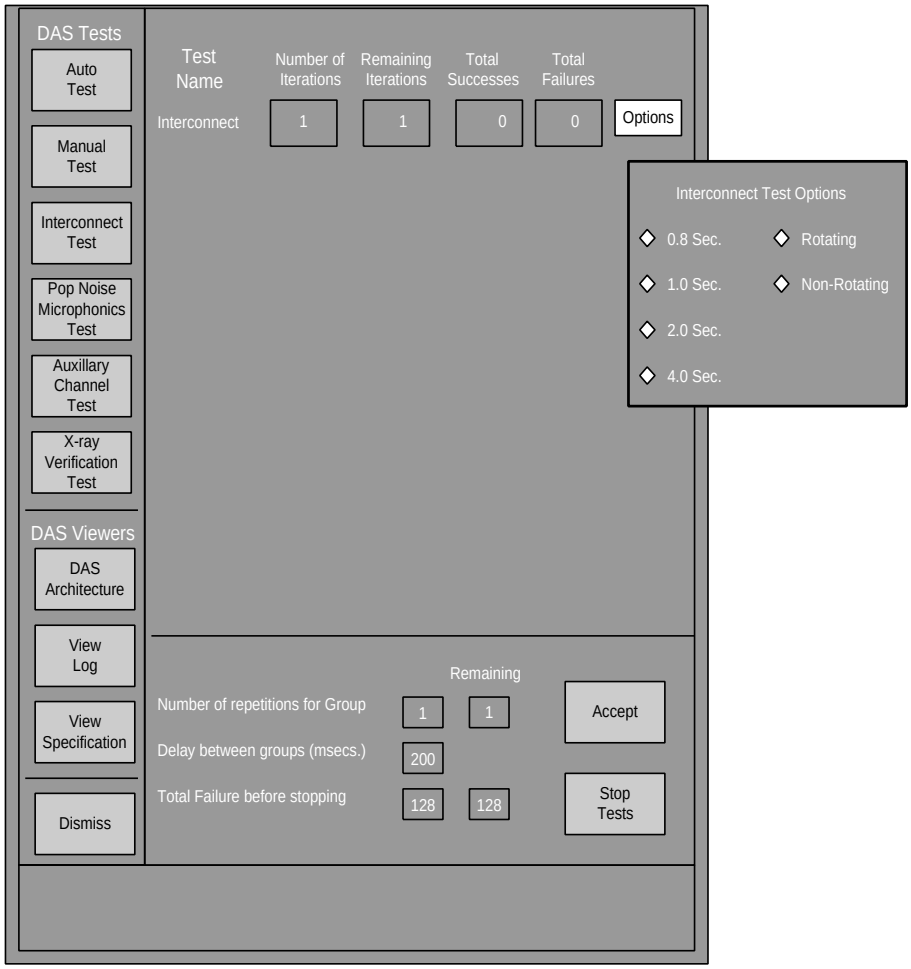


Figure 2-73 Interconnect Test

- If failed channel follows same channel number and same row for two or more scan modes, then the error is reported, Exam/series/scan/channel/Row/Board # Housing #/Elastomer #. Suggested possible problem areas could be converter board or flex-backplane interface. Suggest swapping converter boards and re-running the test to confirm if problem follows board.
- If failed channel between two adjacent scan modes stays on the same channel, but changes rows, error is reported as a failure with Exam/series/scan/channel/Row/Board # Housing #/ Elastomer #. For single channel failure, suggested possible problem is possible detector channel FET is bad. For 32 channel pattern (same side and both rows), then possible cause is module FET set-up, check flex connection on that specific housing, elastomer. For chassis boundaries or just channels 763-765, check cabling, and DCB FET control lines.

Side	MODE Diode	Cal 0 (4 X 1.25)	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5	Cal 6	Cal 7
B	D8							Row 2B	Row 1B
B	D7						Row 2B	Row 1B	
B	D6					Row 2B	Row 1B		
B	D5				Row 2B	Row 1B			
B	D4			Row 2B	Row 1B				
B	D3		Row 2B	Row 1B					
B	D2	Row 2B	Row 1B						
B	D1	Row 1B							Row 2B
A	D1	Row 1A							Row 2A
A	D2	Row 2A	Row 1A						
A	D3		Row 2A	Row 1A					
A	D4			Row 2A	Row 1A				
A	D5				Row 2A	Row 1A			
A	D6					Row 2A	Row 1A		
A	D7						Row 2A	Row 1A	
A	D8							Row 2A	Row 1A

Table 2-15 Interconnect Test

3.4.11 Pop / Noise & Microphonics

A series of predefined rotating scans, w/o x-ray, and the scan data saved on disk for analysis. The scan data is then viewed averaged and the standard deviations are measured against a spec limit.

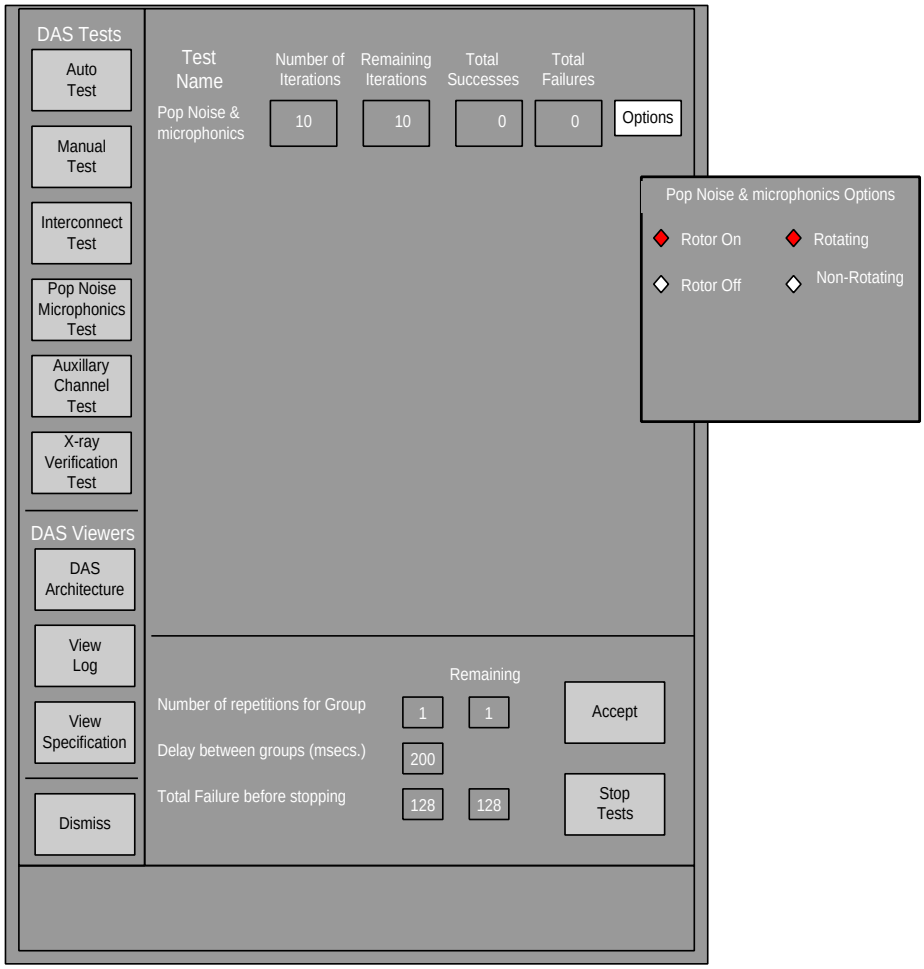


Figure 2-74 Pop Noise and Microphonics Test

This test takes a series of three scans. In the auto-mode, it takes ten iterations of the series. In the manual mode, the user has the ability to select the number of iterations as well as gantry speed and rotor selection. This helps in isolating microphonic problems caused by mechanical rotation issues, or rotor noise.

Failure analysis of this test is dependent on test results. Pop/Noise and microphonics issues can be caused by many system related conditions. Some of the most common could be the DAS/ Detector interface (such as elastomer connection caused by dirt, oil, debris), flex top cover clamp torque incorrect, air plenum not installed or fan orientation not correct, power supply noise, electrical connections, gantry rotation/mechanical issues, and external influences. It is very important to look at patterns relative to DAS/Detector architecture, gantry rotation (azimuth position as well as velocity), and high voltage (with or without x-ray, Rotor on/off).

3.4.12 Auxiliary Channel Test

The auxiliary channel test primary function is to query the DCB and report specific data, such as detector temperature, power supply voltage, converter board temperature, and KV/mA readings as a function of the DCB board. With the exception of the KV/mA channel sub-test, this test uses basic firmware routines to communicate and query the DCB board. It does not use the Scan Acquisition process that DDC uses. The reason is that if the DAS fails power-up diagnostics, the error is reported to software and scanning is prevented, either in applications or Diagnostic Data Collection (DDC). This “tool” allows the user to query the DCB and read the supply voltages, or detector / converter board temperatures “real-time”. The only exception is if the 5 vdc digital supply is so low as to not let the DCB function at all, or if the DCB cannot communicate with the HEMRC Controller board in the OBC.

THE DEFAULT

DASTools will collect data and only report the auxiliary channels to display:

CURRENT DETECTOR HEATER TEMPERATURE AND SPEC.

The detector temperature is measured by the DCB board as is reported in one of the auxiliary channels. The reported value is in the format shown in Table 2-16.

EXPECTED	MEASURED	SPEC.	PASS/FAIL
36 deg		± 1.0	

Table 2-16 Detector Temperature Format

3.4.12.1 Power Supply Voltages

All DAS power supplies will be measured by the DCB circuitry and reported in the auxiliary channels in the form of voltages. The list of supplies are show in Table 2-17.

SUPPLY EXPECTED	MEASURED	SPEC.	PASS/FAIL
+5.0 VDC Digital		+4.75 - +5.25	
+5.0 VDC Analog		+4.75 - +5.25	
-5 VDC Analog		-4.75 - -5.25	
+12 VDC		+11.4 - +12.6	
-12 VDC		-11.4 - -12.6	
+12 VDC CAN		+11.4 - +12.6	

Table 2-17 Power Supply Voltages

3.4.12.2 DAS Converter Board Temperature

The normal operating temperature range of the S-DAS is between 25° - 40° Celsius. If the temperature reaches 55° C, then a warning error message will be posted to the Status Area of the ExamRx Desktop and associated error message in the error log. If the temperature reaches 62° C, then the S-DAS will report an over-temperature fault, and will prevent further scanning until the DAS cools and is reset.

DASTools shall query—real-time—the DAS converter board temperature, compare it to spec, and display test output as indicated below.

>>> Converter Board Temperature <<<

Converter Board 46 Temp: 27.5C Test Status: PASSED (Expected: 26.0 to 62.0C).

Converter Board 47 Temp: 62.5C Test Status: FAIL (Expected: 26.0 to 62.0C).

Converter Board 48 Temp: 27.5C Test Status: PASSED (Expected: 26.0 to 62.0C).

3.4.12.3 KV / mA Channels

These auxiliary channels report the actual KV and mA signals as read from the generator (KV and mA control boards). Since this requires x-ray, this test will not be part of the auto-mode, but can be initiated in the manual test mode with operator intervention. The use of the Scan Enable push-button will be required to initiate x-ray. All x-ray safe guards will be in place, which would terminate x-ray in the event of a system failure, tube cooling limitations, or exposure time limitations.

The test shall take several scans at selected techniques, and the DCB measured KV and mA signals will be compared to the selected techniques, as well as to the system reported measured signals. If the DCB reported signals do not match the system reported output, then this test will fail with the following error message:

DCB board measured KV (or mA) differs than system measured KV (or mA) reading.

If the reading matches the system reported values, but is outside the system spec for selected technique, then the test should fail, but would indicate the DCB aux. channel is working correctly, but KV (or mA) is out of spec. Refer to HV set-up/Troubleshooting.

SCAN #	KV	mA	SCAN TIME	FILTER	SPOT	MODE
1	80	200	1 sec.	Blocked	Sml	Closed
2	100	100	1 sec.	Blocked	Sml	Closed
3	120	40	1 sec.	Blocked	Sml	Closed
4	140	20	1 sec.	Blocked	Sml	Closed

Table 2-18 kV / mA Channel Readings Test

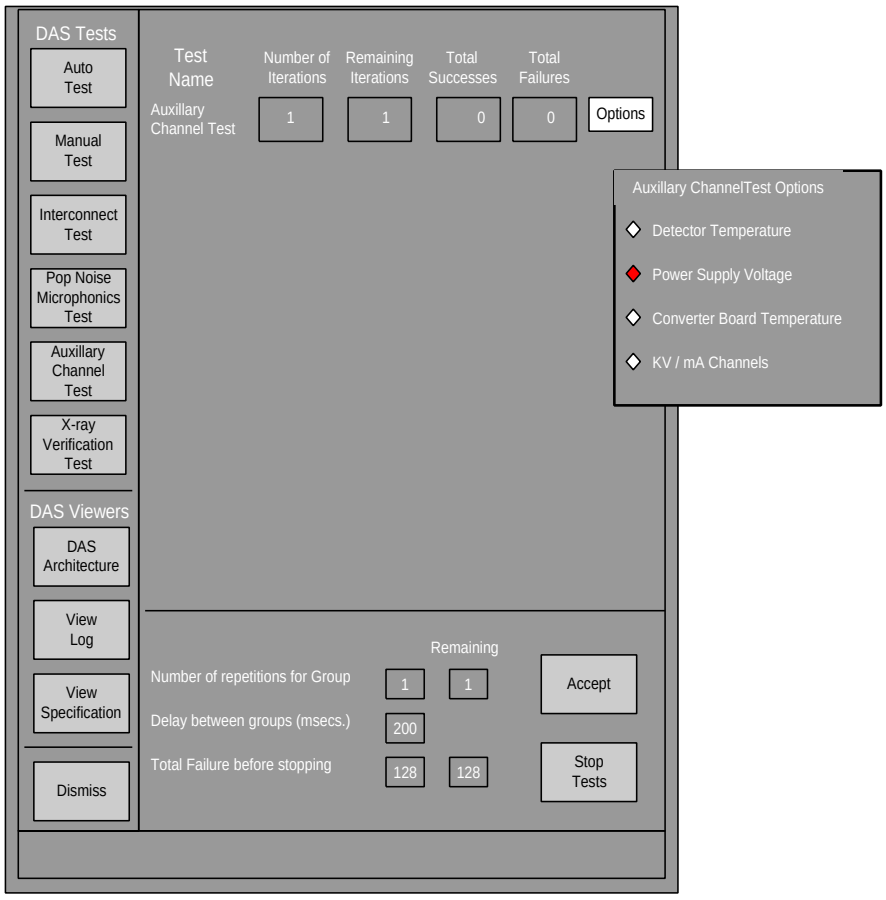


Figure 2-75 Auxiliary Channel Test

3.4.13 X-ray Verification Test

X-ray verification test takes a series of four scans and evaluates the offset correct means counts to specification limits. If the test fails, it will report the exam, series, and scan number along with the failing channel and row number. The scan data can also be plotted using Scan Analysis, to view the data graphically.

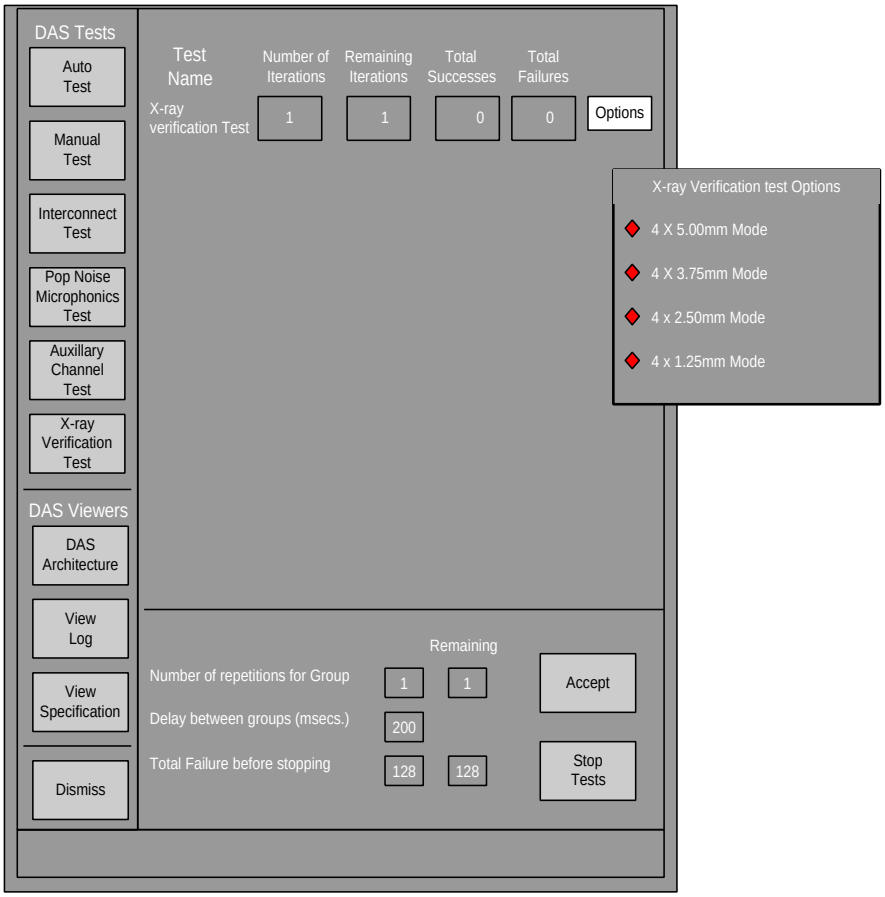


Figure 2-76 X-Ray Verification Test

The four x-ray verification scans and techniques are found in Table 2-19.

Slice Thickness	DAS Gain	DCB Override	X-Ray	Filter	Focal Spot	Scan Time	Gantry Rotation
4 x 5.00	31	0	120KV/ 40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
4 x 3.75	29	0	120KV/ 40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
4 x 2.50	9	0	120KV/ 40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
4 x 1.25	5	0	120KV/ 40mA	Air	Small	1 Sec. 984 views	Stationary, 0°

Table 2-19 X-Ray Verification Test

Analysis of the means count is offset corrected in Table 2-20.

Slice Thickness	DAS Gain	Channel Zone 1 - 64, 705 - 750 (see Note)	Channel Zone 65 - 704 (see Note)	Channel Zone 751 - 762 (see Note)	Channel Zone 763 - 765 (see Note)
4 x 5.00	31	264K - 396K	136K - 204K	384K - 576K	120K - 180K
4 x 3.75	29	209.6K - 314.4K	112.8K - 169.2K	304.8K - 457.2K	
4 x 2.50	9	469.6K - 704.4K	254.4K - 381.6K	684K - 1,462K	
4 x 1.25	5	425.6K - 638.4K	224K - 336K	627.2K - 940.8K	806.4K - 1209.6K
Note: Channel/Channel Variation from Mean = +20%, -40%					

Table 2-20 Analysis of Means Count

3.5 X-Ray Verification

3.5.1 X-Ray Verification Scan - 4 x 5.00 Mode

Technique: Air Scan / 120KV / 40mA / 4 x 5.00 / 1 sec Rotating/Air Filter / Small Spot / DAS Gain 31

Note: This plot and specs are the same for all four rows when all four rows are connected from the detector to the DAS.

Data is plotted “Offset Corrected”.

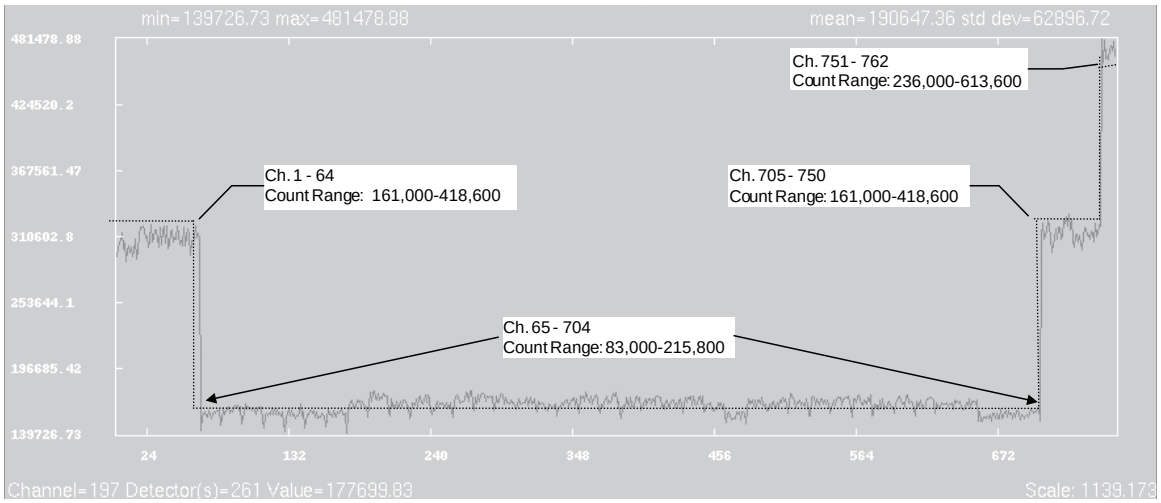


Figure 2-77 4 x 5 Spec. Limits (Means Example)

3.5.2 X-Ray Verification Scans - 4x5 Mode “A” Side Disconnected

Mean plot with ‘A’ side of the detector physically disconnected from DAS.

Technique: Air Scan / 120KV / 40mA / 4 x 5.00 / 1 sec Rotating Air Filter / Small Spot / DAS Gain 31

Note: This plot displays Row 1B when performing x-ray verification on the ‘B’- side of the detector only with the ‘A’- side flexes disconnected from the DAS. The sinusoidal wave pattern of the means counts is due to the capacitive charging/discharging of the unterminated ‘A’- side detector diodes bleeding over to Row 1B. This is a normal plot in this detector/DAS configuration. Data from the disconnected ‘A’- side is not specified, due to unknown results from open inputs to the DAS.

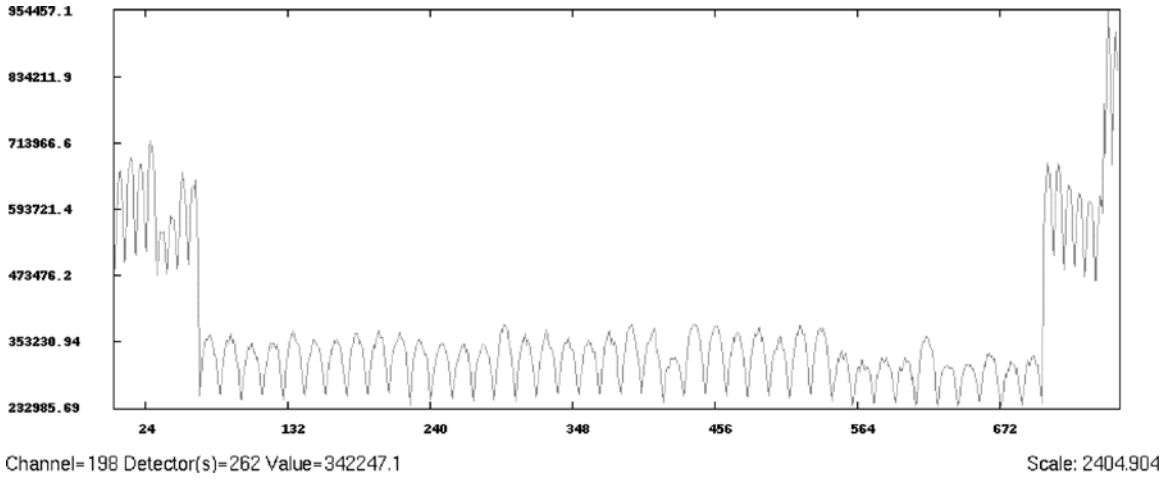


Figure 2-78 "A" side Disconnected (Means Example)

3.5.3 X- Ray Verification Scan - 4x1.25 Mode

Technique: Air Scan / 120KV / 40mA / 4 x 1.25 / 1 sec Rotating Air Filter / Small Spot / DAS Gain 5

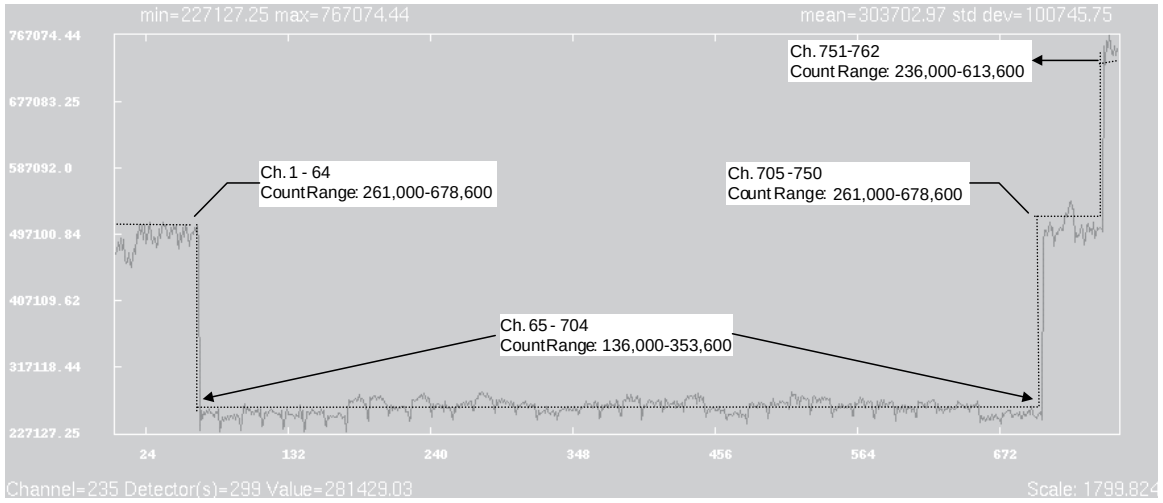


Figure 2-79 4 x 1.25 Spec. Limit (Means Example)

Note: This plot and specs are the same for all four rows when all four rows are connected from the detector to the DAS.

3.5.4 X-Ray Verification Examples

3.5.4.1 "Weak" Detector Module

Figure 2-80 shows an obvious count difference than what is expected. The channels correspond to detector module boundaries, and the detector was suspect of being bad. Do not replace the detector until further analysis has been completed.

A weak detector cell or module may or may not be a problem. The best way to determine if a detector cell or module is ok, take x-ray verification scans and analyze the channels in suspect, and compare them to the minimum and maximum expected counts range. As long as they are within the specifications, then the "weaker" cell or module is acceptable.

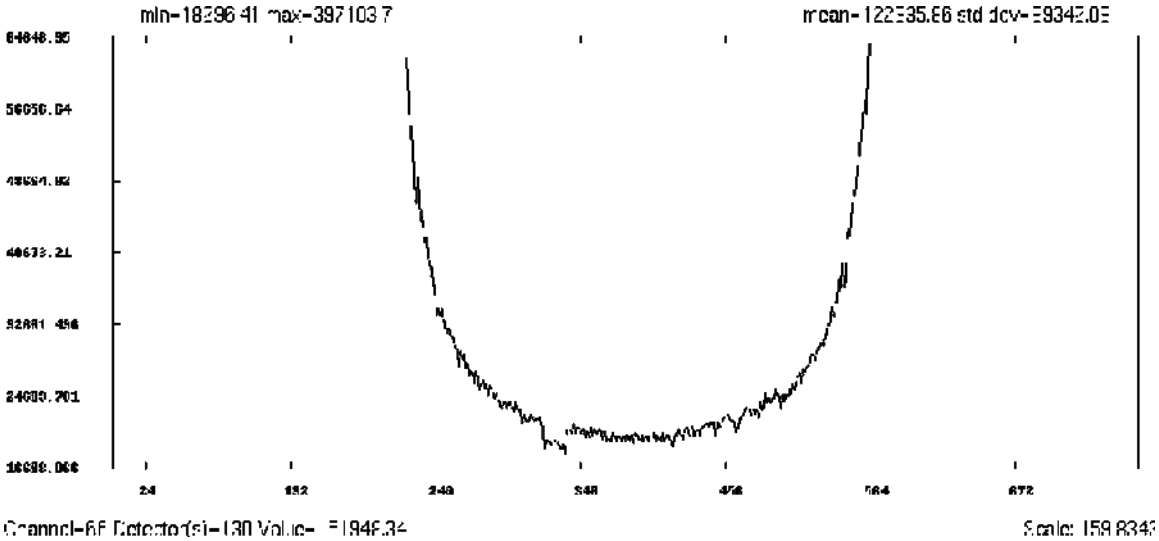


Figure 2-80 "Weak" Detector Module

3.5.4.2 Converter Board Pre-Amp Pattern

Figure 2-81 shows an offset means plot. The four-spike pattern is sometimes typical as a result of an individual pre-amp output either more or less than the other pre-amps on a converter board.

These spikes may or may not be normal. To check, evaluate the means counts of each spike. If the means count value is within the offset means specification, then the pre-amp (or converter board) is still good. If the means fails spec, swap boards with a known good board, verify spikes follow board, and then replace the converter board.

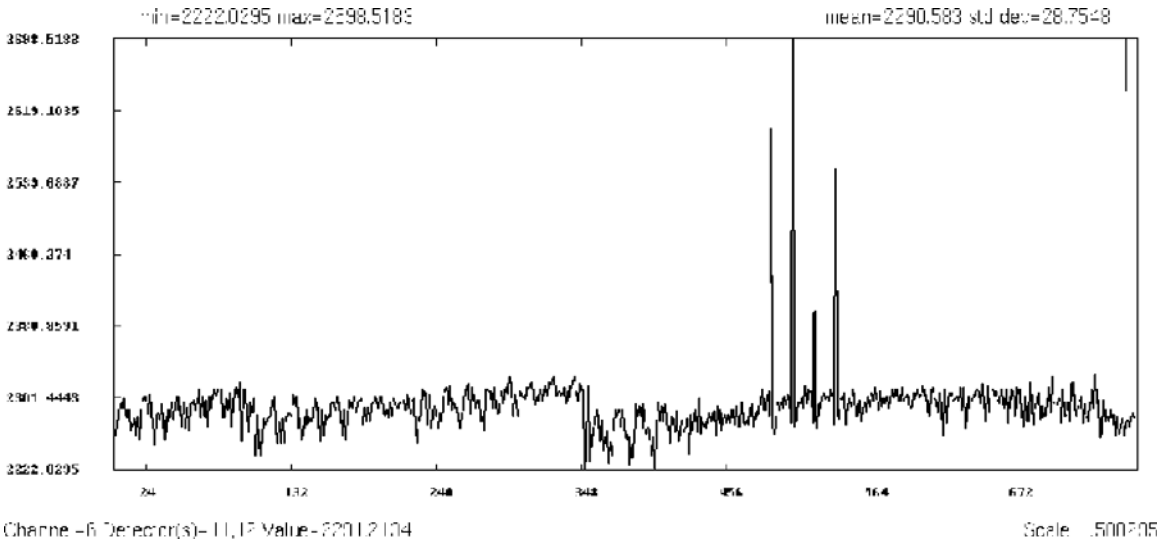


Figure 2-81 Converter Board Pre-Amp Pattern (MSD Plot showing 4 spike pattern)

3.6 X-Ray Generation Tools

Refer to Chapter 8 for: "X-Ray Tube Heat Soak and Seasoning," on page 768.

X-RAY GENERATION DIAGNOSTICS OVERVIEW

Purpose: To describe available tools for isolating problems in the Helios HV subsystem.

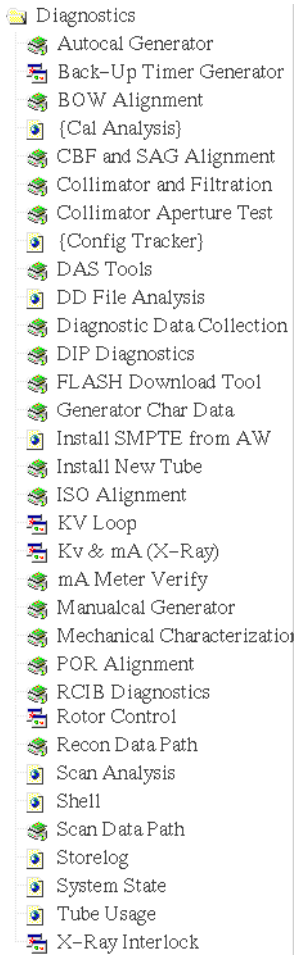


Figure 2-82 Diagnostics List

It starts at the Service Desktop Manager with the selection of DIAGNOSTICS. From there, KV, mA, Generator cal, X-Ray tests can be selected.

3.6.1 FLASH Download

The FLASH Download tool is accessed by selecting SERVICE DESKTOP -> DIAGNOSTICS -> FLASH DOWNLOAD TOOL.

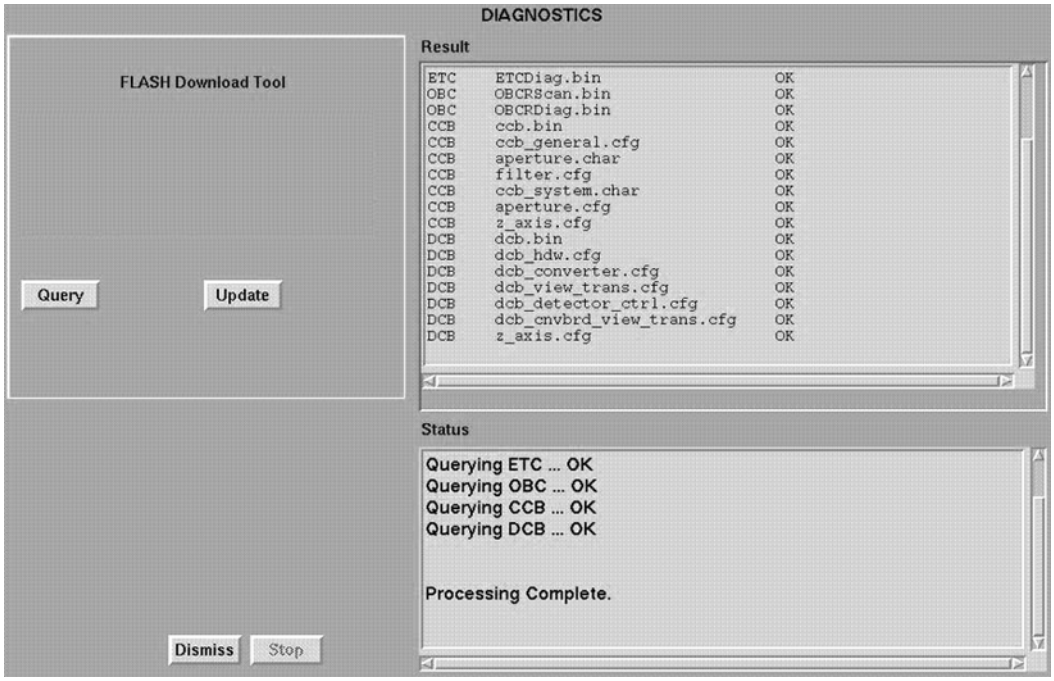


Figure 2-83 Flash Download GUI

Diagnostic Description

This utility loads the FLASH located on the CCB, DCB, OBC, STC, and ETC with the files stored on the system disk. This allows the nodes to initialize quickly after a reset is performed. This utility can also be used to check the nodes for the correct file versions without forcing a download.

When (to use)

1.) This tool needs be used once after upgrading software or replacing the CCB, DCB, STC, ETC, or OBC.

2.) Run tool if an attention window is brought up or an error message is logged indicating a file version mismatch was found.

What (to look for)

Verify that all files are downloaded without errors.

Notes

1.) The OBC must be downloaded to FLASH the CCB or DCB.

2.) Mismatches of files stored on the system disk and FLASH will prohibit scanning.

3.) Artesyn 1 boards must have both jumpers installed for Helios (20MHz).

4.) The "aperture.char" file is unique for each collimator. The numeric part of the serial number must be entered for this file to determine if an upload or download is required.

3.6.2 Collimator Functional Diagnostic Tests

The Collimator Functional Diagnostic tests are accessed from the Service Desktop by choosing Diagnostics. The “Collimator and Filtration” test selected has four sub-functional tests, which are described in the following sections.

3.6.2.1 Collimator Aperture Position Test

SERVICE DESKTOP -> DIAGNOSTICS -> COLLIMATOR AND FILTRATION TEST -> APPLICATION POSITION TEST

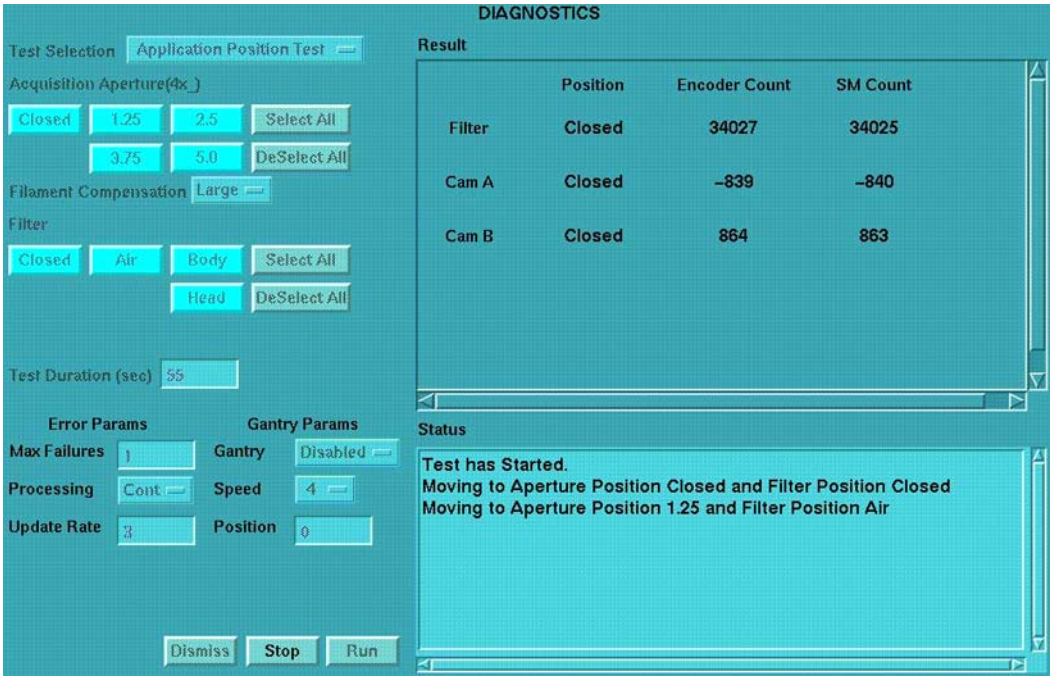


Figure 2-84 Collimator Application Test GUI

Diagnostic Description

This test continuously positions the collimator and filter to the selected position.

When (to use)

1.) Test runs in continuous modes, which help detect intermittent operating conditions.
2.) Means to visually validate the aperture and filter positions.
3.) Functional validation of the operation of the collimator.

What (to look for)

Look for highlighted fields that indicate the cam or filter did not make it to position. Check the log for additional information, when this occurs.

Notes

1.) Test can be run from application or diagnostic firmware download.
2.) Watch for finger pinch hazards.

3.) Attempt to move the filter and/or cams, when test is complete, and verify motor has a lot of holding torque

3.6.2.2 Collimator Continuous Filter Position Test

SERVICE DESKTOP -> DIAGNOSTICS -> COLLIMATOR AND FILTRATION TEST -> CONTINUOUS FILTER POSITION TEST

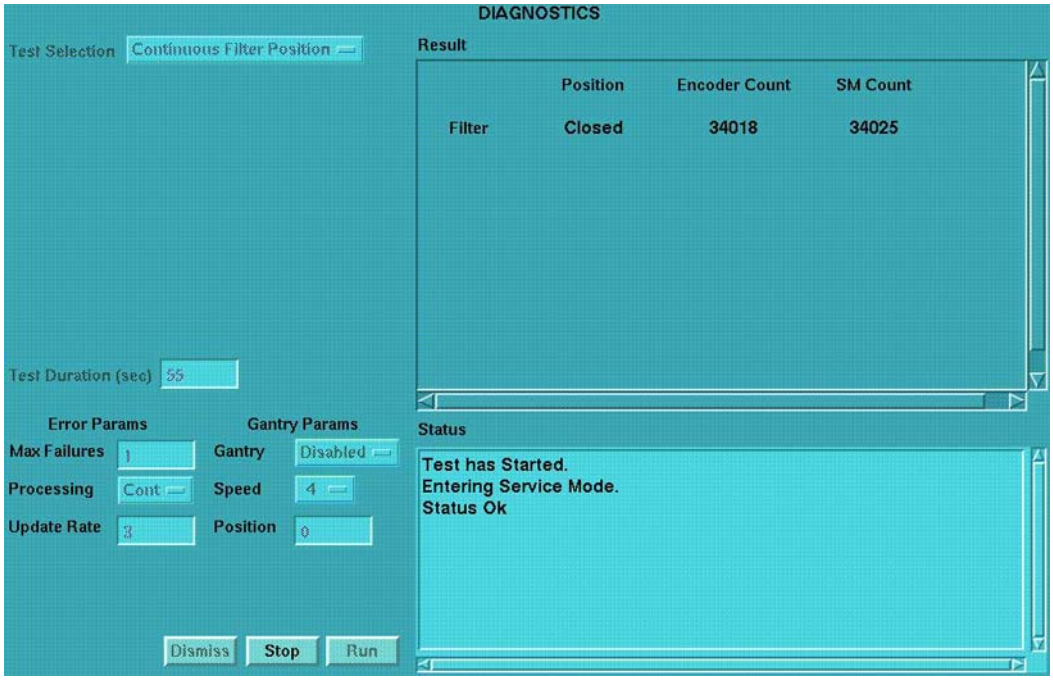


Figure 2-85 Collimator Continuous Filter Position Test GUI

Diagnostic Description

This test continuously moves the filter from one extreme to another.

When (to use)

1.) Verify no mechanical binding is present.
2.) Manual mode for signal tracing.
3.) Check for motion when errors indicate no motion sensed.

What (to look for)

If the display does not indicate changes in the encoder count, visually check the filter for motion:

1.) If filter is moving, failure is in the encode circuit.
2.) If filter is not moving, failure is in the drive circuit.

Notes

1.) Test can be run in the applications and diagnostic download.
2.) Watch for finger pinch hazards

3.) The filter drive can be divided into two functions:
- Motor Drive (Positioning driver)
- Encoder (Position feedback)

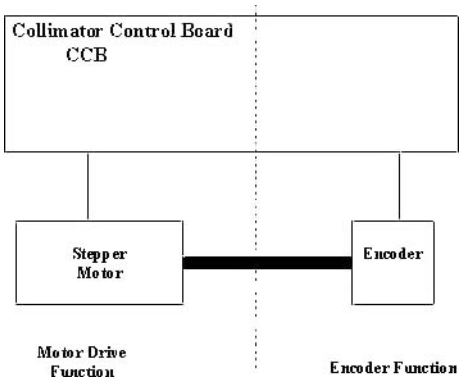


Figure 2-86 Collimator Filter Position

3.6.2.3 Collimator Continuous CAM Rotation Test

SERVICE DESKTOP -> DIAGNOSTICS ->COLLIMATOR AND FILTRATION -> CONTINUOUS CAM ROTATION TEST

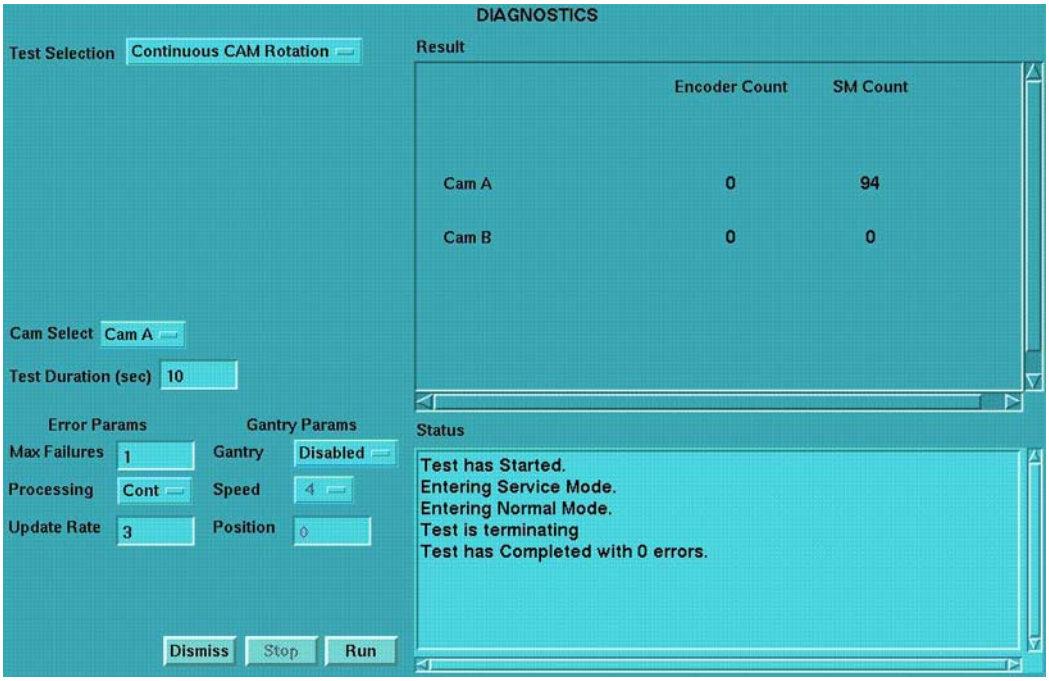


Figure 2-87 Collimator Continuous CAM Rotation Test

Diagnostic Description

This test continuously rotates the selected CAM.

When (to use)

1.) Verify no mechanical binding is present.
2.) Manual mode for signal tracing.

What (to look for)

1.) If the display does not indicate changes in the encoder count, visually check the cam for motion.

2.) Listen for mechanical vibration or binding.

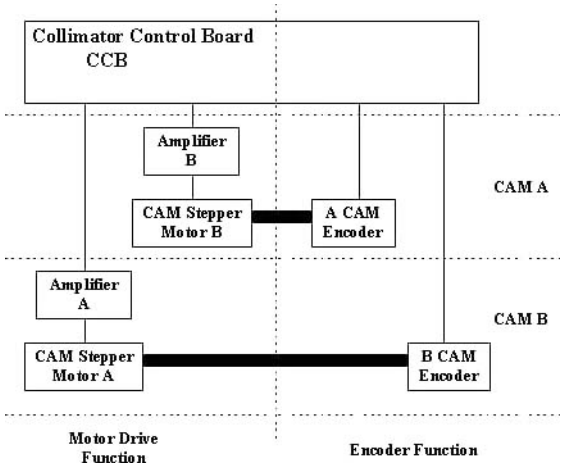


Figure 2-88 Collimator CAM Rotation

Notes

1.) Test can be run in the applications and diagnostic download.

2.) Watch for finger pinch hazards.

3.) CAM A and B circuitry is the same.

4.) CAM operation can be divided into four functions:

CAM	Function
A	Motor and Drive
A	Encoder
B	Motor and Drive
B	Encoder

3.6.2.4 Collimator Encoder Test

SERVICE DESKTOP -> DIAGNOSTICS -> COLLIMATOR AND FILTRATION -> COLLIMATOR ENCODER TEST

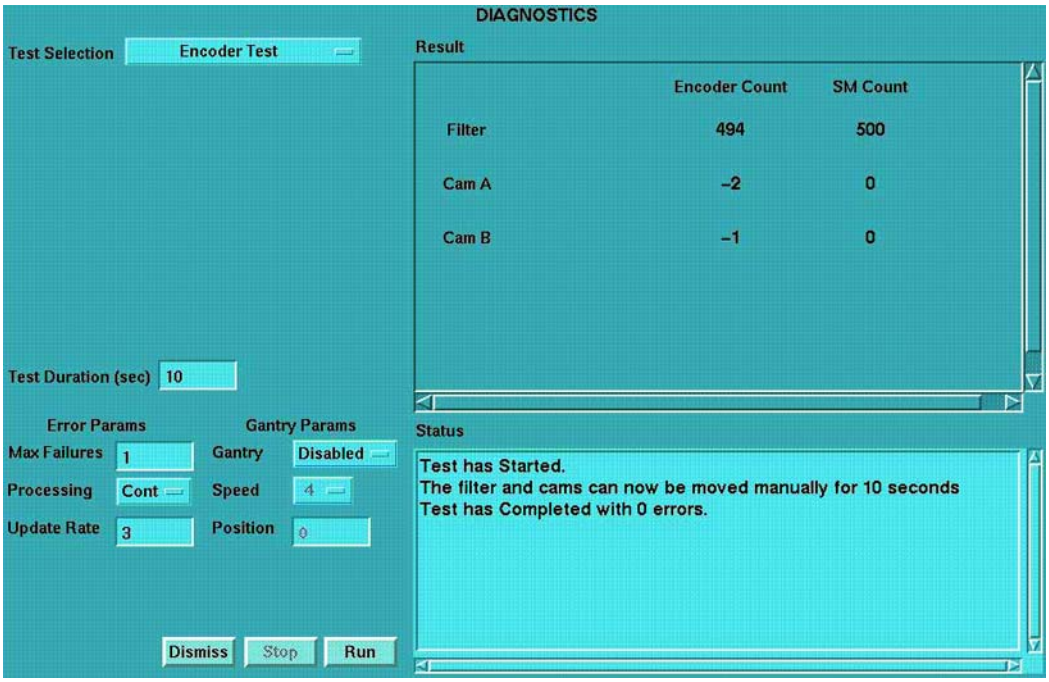


Figure 2-89 Collimator Encoder Test Screen

Diagnostic Description

Reads and displays the CAM and filter encoders while the devices are manually positioned.

When (to use)

Confirm an encoder problem with the collimator.

What (to look for)

Verify encoder reading changes once the cams or filters are moved. See below for relative encoder counts.

Notes

1.) Test can be run in the applications and diagnostic download.
2.) Watch for finger pinch hazards.
3.) Test reduces the cam holding torque to allow the cams to be rotated by hand.
4.) Cams are 2000 counts per rotation.
5.) Filter is 1000 counts per rotation.
6.) Cam encoder requires the whole collimator to be replaced.
7.) Filter encoder is a FRU.

3.6.3 Rotation Controller Interface Bus (RCIB) Functional Diagnostics

These diagnostics are accessed by launching Diagnostics from the Service Desktop.

3.6.3.1 Fault Line Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> RCIB DIAGNOSTICS -> FAULT LINE

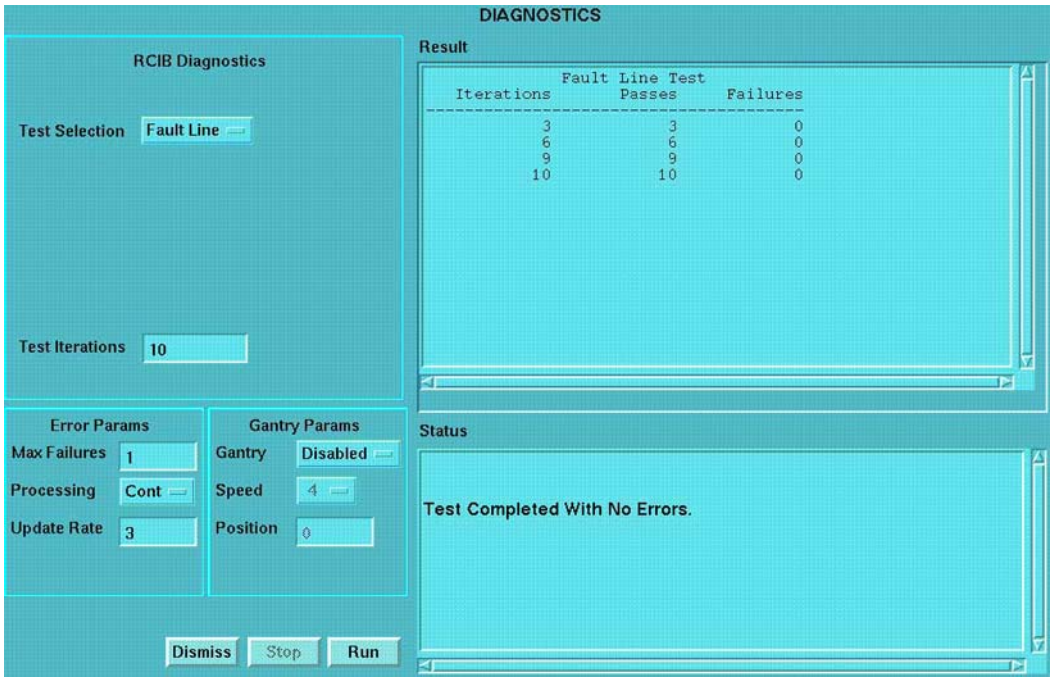


Figure 2-90 Fault Line Screen

Diagnostic Description

The Fault Line Diagnostic validates the parallel and serial fault line between the OBC, DCB, and CCB. Test consists of opening and closing the fault relays on each node and validating that all nodes see the fault.

When (to use)

1.) Run test to detect intermittent fault line failures.
2.) Run after fixing fault line problem to validate fix.

What (to look for)

1.) Look for any failures in the "Failures" column.
2.) Look for cable swap issues.

Notes

1.) Test can be run in the applications and diagnostic download.
2.) OBC must be downloaded for test to run.
3.) Test runs with diagnostic or application firmware downloads

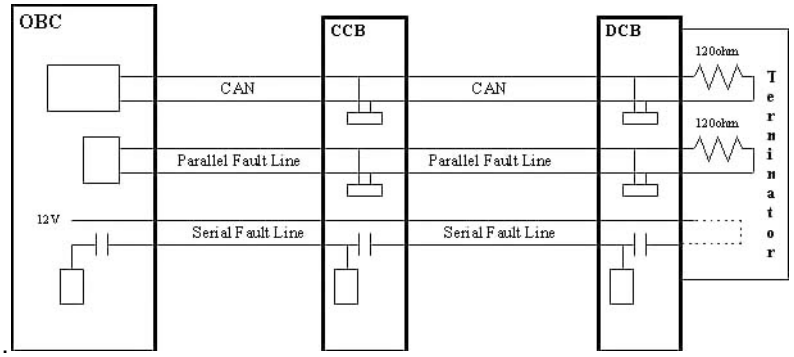


Figure 2-91 Fault Line

3.6.3.2 RCIB Ping Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> RCIB DIAGNOSTICS -> PING

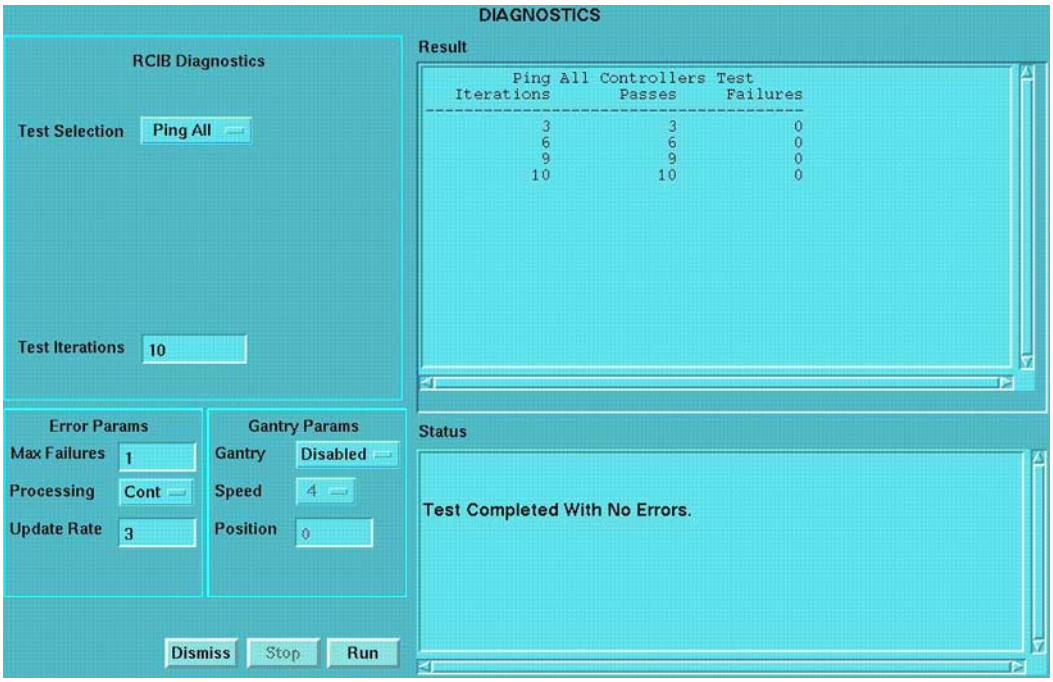


Figure 2-92 PING Screen

Diagnostic Description

The RCIB Ping Diagnostic sends small CAN packets to the selected nodes and verifies the correct response is received. This test works much the same way as a UNIX ping command.

When (to use)

1.) Run test to detect intermittent CAN serial line problems failures.
2.) Run after fixing CAN problem to validate fix.
3.) Test can be run to determine the status of the node.

What (to look for)

Look for any failures in the “Failures” column. Check error log for more information, if a problem is detected.

Notes

1.) OBC must be downloaded for test to run.
2.) Test can be run in the applications and diagnostic download.
3.) Test makes extensive use of slip-ring and ethernet communication lines.

3.6.4 X-Ray Functional Test

SERVICE DESKTOP -> DIAGNOSTICS -> KV & MA (X-RAY)

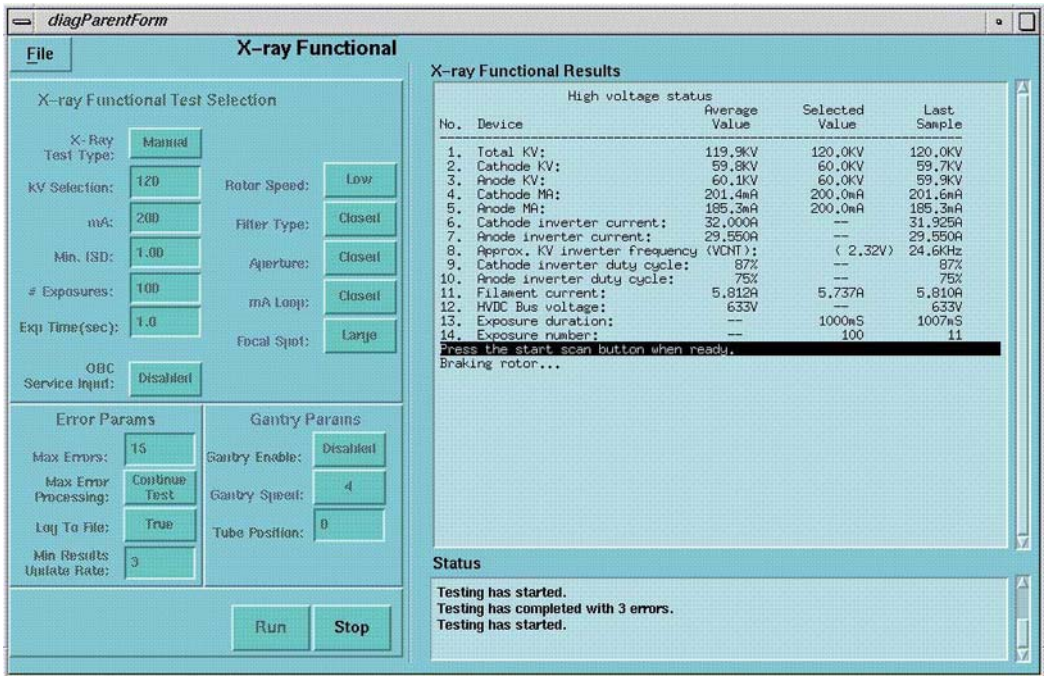


Figure 2-93 Kv & Ma X-ray Screen

Diagnostic Description

This diagnostic enables the collection of HV statistics during an x-ray exposure.

When (to use)

KV or mA errors are reported.

What (to look for)

1.) Symptom: KV out of tolerance (too low).

If one side has a low duty cycle while the other is high (25% or more difference), check the following:

a.) Check for bad light pipe: Run the fiber optic test and check the inverter with the high duty cycle for a missing trigger.

b.) Check that the IGBT connections are correct.

c.) Check for missing feedback cable in the main harness.

2.) The APPROXIMATE inverter current can be found in Figure 2-94.

3.) Verify the inverter frequency is approximately 19kHz if KV is low.
Replace the KV board if this value is closer to 30KHz

4.) See the next section for more information.

Notes

1.) There is a 180 second delay for HEMRC cooling between the start of this test to the start of another.

2.) Tube fans and pumps will remain on for 60 minutes after the test has completed.

3.) The Inverter operating frequency ranges from 19.5kHz (0.2V) to 31.5KHz (5V).

4.) Run the HV functional diagnostic test if over currents, shoot-through, or other types of shorts are reported.

5.) Cathode mA will always be higher than the anode mA for a Gemini tube (Metal casing). This is also true for the inverter currents.

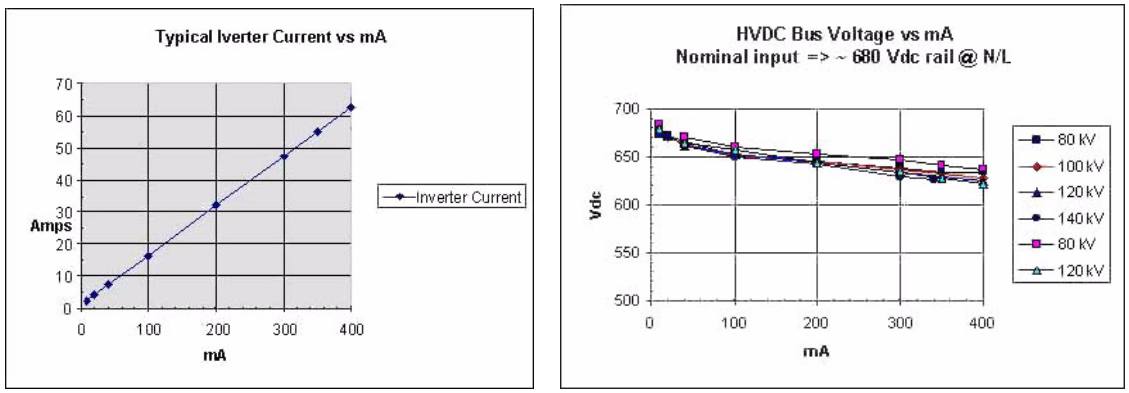


Figure 2-94 Inverter Current vs. mA and HVDC Bus Voltage vs. mA

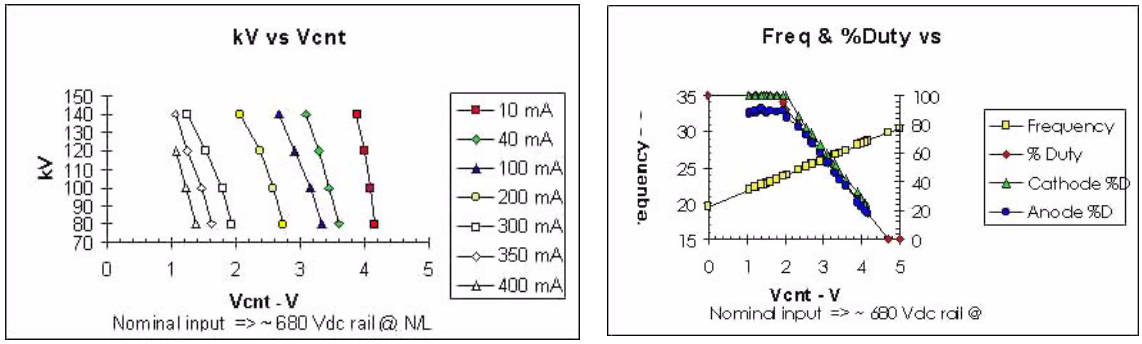


Figure 2-95 kV vs. Vent, and Freq, and Percent (%) Duty vs. Vent

X-RAY TROUBLESHOOTING

The screen below illustrates an open IGBT. The problem was induced by pulling an anode light pipe. Note the low anode AND cathode KV values, and the high duty cycle value for the anode inverter. The anode and cathode KV's will track each other, which means the KV values reported will NOT indicate which node is failing. The key is the duty cycle. The anode is working much harder than the cathode, since one of the IGBTs is not being triggered. Also note the operating frequency. This is at the lowest value, indicating the KV control board is operating correctly to compensate for this problem.

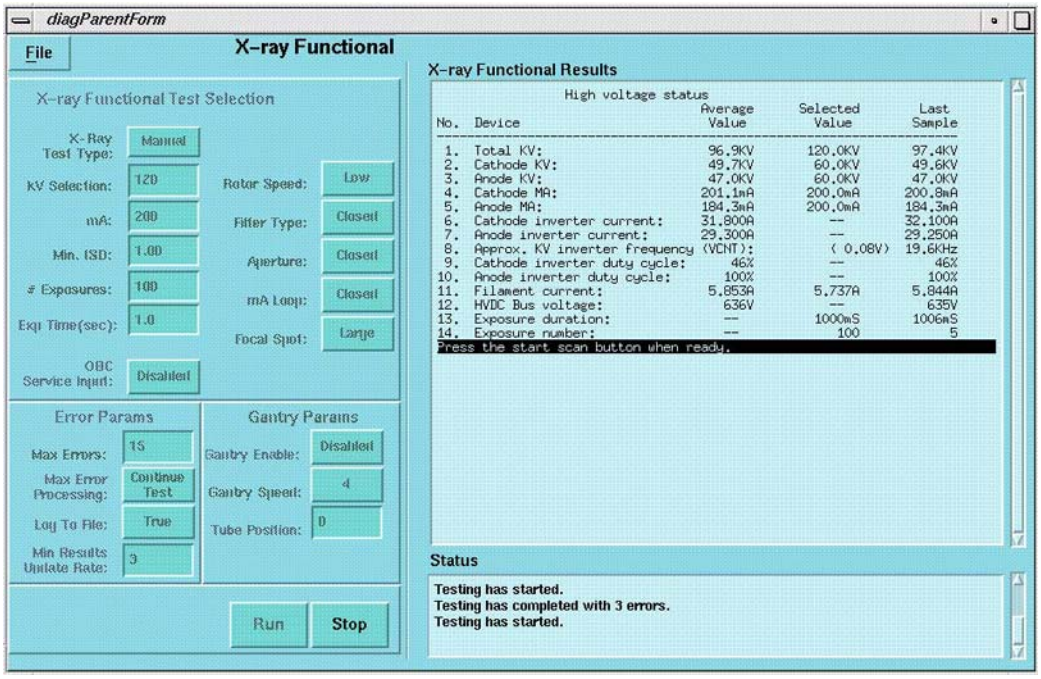


Figure 2-96 X-Ray Functional Screen

3.6.5 CAN Loop-Back Test

SERVICE DESKTOP -> DIAGNOSTICS -> ROTOR CONTROL -> CAN LOOPBACK

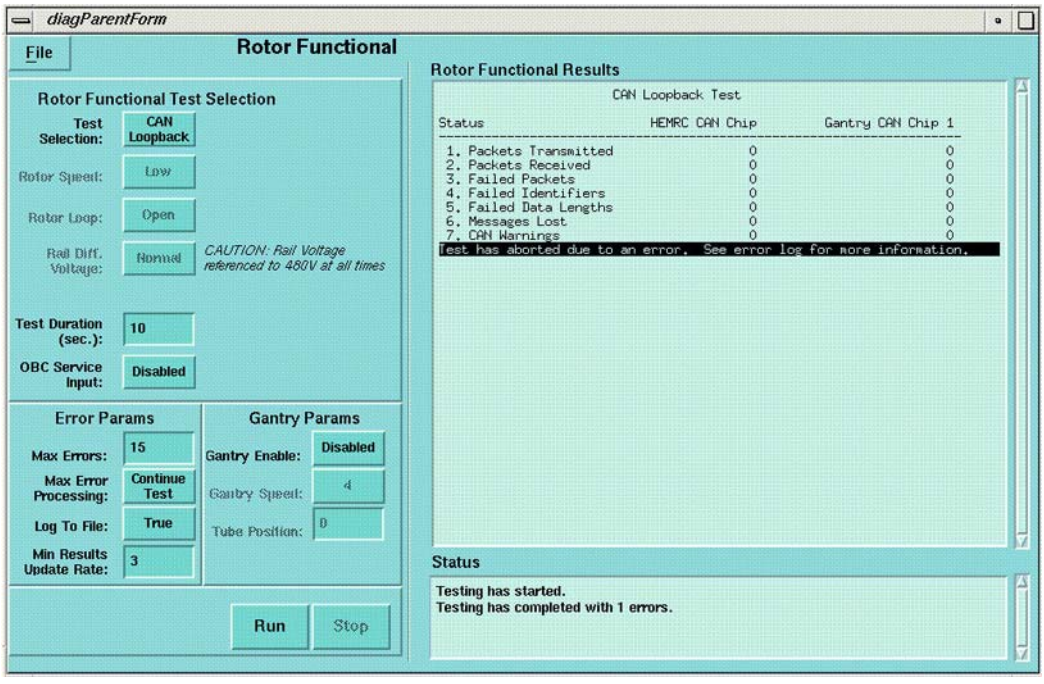


Figure 2-97 Rotor Functional Screen

Diagnostic Description

This diagnostic test loops back the HCAN serial line with the GCAN serial line. The purpose of this test is to validate the HEMRC Control Board CAN networks.

When (to use)

1.) Run test when HCAN communications errors are reported to the user.
2.) HCAN communications operate intermittently.

What (to look for)

Look for the number of failures detected. If the test passed with little or no errors, HEMRC control board is good. Check for bad connections, incorrect wiring, or failed HEMRC drive.

Notes

1.) HCAN communication errors are frequently due to a blown fuse on the HEMRC I/F board.
2.) Check the neon light on the back of the HEMRC drive for a power indication.
3.) The green HRX LED indicates the presence of CAN communications and 12V isolated power.
4.) HCAN drivers are powered by the HEMRC drive.
5.) Future software releases will indicate a 12V isolated power failure from a HCAN failure.
6.) Jumper on HEMRC control board must be moved to perform this test.
7.) HEMRC drive isolated power must be present for this test to pass.

3.6.6 Rotor Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> ROTOR CONTROL

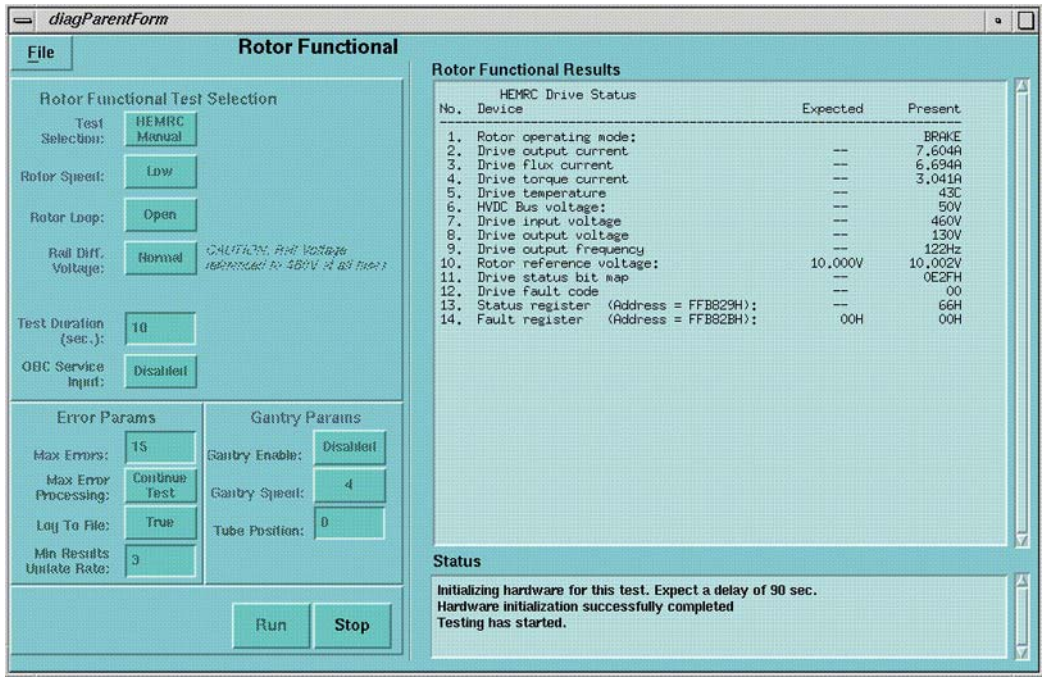


Figure 2-98 Rotor Functional Screen

Diagnostic Description

This diagnostic allows manual operation of the rotor while monitoring the operating parameters.

When (to use)

Run test after getting HEMRC operating errors. This does not include communication errors.

Notes

There is a 180 second delay from the start of this test to when the test can be restarted, due to a HEM-IT heating issue.

3.6.7 kV Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> KV LOOP -> HV MANUAL

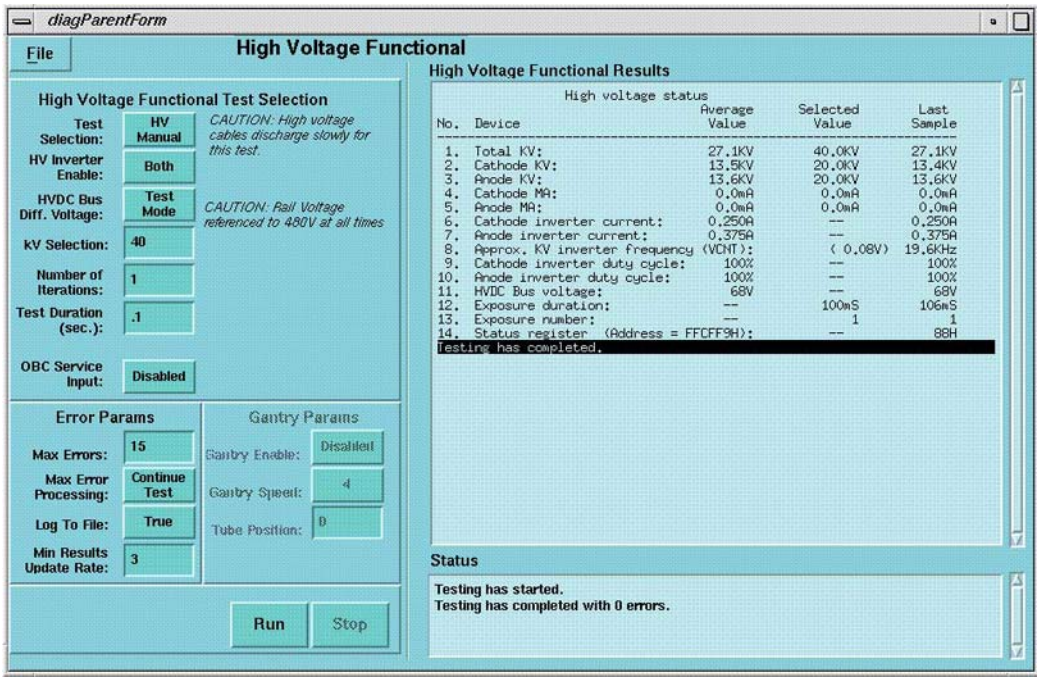


Figure 2-99 kV Diagnostic Screen

Diagnostic Description

This diagnostic operating the KV inverters without mA and at low input voltages. This test does NOT require the connection of the x-ray tube. However, if the tube is disconnected, the HV cables should be connected to a bleeder or disconnected at the HV tanks.

When (to use)

1.) This test should be run with the HVDC set to test mode (~75VDC) when the following errors are detected:
   - Over currents
   - shoot-through
   - mA over currents.

2.) Run test when a shorted x-ray tube or HV cables are suspected.

What (to look for)

1.) Look for where the current stops with the HVDC set to the test mode:
   a.) Inverter currents should be less than 1 to 2 amps of current
   b.) mA should be less than 2mA
2.) High pot the tube (use bleeder) to remove the tube from the circuit and rerun the test.

Notes

1.) Use HVDC test mode (~75VDC) to check for shorts. KV will NOT reach the prescribed value in this mode.
2.) Normal rail voltage should only be used to test for dielectric breakdowns. Turn on one side (cathode/anode) at a time since the bang-bang circuit was not designed for accurate KV loop control.
3.) High potting the tube is very dangerous if not done correctly even with the HVDC bus set to test mode.

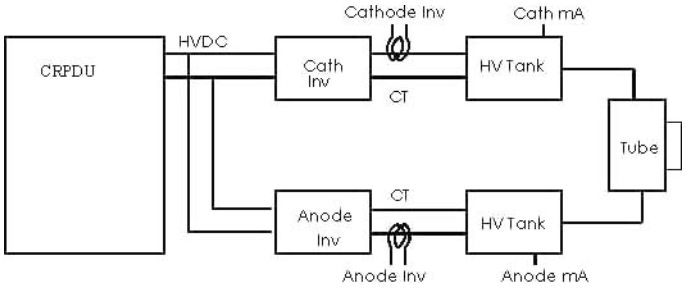


Figure 2-100 HVDC Test Setup

3.6.8 kV Fiber-Optic Test

SERVICE DESKTOP -> DIAGNOSTICS -> KV LOOP -> HV FIBER OPTICS

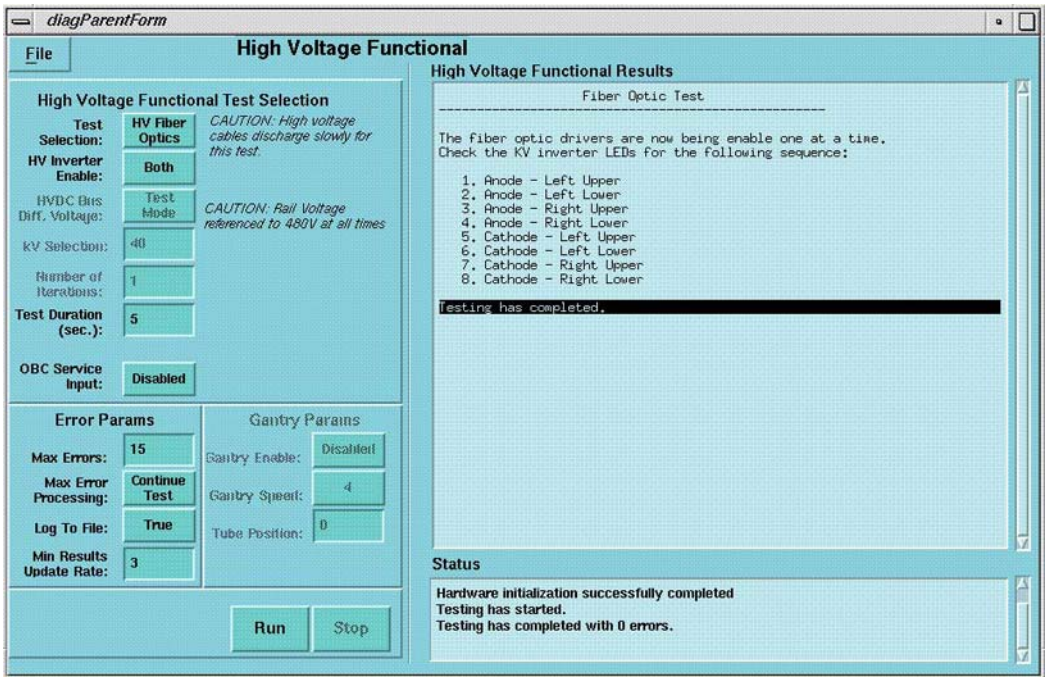


Figure 2-101 kV Fiber-Optic Screen

Diagnostic Description

This diagnostic sequentially enables the fiber optic drivers to the KV inverters.

When (to use)

1.) KV values drop as the mA increases.
2.) Suspect bad fiber-optic connection.
3.) Verification that all fiber optic connections are not miss wired.

What (to look for)

Verify LEDs located on the KV inverters are enabled in the correct sequence.

3.6.9 Filament Diagnostic

Utilize Diagnostic Data Collection [DDC] to interactively select small and large filaments for troubleshooting. Errors will be captured in the system error log [gesyslog].

3.6.10 Additional Diagnostic Tests

3.6.10.1 Backup Contactor Test

Description: Test energizes the contactor for the prescribed amount of time + 2 seconds. The two second delay prevents the rail monitor from detecting false errors. Contactor operation and statuses are verified during test.

3.6.10.2 Backup Timer Test

Description: Test the exposure command, backup timer, and contactor interlock by setting the backup timer and allowing it to expire.

The following describes the order of events:

1.) The timer is downloaded with the selected test duration.
2.) Contactor is energized.
3.) The STC activates the exposure command.
4.) The exposure command is verified.
5.) Timer is allowed to expire.
6.) Backup contactor and timer are checked for the correct states.
7.) The test is repeated for both clock frequencies.

Timer duration is compared to system clock. Only large discrepancies are reported (>150mSec).

Total test duration is twice the selected time.

3.6.10.3 I/O Status Information Test

Description: Reads and display the gentry I/O status for operational verification. Gentry I/O status information is displayed to the user. Except for the monitoring functions, no further testing is performed.

Troubleshooting notes:

- Displays the expected and actual tube ID.
- Tube, anode tank, and cathode tank pressure statuses are displayed.
- Relay driver statuses are displayed for operational verification.

Note: This test does not display system interlock status since the interlock is kept open when not needed during diagnostic testing.

3.6.10.4 HV Meter Test

Description: KV, mA, and rail voltage values are displayed for testing meter accuracy. Test enables user to inject known voltages into the system for the purpose of meter calibration.

3.6.10.5 Tube Fan and Pump Test

Description: manual operation of the tube relay, pump, and fans. Enables tube fans and pumps for a given duration. Test has no effect if fans are already running.

3.6.10.6 Alignment Light Test

Description: manually operate the alignment lights, power supply, and driver.

- This test enables the alignment lights for a given duration.
- Test enables user to isolate between table control problems and OBC.
- Gantry must be at 180 degrees to view alignment lights.

3.6.10.7 Power Supply Test

Description: Read and display the OBC power supplies for the correct operating range. Supplies out of range are highlighted and reported to the error log.

Troubleshooting notes: The 15VDC supply is monitored after the gentry I/O 15VDC inductor causing a 0.2 - 0.3 volt error.

3.6.10.8 Thermistor Test

Description: This test displays the OBC temperatures and limits for a given duration. Thermistors found open are reported as such (0VDC). Temperatures found out of range are highlighted and reported to the log.

Thermistors read:

- Gantry ambient
- OBC ambient

3.6.10.9 Exposure Interlock Test

Description: This test verifies the operation of the exposure interlock. The operator can loop on an error indefinitely or continue the test.

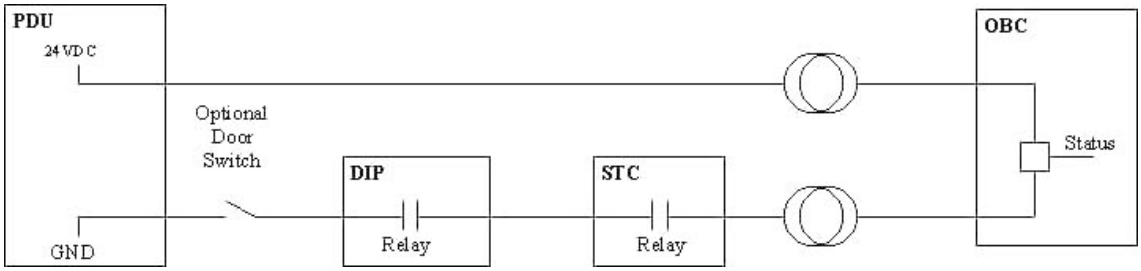


Figure 2-102 Exposure Interlock Testing

3.6.10.10 General Troubleshooting Notes

1.) Insure both jumpers are installed in the Artesyn boards for 20MHz operation.
2.) New Artesyn boards have built in Ethernet connections. The SBX cards are no longer needed.
3.) The DCB must have a terminator connected to the RCIB connection.
4.) Insure the 50 ohm inline terminator is installed at the ETC ethernet connection.
5.) Check the slip-ring stats when troubleshooting LAN watchdog errors.

3.7 Scan Data Path (DAS Control Board to SCU)

This diagnostic will be used to test and isolate problems related to scan data generated in the S-DAS and received at the scan data disk. It will generate known scan data from either the DCB or from each of the converter boards and send this data to the DAS interface processor board and store it on the scan data disk for analysis. The data path is shown in Figure 2-103.

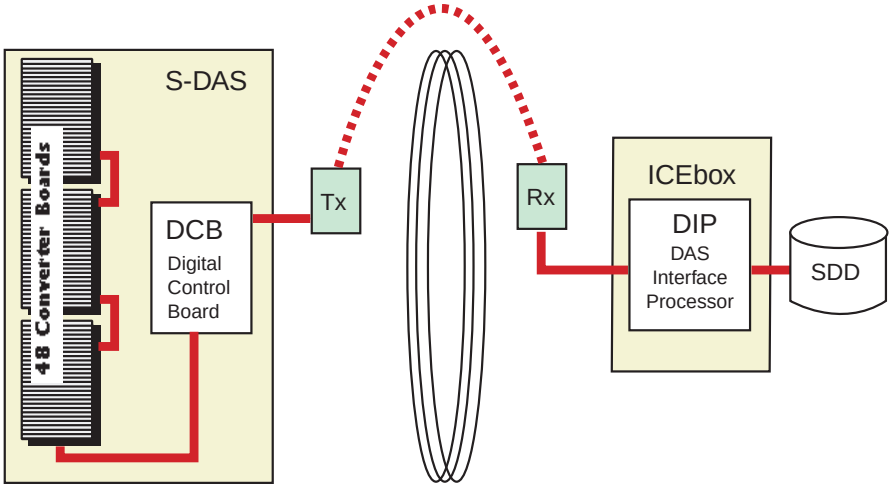


Figure 2-103 Scan Data Test Paths

The Main Diagnostic Menu selection has several options:

1.) Data Path Selection can be either from the DCB or converter boards (Figure 2-104).

a.) DCB: A known data pattern is sent from the DCB to the scan data disk. After the data is collected, the scan file is check summed and compared to a known checksum value. If a discrepancy is found, the test will fail. This will indicate that the path between the **DCB** and the scan data disk is bad.

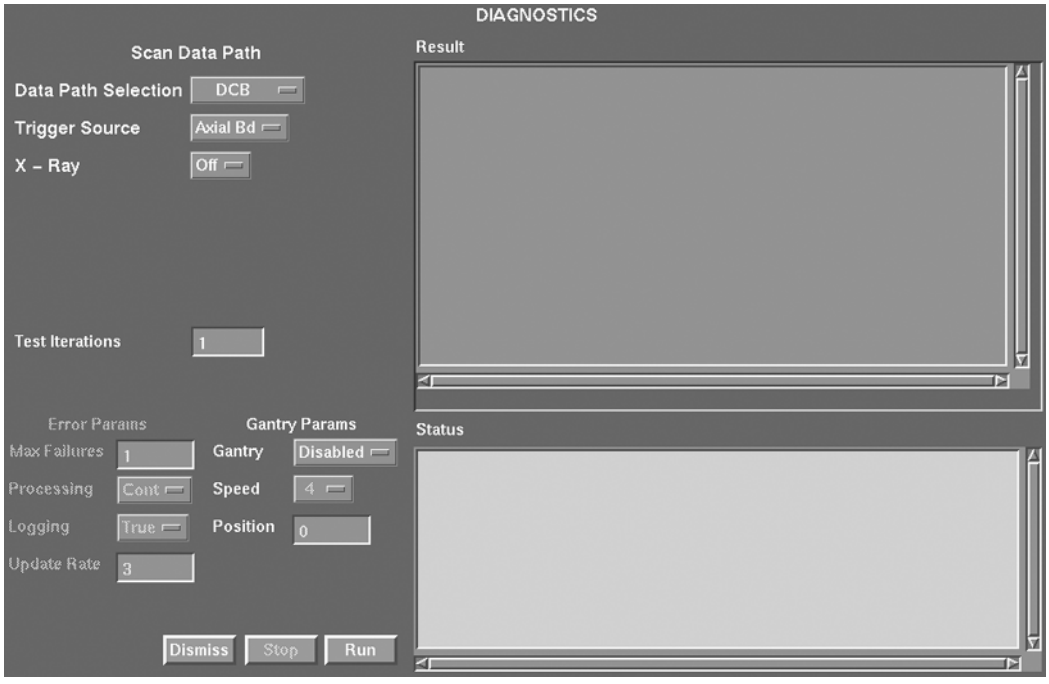


Figure 2-104 DCB Data Path Selection Screen

b.) Refer to the system error log for further details on what may be the cause. Further attempts to isolate the problem may include:

* Running DIP Diagnostics, with and without the loop-back cable
* Bypassing the RF slip-ring by connecting the DCB fiber output directly to the DIP bd.
* Running DCB Diagnostics
* Check DIP stats for FEC error corrections and/or attempts. This step should always be done even if the test passes to see if there is a marginal error condition that FEC is correcting.
* Record the exam number the test uses and plot the data using Scan Analysis to look for errors. Look at ALL four rows. ALL four rows may not look the same. Refer to Figure 2-105, Figure 2-106, Figure 2-107, and Figure 2-108 showing what each of the four rows should look like.

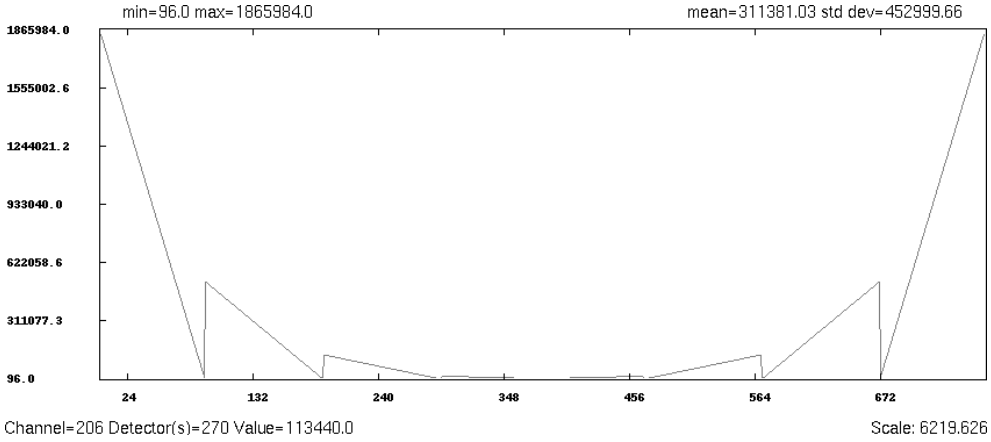


Figure 2-105 DCB Data, Row 2A Screen

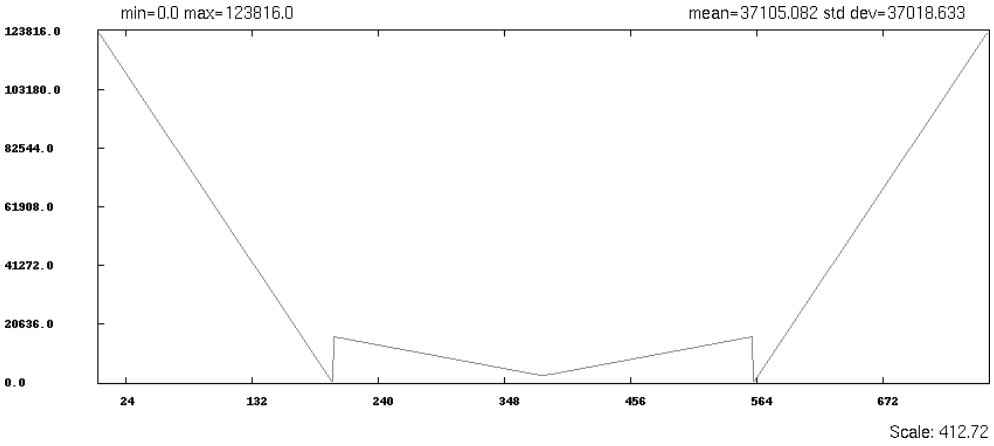


Figure 2-106 DCB Data, Row 1A Screen

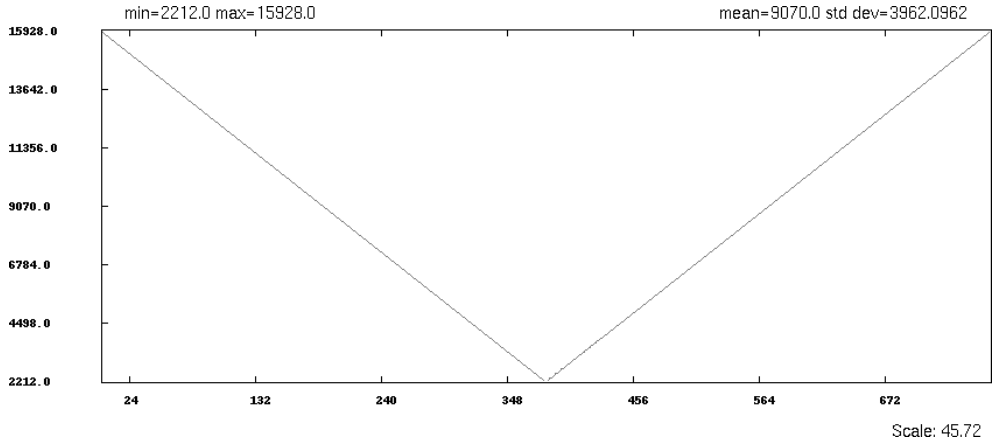


Figure 2-107 DCB Data, Row 1B Screen

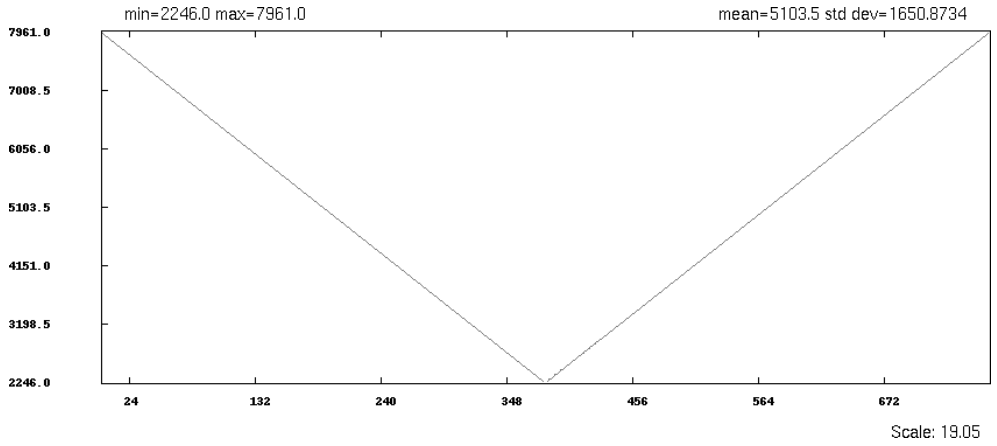


Figure 2-108 DCB Data, Row 2B Screen

c.) **Converter Boards** - A known value is input to the front-end of each of the 48 converter boards. Again, this data is sent to the scan data disk and check summed and verified for any discrepancies. Using the converter board path will help isolate if the problem is between the converter boards and the DCB Board. The reason why the DCB is the default option is that if the DCB data path fails, then most likely the converter data path will fail also. Fix the DCB data path first (refer to Figure 2-109).

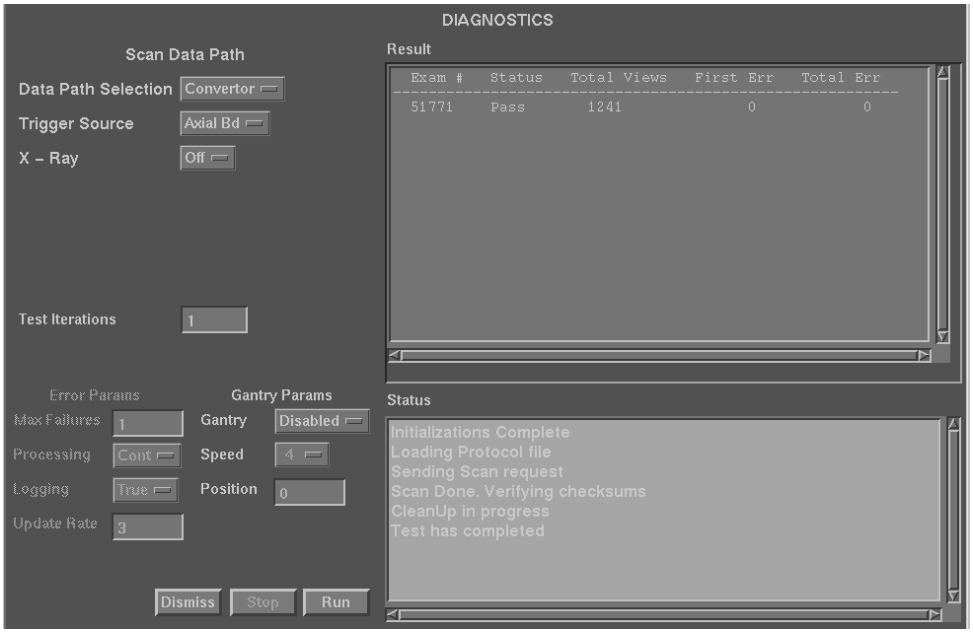


Figure 2-109 Converter Data Path Selection Screen

See Figure 2-110, Figure 2-111, Figure 2-112, and Figure 2-113 for corresponding row output screens.

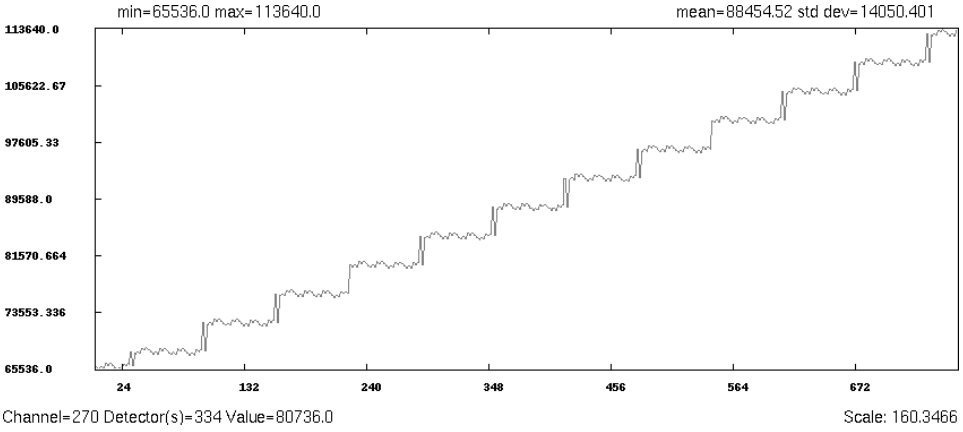


Figure 2-110 Converter Data, Row 2A Screen

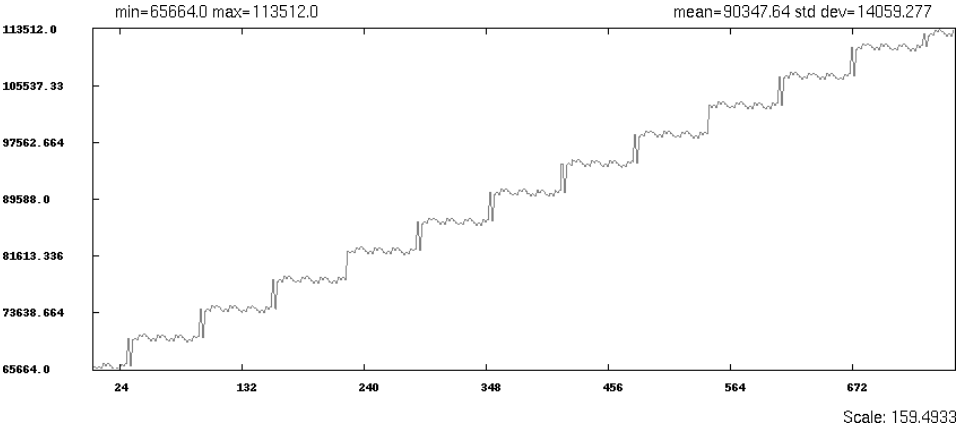


Figure 2-111 Converter Data, Row 1A Screen

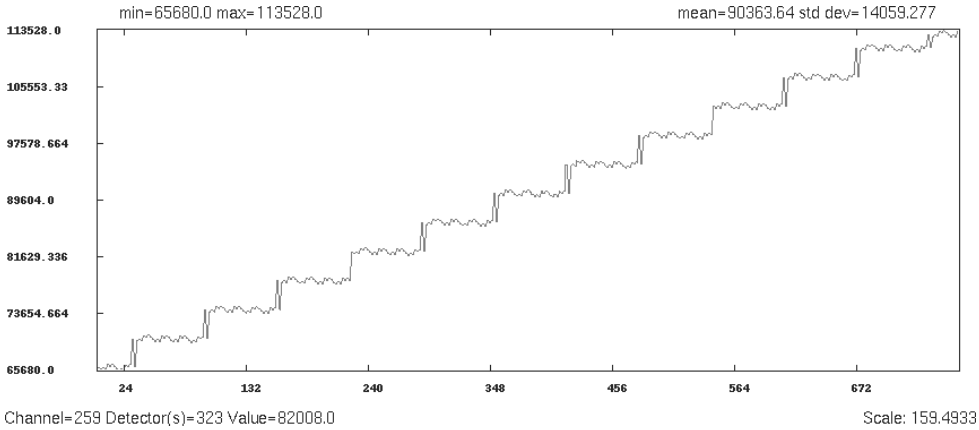


Figure 2-112 Converter Data, Row 1B Screen

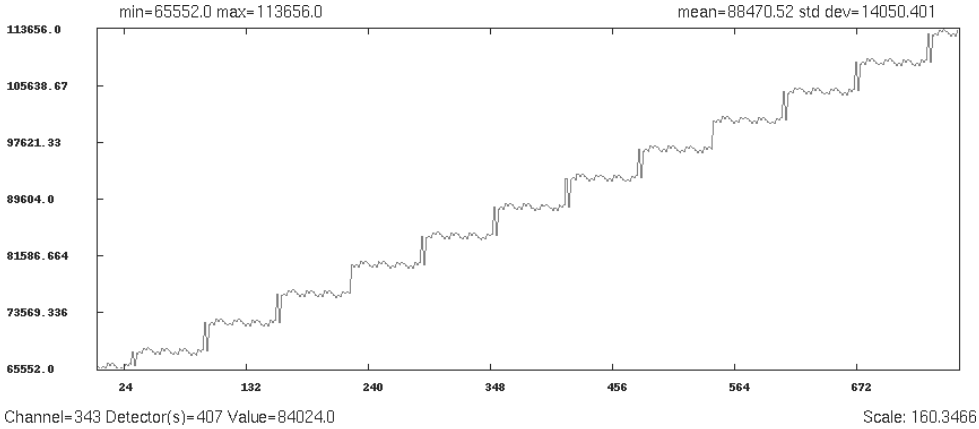


Figure 2-113 Converter Data, Row 2B

2.) **Trigger Source** - Defaults to the axial board, which is the only option at this time. Future releases may include the DCB as an internal trigger source to help isolate trigger related faults.

3.) **X-Ray** - This option enables a low technique scan to determine if rotor and high voltage is the cause of data errors. If selected, x-ray can be initiated during data collection to flag HV related issues during data collection. Technique shall be kept to a minimum and follow all x-ray initialization constraints, such as techniques, scan times, and tube cooling. Default test prescription will NOT have x-ray. For testing with x-ray, scan technique shall be 80KV/20mA/1 sec/filter in closed position, and collimator at minimum opening. This option is not for use by InSite without operator initialization utilizing the Scan Push button. The default selection is No X-Ray.

4.) **Gantry Rotation** - This test shall be functional in a stationary gantry utilizing DAS internal triggers. The test shall be functional in a rotating gantry at various gantry speeds (0.8, 1.0, & 2.0 seconds) using system generated triggers. This feature will be chosen via the GUI and will require the scan push-button to enable the rotation. Stationary data collection will be the default option and primarily used by InSite.

3.8 Recon Data Path Test

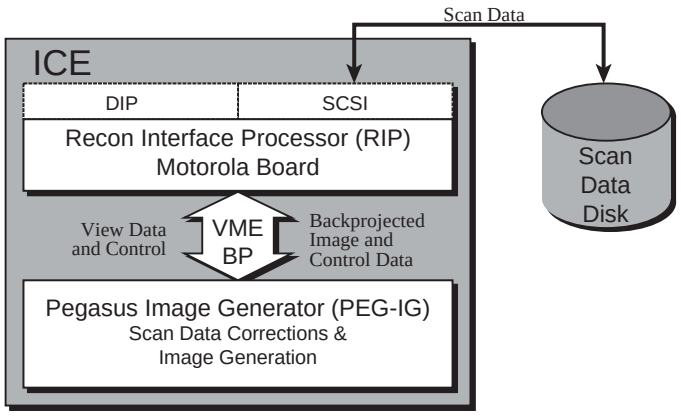


Figure 2-114 Reconstruction Data Flow Block Diagram

3.8.1 Test Description

The Recon Data Path Test validates the image reconstruction hardware and software. Testing consists of creating images from scan data loaded by the diagnostic and stored on the scan data disk and validates their checksums. Errors detected by this diagnostic should be the same as those detected during patient scanning since the same image reconstruction hardware and software is utilized in both situations. Scouts, axial and helical type images are tested. Refer to Tables 2-21 through 2-25, which list the specific scan files and images used by this test.

Images are reconstructed silently and are NOT saved or displayed. The Recon Status Area on the Service Desktop provides the status of each completed image during the test. Any failure encountered will be reported to the user and errors logged.

3.8.2 Test Initialization

3.8.2.1 Check/Load Scan Data Files

The scan database must contain the Image Generation Test scan files before testing can begin. If these files are not present, the test automatically loads the scan file from the SBC's /usr/g/service/tools/added_tools/IMG_GEN directory into the scan database.

3.8.2.2 Create Test Error Log

During the execution of the diagnostic, any error messages that occur will be logged under the View Failure Logs RECENT button. Errors logged under RECENT are written to the failure.log file in the SBC directory: /usr/g/service/tools/added_tools/Image_Gen_Test. The next time the diagnostic is executed, the contents of the failure.log file will be appended to the HISTORICAL file called failure.log.bak and a new failure.log file will be created. Note if there have been no failures during previous executions or recent executions, these logs will empty.

3.8.2.3 Read Test Protocol File

The Img_Axial.rat, img_helical.rat, and image_scout.rat files are read by the Recon Data Path Test at initialization. This file contains the protocols and image checksums used by the test.

3.8.3 Test Termination

The STOP button on the test main menu halts further testing and removes the shell window. The scan files used by this test remain on the disk until overwritten by another scan file.

3.8.4 Test Coverage

The hardware and software required to create images is verified by this test. The hardware includes the Scan Data Disk, Reconstruction Image Process (RIP) board, and the Pegasus Image Generator (PEG-IG) board.

3.8.4.1 Scout

Scan Protocol:Exam 19/1/1				Scan Rx			
Series	Scan Type	Phantom	SFOV	kV	mA	Time(sec.)	Range
1	scout	any	-	120	80		1500mm

Table 2-21 img_scout.rat Test File

3.8.4.2 Axial

Scan Protocol:Exam 19/5/1				Scan Rx			
Series	Scan Type	Phantom	SFOV	kV	mA	Time(sec.)	Range
5	axial	QA high res	small	140	200	1.0	4x5mm

Table 2-22 img_axial.rat Test File

Recon Protocol:

Series	Algorithms	DFOV	Targeting	IBO	Peristalic	Axial sigmaB	Series/Image
5	Soft	20	Center	Off	Off	4i	105/1-4
5	Detail	9.6	L	Off	Off	4i	105/5-8

Table 2-23 img_axial.rat Test File

3.8.4.3 Helical

Scan Protocol: Exam 19/7/1				Scan Rx						
Series	Scan Type	Phantom	SFOV	kV	mA	Time(s)	Range	Mode	Image Thichness	mm/ Rotation
7	Helical	QA High Res	small	140	140	0.8	4x3.75mm	Hispeed	7.5mm	22.5

Table 2-24 img_helical.rat Test File

Recon Protocol:

Series	Algorithms	DFOV	Targeting	IBO	Peristalic	Axial sigmaB	Heical Start	Helical Increment	Series/ Image
7	Bone	20	Center	Off	Off	2.0x	1	50% overlap	107/6-8
7	Detail	10	Center	Off	Off	1.33x	0.5	contigous	107/9-11
7	Detail	25	A/L 80%	Off	Off	1.33x	1	50% overlap	107/17-21

Table 2-25 img_helical.rat Test File

3.8.5 IG Test Usage

Touch the RECON DATA PATH button to bring up the Graphical User Interface, (GUI). The following GUI is displayed:

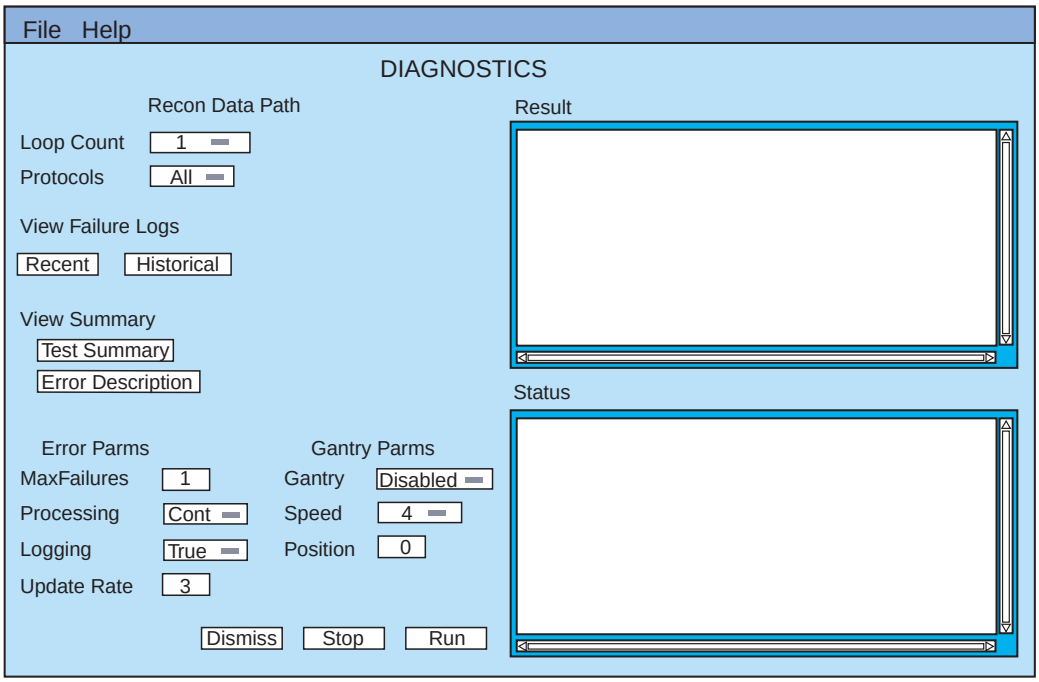


Figure 2-115 Recon Data GUI

MENU OPTIONS - "A DESCRIPTION"

RUN - Pressing RUN invokes the reconstruction of images with user selectable parameters.

LOOP COUNT - Pressing LOOP COUNT displays a pull-down menu from which you can choose a loop count of 1, 5, or continuous. This determines how many iterations of the test will be performed.

PROTOCOL - Pressing PROTOCOL displays a pull-down menu from which you can choose All, Axial, Helical, or Scout. This parameter determines which protocol to use, and consequently which images to reconstruct. Selecting All will reconstruct images using all available protocols.

ERROR DESCRIPTIONS - Upon the completion of a set of reconstructions Recon Data Path displays a summary of successes and failures (both checksum discrepancies and other reconstruction failures). More detailed information on the failures can be obtained by pressing the ERROR DESCRIPTIONS button. For additional information refer to section 3.8.6, below.

TEST SUMMARY - A summary of the most recently run tests will be displayed in the results window by pressing the TEST SUMMARY button.

Image Checksum Errors:	0
SDC Prep Checksum Errors	0
SDC Post Checksum Errors	0
Total Successes:	24
Total Failures	0

Press "Error Description" Button for more information

VIEW LOGS - Recon Data Path logs information on reconstruction failures. The results of the most recent test can be viewed by pressing the RECENT button under the VIEW LOGS heading. The historical results can be viewed by pressing the HISTORICAL button.

STOP - A test can be aborted by pressing the STOP button.

DISMISS - Pressing the DISMISS (terminate tool) button terminates the GUI.

RECON DATA PATH - This option executes the Image Generation Test after the number of passes are entered. A valid entry for the number of passes is from 1 to 9999. The default value is 1. Each pass takes approximately 1 minute to complete.

Note: Before executing the test, the Recon Status Box located at the top of the screen should display an "Idle" state. This state indicates the Image Reconstruction Process is ready to create images. Other possible states are "Active" and "Shutdown". An "Active" state indicates the reconstruction process is busy creating images. You should wait for these images to complete before continuing. If a "Shutdown" state is indicated, the Image Reconstruction Process has been halted, usually due to an error condition. Restart the process by selecting RECON MANAGEMENT and "RESTART RECON" before beginning the test.

3.8.6 Error Messages and Error Descriptions

After completing a test, pressing the TEST SUMMARY button or the RECENT button, will display a summary of the most recently run tests in the results window. If errors were encountered, the system message log and the RECENT error log should be examined after the test completes. To help determine the faulty FRU, select ERROR DESCRIPTIONS. A window will be displayed at the same time as the summary information, allowing the user to simultaneously view which errors were detected and what they imply. This is shown in the message below.

IMAGE CHECKSUM ERROR

Possible Causes: Bad IG Board

SDC PREP CHECKSUM ERROR

Possible Causes: Bad SDC Board

SDC POST CHECKSUM ERROR

Possible Causes: Bad SDC Board

FAILED TO ENQUEUE

See message log for more information

TIMEOUT WAITING FOR RECON RESPONSE

Possible Causes:

Queue Paused. Verify that queue is active.

Bad RIP board

See message log for more information

RECON REPLY ERROR

Possible Causes: Bad RIP Board

See message log for more information

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www.gehealthcare.com

GE Healthcare

LightSpeed 2.X

Service Manual - General

OPERATING DOCUMENTATION

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Book2 of 6:

- Chapter 3 (OS/Apps/SW Features)
- Chapter 4 (Camera)

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Effectivity

The information in this manual applies to the following GE Healthcare LightSpeed 2.X CT Scanners:

- LightSpeed Plus (SDAS)
- LightSpeed QX/i (SDAS)

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Chapter 3
Operating System & Application SW/Features

Section 1.0
Overview

1.1 LightSpeed Plus Host Architecture

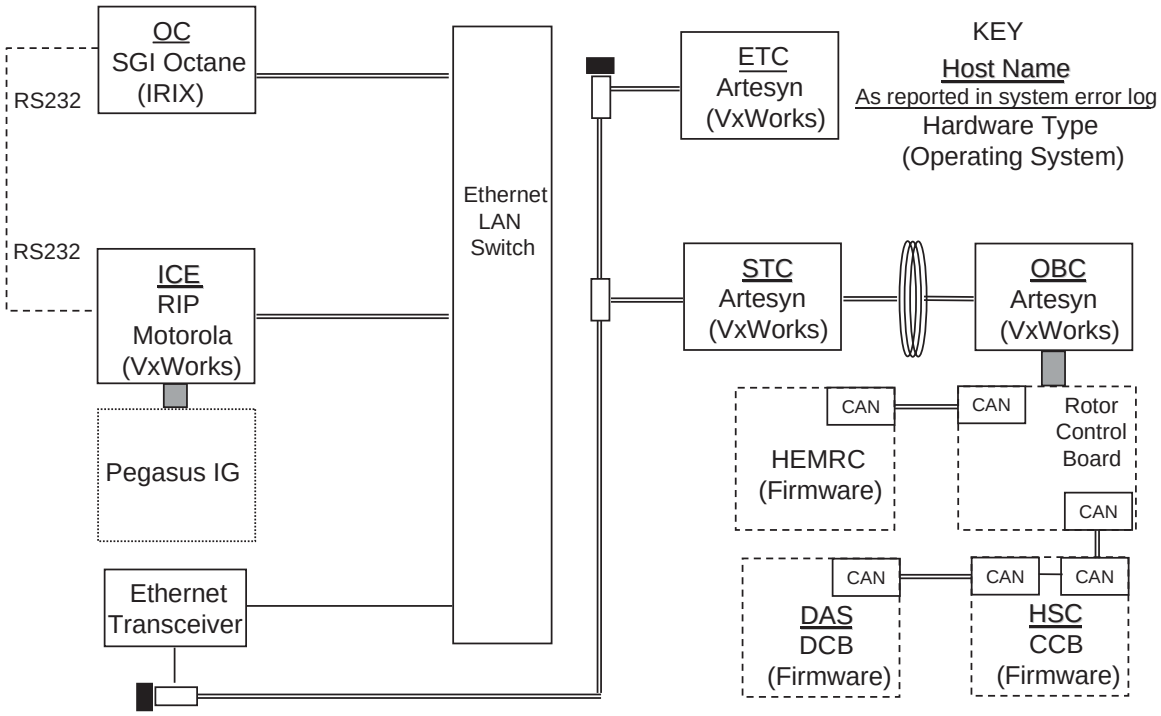

Figure 3-1 Plus Host Architecture

Figure 3-1 shows the Plus system's computers and communications paths used to control system operation. The serial, LAN, CAN, VME bus, and slip-ring communication paths shown are also used to distribute and bring up software during the boot-up process. Figure 3-1 also shows that several different software operating systems are used by the variety of computers in the system.

1.2 Host Operational States

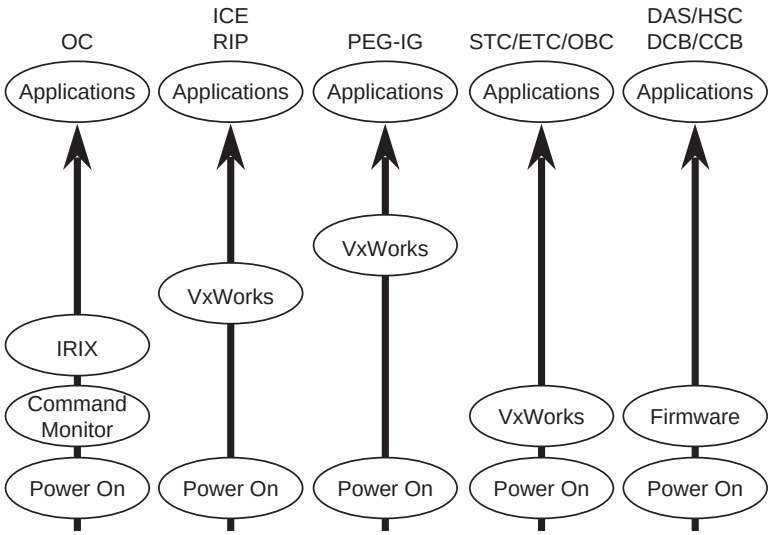

Figure 3-2 Hosts Operational states

Figure 3-2 shows that as the system is brought up from a power-off state, the computer's transition through several levels of operation to load their specific operating system and CT application software.

The specific levels of operation are commonly referred to as the Command Monitor, IRIX, and Applications levels from the perspective of the OC computer. Each level of operation provides different service capabilities. For service purposes, it is necessary to operate the system at each level. Procedures for changing the system level of operation as well as the service capabilities at each level are described in this chapter.

1.3 Auto Boot-up Sequence

Table 3-1 describes the software distribution and boot-up process from power-up to applications.

OC	ICE	PEGASUS IG	STC/ETC/OBC	DCB/CCB
1. Power up diagnostics	1. Power up diagnostics	1. Power up	1. Power up diagnostics	1. Power up diagnostics
2. Boot IRIX from OC disk	2. Wait for serial input activity	2. Wait for ICE boot-up	2. Attach ROM resident VxWorks. Wait for input on LAN	2. Wait for input on CAN Bus
3. Start CT Applications software	3. Load VxWorks and applications software via the LAN			
	4. Find and initialize the Pegasus IG Board.	3. Boot VxWorks off of ICE		
4. Start up Artesyn controllers via the Table/ Gantry LAN		4. Apps load through the ICE	3. Applications firmware downloaded and started	3. OBC initializes via CAN bus
Applications start-up complete				

Table 3-1 Auto Boot-up Sequence

1.4 Operating System Overview

1.4.1 Processes

UNIX allows many users with many different programs to share the CPU and memory. This is done by time-sharing all the resources. Every task done is a PROCESS, and every time any user starts a new task, the system starts a PROCESS and gives it a unique process ID that will identify the program. Some processes are started on power-up and run all the time. One process might start another process, which then becomes the CHILD process. The process that started the child is the PARENT process. When a program has finished its task, it must shutdown all the processes. Child processes and parent processes must be TERMINATED. This will free up all the memory and close all the files that were used by the process.

1.4.1.1 Kernel

UNIX is always running several programs in the background. The most important one, the KERNEL, is the heart of the operating system itself. It is loaded into memory on startup, and will stay in real memory all the time UNIX is running. The kernel is the “minimum system” that is needed to run any operating system. It assigns memory for each program that is running and allocates the time for each program to use the CPU, often refereed to as a “time slot”.

Any program or process will have the CPU for the maximum time of 1 second. If the process has not finished all its tasks, the kernel will swap the process out of memory and give the next process access to the CPU. If the active process needs data that is not directly accessible from real memory, then it will go to a WAITING state, which will signal the kernel to start another process that is ready to run. If the program itself determines it has nothing to do—that is, if it waits for another process to finish or give it some more data to work on—it will “go to sleep”. Each process and the state of each one can be listed with the `ps` command.

The kernel will also handle all input and output requests (I/O) to disc drives, printers, network and terminals. The kernel will also use parts of the disc as VIRTUAL memory. This is called the SWAP partition. When a process requests data from memory, the kernel determines if the address is REAL or VIRTUAL. In the latter case, it then needs to copy the data from disc to real memory before letting the process continue. The kernel is “custom built” for the hardware that makes up the computer. Before turning off power to the system, UNIX will have to move all the data for all the processes to disc drive and stop all active processes. This is done with the shutdown command.

Most “panic” messages on the terminal are from the kernel. If it gets a request to do something that it cannot handle, then the kernel will often just halt the system by stopping the CPU. A “kernel abort” message could be caused by faulty hardware or a bad program. The next time the system boots, UNIX will recognize something went wrong and if the power has not been turned off, the “bad program” will still be in memory and the system will try to copy all the data in memory and the register data to a file on the disc drive. This is the CORE file dump, and you can get a file that will take up 100 Mb or more.

1.4.1.2 Daemons

Many small programs are needed to handle utilities such as mail, printing, keeping track of the time and networking to other systems. These are commonly known as the DAEMONS. Each one can be started by the kernel, and wake up to do its task on demand. When it is finished, it will go to sleep and wait until it is needed again. Most daemons are well behaved watch dogs and will do their job without ever complaining. If they fail, then we get aborts and core files, which are quite similar to the kernel aborts. In either case, UNIX will try to inform you about what happened by sending a message to the boot terminal and enter some text in the system error log.

1.4.1.3 Processes

When the system is up and running there are many processes. Using the UNIX command **`ps -ef`**, a list of currently active processes can be displayed to the screen. If the system is running CT applications, many more active processes will be displayed. For additional information on using **`ps`**, see the UNIX **`man`** pages command (Section 6.12, on page 215). An example of the **`ps -ef`** command follows:

```
{ctuser@msecrp1}[12] ps -ef
UID      PID  PPID  C    STIME TTY      TIME COMD
root       0     0  0 08:38:01 ?        0:02 sched
root       1     0  0 08:38:01 ?        0:00 /etc/init
root       2     0  0 08:38:01 ?        0:00 vhand
root      76     1  0 08:38:29 ?        0:00 /usr/etc/syslogd
root     385     1  0 08:38:42 ?        0:00 /usr/bin/X11/xdm
ctuser   803     1  0 08:39:56 ?        0:01 /usr/g/bin/cupMonitor
ctuser   816   803  0 08:40:01 ?        0:00 awStart
ctuser   818   803  0 08:40:01 ?        0:02 examRxEnv dual
ctuser   917     1  0 08:40:30 ?        0:00 imserver
ctuser   919   917  0 08:40:30 ?        0:00 imserver
ctuser   960   803  0 08:40:46 ?        0:08 examRxDisplay dual
ctuser   987   803  0 08:41:42 ?        0:00 stcIf /dev/ttya5
ctuser   988   987  0 08:41:43 ?        0:00 stcIf /dev/ttya5
{ctuser@msecrp1}[13]
```

The first column (`UID`) lists the owner, or who started the process. The `PID` is the process identification number and will increment every time a new process is started. If any process is started by a “parent” process, then the `PPID` is the `PID` of that parent. This is used to control sub processes. If the parent is finished and wants to shut down, it must first take control of all “child” processes and shut each one down before the parent process can stop. The start time for each process and how long it has been running is listed in `STIME` and `TIME`. The name of each process is listed in the last column. This will often give you a good idea of what each one is doing.

From the listing above, the first process is “sched”. This is the scheduler, which manages the time sharing of the CPU. This is started by root and gets process `id 0`. This process is started automatically on power-up. The sched will start `/etc/init`, which starts `/usr/etc/syslogd`. This is the error logging routine. The syslogd is a daemon process that logs any errors. The “`init`” process will also start `/usr/g/bin/cupMonitor`, which is the CT application startup. We have four desktop applications running at the same time, and each of these is an X-Windows application. On the list above are 2 of the applications: `awStart` and `examRxDisplay`.

To terminate any process, we have the **`kill`** command, which is used together with the process id or the process name. The kill has some options or flags. For example, option **`-15`** will instruct the **`kill`** command to find all the child processes first and terminate each one before the parent. Only the owner of the process should terminate it. The root user can terminate any process.

When you think of how we organize directories as trees you can now see the same structure in process control. Every directory has a parent directory with one exception, the root directory. Every process has a parent process, with the exception of the scheduler. Any directory might have child directories, and any process might have child processes. Just as the root user can access any file, the root user can also control any process.

1.4.2 Environmental Paths

With so many executable commands, programming tools and utilities available, we need some common organization of the most used files. All these tools are located in different sub-directories to make it easier to upgrade or change individual components. When you type the name of a command, the shell first checks to see if it is a built-in command and if it is, then executes it. If the command name is an absolute pathname, such as `/usr/bin`, then the command is executed. If the command is neither built-in nor specified with an absolute pathname, then the shell looks in its search path for an executable program or script with the given name. The PATH string specifies which directories the shell should look in first to find the executable file for any command you have given the shell. The search path is not built into the shell. You specify this in your shell setup file. For the c-shell this is the `.cshrc` file in the user home directory. Many variables are specified in the `.cshrc`; the path is just one of them. The following is an example of a short cut to show the `.cshrc` file.

```
{ctuser@msecrp1}[2] more .cshrc
#!/bin/csh -e
umask 0
set window_choice=4Dwm
setenv GDIR /usr/g
setenv BINDIR   $GDIR/bin
set std_path = (/usr/g  /usr/g/bin  /usr/g/scripts  /sbin  /usr/sbin  /
bin  /usr/local  /usr/ucb /usr/bin  /usr/etc  /etc  /usr/bsd  /usr/atria/
bin   ~ .)
alias cp        '/bin/cp -i'
alias mv        '/bin/mv -i'
alias rm        '/bin/rm -i'
set autologout=0
set history=100

set prompt='{'$USER@`/usr/bsd/hostname`'}''[\!] '
```

We can examine some of the variables that are defined here to better understand what is available on the system. The first line "`#!/bin/csh -e`" specifies this is a c -shell. The command syntax is quite similar to the c programming language and allows scripts with if statements and so on. The line "`set std_path`" specifies which directories and in which order the shell should go through each one when it looks for any external commands. The lines that start with "`alias`" specify what options to use for each command. Any time you type `rm` on the command line, the shell will substitute with the `rm -i` (the `-i` is for interactive mode), and the system will then ask you to verify that you really want to remove the file on the command line. The intention of aliases are to make the system more user friendly. The line "`set history=100`" will tell the shell to remember the last 100 command lines you have typed. This is very helpful when you want to retype any command you have used recently. We repeat a command with the "`bang`" command (more about this later). The last line "`set prompt=`" specifies what the command line prompt should be.

Section 2.0
Boot Prom, Boot-up, and Devices

2.1 Boot Environment

2.1.1 Command Monitor

The Command (PROM) Monitor program controls the boot environment for all Silicon Graphics workstations. With the Command Monitor, you can boot and operate the CPU under controlled conditions, run the CPU in Command Monitor mode, and load programs like the operating system kernel or special debugging and execution versions of the kernel.

PROM stands for Programmable Read-Only Memory. Most PROM chips are programmed at the factory with software that 1) allows the CPU to boot, and 2) allows you to perform system administration and software installations. The PROMs are not part of your disk or operating system; they are the lowest level of access available for your system. You cannot erase or bypass them.

2.1.2 Entering the Command (PROM) Monitor

2.1.2.1 Summarized

Shutdown then restart the system, or if the system is already off, turn it on. By default, the PROM attempts to boot the OS when the system is powered on or reset. To prevent the boot-up and get to the command prompt monitor, press **ESC** or click the STOP FOR MAINTENANCE button. Select item 5 on the following menu:

```
System Maintenance Menu
1    Start System
2    Install System Software
3    Run Diagnostics
4    Recover System
5    Enter Command Monitor
6    Select Keyboard Layout
>
```

2.1.2.2 Procedure - Entering Command Monitor

The procedure for entering Command Monitor follows:

1.) Restart the system: If the host computer is OFF, turn it ON and proceed to Step 2. If the host computer is ON, bring it down appropriately. After a few seconds, the screen will clear and you will see a notification like the one shown in Figure 3-3. Select the RESTART button.

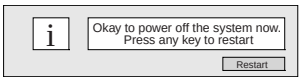

Figure 3-3 Okay to Power Off System - Notification Screen

Note: If the system is malfunctioning and a user cannot communicate with it using the mouse or keyboard, then press the reset switch on the front chassis.

2.) **Immediately** click on STOP FOR MAINTENACE or press the **ESC** key. You only have three to five seconds to perform this action (refer to Figure 3-4).

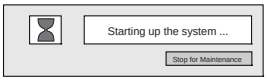

Figure 3-4 Maintenance Option Menu

3.) The following Host Maintenance menu appears. Select item 5 in the following menu.

```
System Maintenance Menu
1    Start System
2    Install System Software
3    Run Diagnostics
4    Recover System
5    Enter Command Monitor
6    Select Keyboard Layout
```

2.1.3 Command Monitor Summary

The following commands are available at the boot PROM level.

COMMAND	WHAT IT DOES	SYNTAX
auto	Boots default operating system (no arguments). This has the same effect as choosing Start System from the PROM Monitor initial menu.	**auto**
boot	Boots the named file with the given arguments.	**boot** ***[-f][-n] pathname***
date	Displays or sets the date and time.	**date** ***[mmddhhmm[ccyy|yy][.ss]]***
printenv eaddr	Prints the Ethernet address of the built-in Ethernet controller.	**printenv eaddr**
exit	Leaves Command Monitor and returns to the PROM menu.	**exit**
help	Prints a Command Monitor command summary.	**help** ***[command] ? [command]***
hinv	Prints an inventory of known hardware on the system. Some optional boards may not be known to the PROM monitor.	**hinv**
init	Partially restarts the Command Monitor, noting changed environment variables.	**init**
ls	Lists files on a specified device.	**ls*devicename***
printenv	Displays the current environment variables.	**printenv** ***[env_var_list]***
resetenv	Resets all environment variables to default.	**resetenv**
resetpw	Resets the PROM password to null (no password required).	**resetpw**
setenv	Sets environment variables. Using the -p flag makes the variable setting persistent, that is, the setting remains through reboot cycles.	**setenv** ***[-p] variable value***
single	Boots the system into single-user mode.	**single**
unsetenv	Un-sets an environment variable.	**unsetenv variable**
version	Displays Command Monitor version.	**version**

Table 3-2 Command Monitor (Command Summary)

2.1.4 Boot-Up Environment Variables

Variables are used to tell the Host how to boot-up. These “environmental” variables are stored on the Host Computer (Octane), within PROM. Use the **printenv** command to list the current state of these variables.

The following is a typical example of these variables and their associated values. Although comments are provided (in italics), use the UNIX command **man prom** for additional information. Compare your default settings to those listed below.

```
> printenv

AutoLoad=Yes
```

Controls if the system boots automatically on reset/power cycle

```
console=g
```

The console variable “g” indicates it is connected to a graphics display

```
diskless=0
```

Sets the system to boot from disk

```
nogfxkbd=1
dbaud=9600
```

This is the diagnostic baud rate. It can be used to specify a baud rate other than the default when a terminal connected to serial port #1 is to be used as the console

```
volume=0
```

Sets the speaker volume during boot up

```
sgilogo=y
```

Set to y, the SGI logo shown during boot-up

```
autopower=y
```

The y setting allows the system to automatically power back on after an AC power failure

```
netaddr=192.9.220.10
```

The OC's assigned internet address. Used when booting or installing software from a remote system by Ethernet

```
eadder=08:00:69:0a:27:b6
```

The ethernet address of the built-in Ethernet controller. Set at factory, cannot be changed

```
boottune=1
```

Setting of 1 is default tune. Not supported in Octane even though it is listed

```
ConsoleOut=video( )
```

Set at system startup automatically from the console variable.

```
ConsoleIn=keyboard( )
```

Set at system startup automatically from the console variable

```
cpufreq=195 (or 225)
```

processor frequency

```
SystemPartition=xio(0)pci(15)scsi(0)disk(1)rdisk(0)partition(8)
```

The device where the operating system loader is found

`OSLoadPartition=xio(0)pci(15)scsi(0)disk(1)rdisk(0)partition(0)`

The device partition where the core IRIX operating system is found

`OSLoadFilename=/unix`

This is the filename of the operating system kernel

`OSLoader=sash`

This is the operating system loader, which is sash for IRIX

`gfx=alive`

Enables graphics on the console

2.1.5 Keyboard Languages

If a new keyboard is not set to the site's language, press STOP FOR MAINTENANCE while the SGI host is booting to get its System Maintenance Menu. Then select the last item on this menu to get the *Keyboard Layout* choices. Select the desired language, like US for USA English.

KEYBOARD LAYOUT CHOICE	LANGUAGE	SUPPORTED BY CT
BE	Belgian	
DE	German	X
de_CH	Swiss German	
DK	Danish	
ES	Spanish	
FI	Finnish	
FR	French	X
fr_CH	Swiss French	
GB	Great Britain	
IT	Italian	
NO	Norwegian	
PT	Portuguese	
SE	Swedish	
US	United States	X

Table 3-3 Keyboard Choices (Language)

2.1.6 chkconfig on the OC Octane

There are a number of operating system configuration parameters (flags) that are set automatically during the CT application load on the OC Octane. Under normal conditions, you should never have to manually change the state of these flags. In the unlikely event of a software corruption, as a part of troubleshooting, one can view the state of each of the flags to verify they are set correctly by running **`chkconfig`**. Also, if one of the states is found wrong, **`chkconfig`** can be used to set it back to the correct state.

Table 3-4 shows a list of the flags and the states that they should be in after the application load for the OC Octane. Enter the following to list the flags and their current states:

1.) Verify that Applications is shut down.

2.) Open a UNIX shell from the Toolchest.

3.) **`su -`** ENTER.

4.) **`chkconfig`** ENTER.

FLAG	STATE	FLAG	STATE
autoconfig_ipaddress	off	proclaim_relayagent	off
autofs	off	proclaim_server	off
automount	on	rarpd	off
change_sts	off	routed	off
desktop	on	rsvpd	off
fcagent	on	rtmond	on
fontserver	off	rwhod	off
gated	on	sar	off
impact_trace	on	savecore	on
ipaliases	on	sendmail	on
lockd	on	snetd	on
lp	on	soundscheme	off
mediad	off	timed	off
miser	off	timeslave	off
mrouted	off	verbose	off
named	off	videod	off
nds	off	visuallogin	off
network	on	vswap	off
nfs	on	windowsystem	on
noiconlogin	off	xdm	on
nostickytmp	off	yp	off*
nsd	on	ypmaster	off
pmcd	off	ypserv	off
privileges	on		

*This parameter may be on if site is running NIS (yellow pages)

Table 3-4 OC Octane: States and Flags

⚠ **NOTICE**
Potential for Data Loss

Setting these flags to a wrong state can prevent the system from coming up properly. Use caution.

To manually change the state of a flag (only if it is improperly set), enter the following:

1.) **`chkconfig <flag> <state>`** ENTER (where state is on or off).
2.) **`reboot`** ENTER.

After the reboot, the flag(s) will be re-read and the change(s) made will take effect. For further details on each of the flags, look at the man page for **`chkconfig`**.

1.) **`su -`** ENTER
2.) **`man chkconfig`** ENTER

2.2 Boot-Up Sequence

2.2.1 Description of the Boot-Up Sequence

When the system is first powered on, the PROM runs a series of tests on the core components of the system. It then performs certain hardware initialization functions such as starting up SCSI hard disks, initializing graphics hardware, and clearing memory. Upon successful completion of these tasks, the PROM indirectly starts the operating system by invoking a bootstrap loader program called "sash", which in turn reads the IRIX kernel from disk and transfers control to it.

2.2.2 OC (Host) - SYSLOG and Boot-up

The host computer records startup, errors and shutdown information.It recorded in a text file called SYSLOG that's located in the directory /var/adm. The file SYSLOG is the most recent log. The SYSLOG files with the extension 0 through 7 are from the last eight days. In this example we have nothing for logs 4 through 7, because a software load was previously done on the 21st of the month.

Example: Listing available **SYSLOG** files

```
{ctuser@msecrp2}[4] cd /var/adm
{ctuser@msecrp2}[5] pwd
/var/adm
{ctuser@msecrp2}[6] ls -al SYSLO*
-rw-r--r--    1 root     sys         8405 Feb 25 11:18 SYSLOG
-rw-r--r--    1 root     sys          129 Feb 24 03:00 SYSLOG.0
-rw-r--r--    1 root     sys           44 Feb 23 00:00 SYSLOG.1
-rw-r--r--    1 root     sys         5596 Feb 22 12:52 SYSLOG.2
-rw-r--r--    1 root     sys         5761 Feb 21 19:18 SYSLOG.3
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.4
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.5
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.6
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.7
{ctuser@msecrp2}[6]
```

The following example shows is a typical Host (Octane) boot-up sequence. Comments have been added for clarification.

Example: Listing current **SYSLOG** file

```
{ctuser@msecrp2}[7] more SYSLOG
Jul 6 14:57 :ct unix: syslogd: restart
```

Comment: Beginning start-up of Kernel

```
Jul 6 14:57 :ct unix: IRIX Rel. 6.5 IP30 Version 05190004 System V-64 Bit
Jul 6 14:57 :ct unix: Copyright 1987-1998 Silicon Graphics, Inc.
Jul 6 14:57 :ct unix: All Rights Reserved.
Jul 6 14:57 :ct unix:
Jul 6 14:57 :ct unix:
```

Comment: Initialize PCI Serial Card

```
Jul 6 14:57 :ct unix: Digi International STS R1.10
Jul 6 14:57 :ct unix: Digi ClassicBoard PCI driver 1.1.0 configured
Jul 6 14:57 :ct unix: 0: Digi ClassicBoard 4 PCI in PCI slot 2
Jul 6 14:57 :ct unix:
```

Comment: Begin Mounting Filesystems

```
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /
Jul 6 14:57 :ct unix: NOTICE:Starting XFS recovery on filesystem:
/(dev: 0/258)
Jul 6 14:57 :ct unix: NOTICE: Ending XFS recovery for filesystem:
/(/hw/node/xtalk/15/pci/0/scsi_ctlr/0/target/1/lun/0/disk/partition/0/block)
Jul 6 14:57 :ct unix:  NOTICE: Start mounting filesystem: /usr
```

```
Jul 6 14:57 :ct unix:  NOTICE: Starting XFS recovery on filesystem:/usr
(dev: 0/208)
Jul 6 14:57 :ct unix:  NOTICE: Ending XFS recovery for filesystem: /usr
(/hw/node/xtalk/15/pci/0/scsi_ctlr/0/target/1/lun/0/disk/partition/6/block)
Jul 6 14:57 :ct unix: NOTICE:
Jul 6 14:57 :ct unix: NOTICE: Ending clean XFS mount for filesystem: /usr/g
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /usr2
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /data
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /usr/g
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:/usr2
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:/data
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:/usr/g
```

Comment: May have more image pools when or if the image space is increased.

```
Jul 6 14:57 :ct unix:NOTICE: Start mounting filesystem:
/usr/g/sdc_image_pool
/usr/g/sdc_image_pool
/usr/g/sdc_image_pool2
/usr/g/sdc_image_pool3
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:
 /usr/g/sdc_image_pool
```

Comment: Start Gateway routing daemon

```
Jul 6 14:57 5D:ct10_oc gated[209]: Start gated version 1.9.1.3
Jul 6 14:57 5D:ct10_oc gated[209]: if_init: Acting as RIP supplier to our
direct nets
Jul  6 14:57:42 5B:ct10_oc sendmail: starting
Jul  6 14:57:47 5E:ct10_oc su[704]: succeeded: console changing from root
to root
Jul  6 14:57:47 5E:ct10_oc su[704]: succeeded: console changing from root
to root
Jul  6 14:57:47 6C:ct10_oc sendmail[785]: starting daemon
(950413.SGI.8.6.12): SMTP+queueing@00:15:00
```

Comment: False Error Message: Ignore output that follows.

```
Jul  6 14:57:49 3B:ct10_oc rld[830]:  830:/usr/etc/checkmidi: rld: Fatal
Error: Cannot Successfully Map soname 'libmd.so' under any of the
filenames /usr/lib32/libmd.so:/usr/lib32/internal/libmd.so:/lib32/
libmd.so:/opt/lib32/libmd.so:/usr/lib32/libmd.so.
1:/usr/lib32/internal/libmd.so.1:/lib32/libmd.so.1:/opt/lib32/
libmd.so.1:
Jul  6 14:57:49 6D:ct10_oc dmb[827]: started
Jul  6 14:57:49 3B:ct10_oc rld[832]:  832:/usr/etc/setmididefault: rld:
Fatal Error: Cannot Successfully Map soname 'libmd.so' under any of the
filenames /usr/lib32/libmd.so:/usr/lib32/internal/libmd.so:/lib32/
libmd.so:/opt/lib32/libmd.so:/usr/lib32/libm
d.so.1:/usr/lib32/internal/libmd.so.1:/lib32/libmd.so.1:/opt/lib32/
libmd.so.1:
```

Comment: End of False Errors

```
Jul  6 14:57:49 3B:ct10_oc rld[834]: 834:/usr/etc/setmididefault: rld:
Fatal Error: Cannot Successfully Map soname 'libmd.so' under any of the
filenames /usr/lib32/libmd.so:/usr/lib32/internal/libmd.so:/lib32/
libmd.so:/opt/lib32/libmd.so:/usr/lib32/libm
d.so.1:/usr/lib32/internal/libmd.so.1:/lib32/libmd.so.1:/opt/lib32/
libmd.so.1:
```

Comment: Timeout and reset normal

```
Jul  6 14:58:12 :ct unix: ql1d4: SCSI command timeout:2 commands:0x8 0x12
Jul  6 14:58:12 :ct unix: ql1: Resetting SCSI bus.
```

Comment: Central Data Box alive

```
Jul  6 14:58:12 :ct unix: NOTICE: STS: recvcomp: stat=0x5,scsistat=0x0
Jul  6 14:58:12 :ct unix:
Jul  6 14:58:16 :ct Xsession: ctuser: login
```

Comment: Begin False Error Message

```
Jul  6 14:58:18 :ct Xsession: ctuser: UX:sh (Xsession.dt): ERROR: /usr/g/
ctuser/.desktop-ct10_oc/configchecks/autoconvert: Cannot create
Jul  6 14:58:18 :ct Xsession: ctuser: UX:sh (Xsession.dt): ERROR: /usr/g/
ctuser/.desktop-ct10_oc/configchecks/cleanupSearchbook: Cannot create
Jul  6 14:58:18 :ct Xsession: ctuser: UX:sh (Xsession.dt): ERROR: /usr/g/
ctuser/.desktop-ct10_oc/configchecks/pluginVersions: Cannot create
```

Comment: End False Error Message

```
----------
```

2.2.3 VME Chassis Boot-Up - iceConsole.log

When the VME chassis boots up, the Motorola powerPC (RIP) logs bootup and application startup communications. The output is logged to `/usr/g/service/log/iceConsole.log` file. There are two methods for viewing this log. One method is using the service desktop, another is using a Unix shell and typing commands.

The following shows a typical sequence of communications that occur of these boards, taken from the iceConsole.log file along with a brief description/interpretation of the output. At a prompt, enter the following:

Example: iceConsole.log

```
{ctuser@bayxx}[1]: cd  /usr/g/service/log
{ctuser@bayxx}[2]: more iceConsole.log
```

Comment: Begin Apps startup

```
Logfile updated Thu Mar 22 10:50:04 2001
```

"Proc_Ice" records the beginning of applications process startup in the "iceConsole log, as above.

Comment: Reset VME Chassis

```
[VxWorks Boot]: b
```

Upon executing the “b” command from boot PROM, a VME reset takes place.

Comment: VME reset successful

```
Copyright Motorola Inc. 1988 - 1999, All Rights Reserved
```

First header printed after a successful VME reset.

Comment: List Version &date

```
PPC1 Debugger/Diagnostics Release Version 4.5 - 09/24/99 RM01
```

Version and dates vary with release.

```
COLD Start
```

Comment: List Clock Speeds

```
Local Memory Found =08000000 (&134217728)
MPU Clock Speed =333Mhz
BUS Clock Speed =67Mhz
```

MPU speed can vary

```
Reset Vector Location  : ROM Bank B
Mezzanine Configuration: Single-MPU
Current 60X-Bus Master : MPU0
Idle MPU(s)            : NONE

L2Cache:       NONE
```

Comment: Check Memory

```
Initializing System Memory (DRAM)...          System Memory: 128MB, ECC Enabled
(ECC-Memory Detected)
```

128MB of system memory must be recognized for applications to startup.

```
PPC1-Bug>rb ;v
```

Comment: Begin Transfer of Control

Boot ROM command prompt.

```
ROMBoot about to Begin... Press <ESC> to Bypass, <SPC> to Continue

Direct Adr: FF000000 FF000000: Searching for ROMboot Module at:  FF000000
Executing ROMboot Module "VxWorks Boot ROM" at FF000000
```

Comment: Check that firmware is good

Good Firmware found, transfer control to VxWorks Boot ROM now.

```
                                VxWorks System Boot

Copyright 1984-1998  Wind River Systems, Inc.
CPU: Motorola MVME2300 - MPC 604e
Version: 5.4
BSP version: 1.2/0
Creation date: Mar 20 2001, 21:12:23
```

Comment: VxWorks started

Comment: Screen Output

Creation Date above can vary

```
[VxWorks Boot]:

[VxWorks Boot]: $dc(0,0)oc:/usr/g/ice/bin/vxWorks.mv2300 e=192.9.220.11
b=192.9.220.12:ffffffff h=192.9.220.1 u=target tn=ice s=/usr/g/ice/bin/init.sh
```

Comment: VxWorks Boot String Executed

```
boot device          : dc
unit number          : 0
processor number     : 0
host name            : oc
file name            : /usr/g/ice/bin/vxWorks.mv2300
```

Comment: Begin Parsed Boot string ouput

File /usr/g/ice/bin/vxWorks.mv2300 is located on the host computer

```
inet on ethernet (e) : 192.9.220.11
inet on backplane (b): 192.9.220.12:ffffffff
host inet (h)        : 192.9.220.1
user (u)             : target
flags (f)            : 0x0
target name (tn)     : ice
startup script (s)   : /usr/g/ice/bin/init.sh
```

Comment: Kernel location specified

Comment: End parsed output

```
Attached TCP/IP interface to dc0.
Attaching network interface lo0... done.
Loading... 1418644
Starting at 0x100000...
```

Comment: Begin Kernel download

Comment: End Kernel download

The number of bytes loaded can vary. A loading of Zero (0) bytes indicates a possible problem.

```
Auto-configuring SCSI bus...

ID LUN VendorID    ProductID      Rev. Type  Blocks  BlkSize pScsiPhysDev
-- --- --------- ---------------- ---- ---- -------- ------- ------------
 1  0  SEAGATE  ST318404LW       0006   0  35843670    512    0x017dda88
```

Comment: Configure & report SCSI Devices

Comment: Setup NFS connection on Host Computer

```
Attached TCP/IP interface to dc unit 0
Attaching interface lo0...done
Initializing backplane net with anchor at 0x4100... done.
Backplane anchor at 0x4100... Attaching network interface sm0... done.
Creating proxy network: 192.9.220.12
Mounting NFS file systems from host oc for target ice:
```

Comment: Mount /usr/g directory

```
/usr/g
...done
```

A good /usr/g directory NFS mount is important.

Comment: Load Symbol Table

```
Loading symbol table from oc:/usr/g/ice/bin/vxWorks.mv2300.sym ...done
```

Using a rsh, load the symbol table located on the host.

Comment: Begin output from VxWorks Kernel Boot

```
 ]]]
```

Comment: Setting Memory Options

```
#
# Don't suspend any proxy if memPartFree() invalid block
#
# 0x01 -- MEM__ALLOC_ERROR_LOG_MSG
# 0x04 -- MEM_BLOCK_ERROR_LOG_MSG
# 0x10 -- MEM_BLOCK_CHECK
memOptionsSet (0x01 | 0x10 | 0x04);
```

Comment: value = 0 (good)

```
value = 0 = 0x0

#
# Dynamically load all modules before starting code.
#

#
```

Comment: Load Apps SW Modules

```
# load application modules
#
cd "/usr/g/ice/bin";
```

Comment: value = 0 (good)

```
value = 0 = 0x0
ld < vxMonitor_pegasus.ppc
```

Comment: value = 0 (bad)

```
value = 24347656 = 0x1738408
```

An error message here means that Application SW will not likely start.

```
#
# disable scanfile debug messages
#
```

Comment: value = 0 (good)

```
_scanfile_debug = 0;
_scanfile_debug = 0x1283010: value = 0 = 0x0

#
# Add the rest of the heap before starting code,
# but after loading modules.  DO NOT LOAD ANY MODULES AFTER THIS.
#
```

Comment: value = 0 (good)

```
memPartAddToPool (memSysPartId, sysMemTop (), sysPhysMemTop () - sysMemTop ());
value = 0 = 0x0


#
# call the static constructors
#
```

Comment: value = 0 (good)

```
cplusCtors (0);
value = 0 = 0x0
```

Comment: Begin comments(#)

```
# task option defines
# VX_FP_TASK (0x0008)
#     execute with floating-point coprocessor support.
# VX_PRIVATE_ENV (0x0080)
#    include private environment support (see envLib).
# VX_NO_STACK_FILL (0x0100)
#     do not fill the stack for use by checkStack( ).
#VX_UNBREAKABLE (0x0002)
#     do not allow breakpoint debugging.
#
```

Comment: End Comments

```
# enable round-robin time slicing between equal tasks
#
```

Comment: value = 0 (good)

```
kernelTimeSlice (1);
value = 0 = 0x0
```

Comment: Sart HW watchdog timer on Motorola Bd.

```
#
# Setup the HW watchdog timer in case CPU gets so we can't reboot normally
# Task runs every 90 seconds and sets watchdog timeout to 124 seconds
taskSpawn ("watchDog", 100, 0x0008, 20000, periodRun, 90, sysHwWatchdogSet, 124,
1, 0, 0, 0);
value = 134174256 = 0x7f0xf56307ff5630 (watchDog
): sysHwWatchdogSet[
0]: timer set to #124 seconds; reset=
1
# Initialize ermes database
#
```

Comment: value = 0 (good)

```
putenv ("LOGHOST=oc");
value = 0 = 0x0
```

Comment: value = 0 (good)

```
msgHandlerInit ();
value = 0 = 0x0

#putenv("RECONMGRDEBUG=0x00001000");

#
# set the network credentials for file access
#
```

Comment: value = 0 (good)

```
nfsAuthUnixSet ("oc", 100, 100, 0, 0);
value = 0 = 0x0
```

Comment: Begin Scan Data Disk Configuration & Mount function

```
#
# configure and mount the scan disk
#
usrScsiDiskInit (1, "/raw_data");
/raw_data/  - disk check in progress ...

WARNING : dosChkLib : system clock is being set to THU MAR 22 06:32:22 2001
Value obtained from file system referenced by volume descriptor pointer: 0x7ff9ea8
The old setting was THU JAN 01 00:00:00 1970
Accepted system dates are greater than FRI JAN 01 00:00:00 1999
/raw_data/  - Volume is OK

         total # of clusters:17,503
          # of free clusters:3,762
            # of bad clusters:0
             total free space:3,762 Mb
     max contiguous free space:  1,845,493,760 bytes
                 # of files:433
               # of folders:18
          total bytes in files:13,521 Mb
              # of lost chains:0
```

```
   total bytes in lost chains:  0

volume descriptor ptr (pVolDesc):0x7ff9ea8
cache block I/O descriptor ptr (pCbio):0x7ffb520
auto disk check on mount:DOS_CHK_ONLY | DOS_CHK_VERB_1
max # of simultaneously open files:34
file descriptors in use:0
# of different files in use:0
# of descriptors for deleted files:0
# of  obsolete descriptors:0

current volume configuration:
 - volume label:NO LABEL ; (in boot sector:)
 - volume Id: 0xee220200
 - total number of sectors:35,843,670
 - bytes per sector:512
 - # of sectors per cluster:2,048
 - # of reserved sectors:32
 - FAT entry size:FAT32
 - # of sectors per FAT copy:137
 - # of FAT table copies:2
 - # of hidden sectors:0
 - first cluster is in sector #306
 - directory structure:VFAT
 - root dir start cluster:2

FAT handler information:
------------------------
 - allocation group size:2 clusters
 - free space on volume:3,944,742,912 bytes
Disk Cache, /raw_data:
Cached Block I/O Device, handle=0x7ffb520
       Description: Disk Cache - LRU
       Disk size 17 Gbytes, RAM Size 2097152 bytes
       Block size 512, heads 0, blocks/track 0, # of blocks 35843670
       partition offset 0 blocks, type Fixed, Media changed No
Total cache Blocks 3774, 0 blocks (%0) dirty
Tunable Params:
   Bypass Threshold 2, Max Dirty 254, Read Ahead 32 blocks, Sync interval 0 sec
Hit Stats: Cookie Hits 16948 Miss 272, Hash size 2221 Hits 2495 Miss 1651
   LRU Hits 2493, Misses 127, Hit Ratio %95
Write Sstats: Foreground 0, Background 0, Hidden 0, Forced 137

Subordinate Device Start:
Cached Block I/O Device, handle=0x7ffb5a8
       Description: Block Device
       Disk size 17 Gbytes, RAM Size 0 bytes
       Block size 512, heads 0, blocks/track 0, # of blocks 35843670
       partition offset 0 blocks, type Fixed, Media changed No
Subordinate Device End:
value = 0 = 0x0
```

Comment: End configuration and mounts

A value of zero is returned by the "usrScsiDiskInit" function, if successful.

```
ttsFlag = 0
ttsFlag = 0x128330c: value = 0 = 0x0
#
# Start the applications
#
```

Comment: Start VxMonitor

```
taskSpawn ("vxmonitor", 100, 0x0008, 500000, vxmonitor);
value = 132051792 = 0x7def350THU MAR 22 10:50:5
5.000 2001
```

Value can vary by SW release. VxMonitor is started to spawns and manages task on Motorola.

```
#
# put the nettask same as dataacq

#
netTaskPriority = 52;stderr i
s redirected to fd netTaskPriority15 = 0x
241f14: value = 52 = 0x34 = '4'
taskPrioritySet(taskNameToId("tNetTask"), netTaskPriority);
value = 0 = 0x0

#
# done
#
```

Comment: End Startup Script

```
Done executing startup script /usr/g/ice/bin/init.sh
```

Comment: Applications SW startup Output

```
-> num_offset_views : 512
offset_first_view : 0
offset_reuse_window : 30.000000
rebin:successfully initialized.
daGetConfigValue: dataacq.cfg, da_timeout_delta, '0'
daGetConfigValue: dataacq.cfg, da_dip_mem_and_save_size, '2048'
daGetConfigValue: dataacq.cfg, da_debug, '0x00000'
dip_execute_test_sequence: 0
dip_execute_test_sequence: 2
dip_execute_test_sequence: 5
RESTORE successfully initialized
```

Comment: Startup complete

```
*** reconmgr: GOING INTO EVENT LOOP  ****
```

Recon subsystem is now up and running.

Comment: Shutdown requested

```
-> mv2305_vme_reset
```

The above command indicates a shutdown has been requested by the host.

2.3 Attached Devices

2.3.1 Host Devices

HOST DEVICE	OCTANE	COMMENTS
serial port 1	/dev/ttym1	used for modem (with PPP)
----------	/dev/ttyd2	Used for Service Key
serial port 1	/dev/console	if EPROM configured for serial console(d)
ethernet	/ef0	Internal ethernet network for scanner operation
ethernet	/ef1	External ethernet network connection via PCI Card to hospital network
printer	/dev/plp	Centronics parallel printer port (NOT USED)
audio in/out		system audio and AutoVoice record/play
keyboard	/dev/keybd	PS/2 keyboard (type 3)
ice	/dev/ttydp02	RIP (CPU) Board - Serial
rhard	/dev/ttydp00	Hard reset line to Gantry - Serial
pig	/dev/ttydp01	Pegasus Board - Serial
mouse	/dev/mouse	PS/2 mouse

Table 3-5 Host Devices - Filesystem Names

2.3.2 Host High Speed Bus Devices

These are the boards used for graphics and/or communications.

Note: Graphics Head Assignment

If the board controlling the primary monitor is removed, the secondary board and monitor become the primary head by default.

Because the boards are interchangeable, this feature is useful in determining whether one board is good or possibly defective. If one of the monitors is blank or faulty, you can use the **/usr/gfx/gfxinfo** command to see which boards the host recognizes and swap their locations.

COMMAND	XIO (OCTANE)	COMMENTS
/dev/gfx	SI with TRAM	Primary head is controlled by first recognized gfx
/dev/gfx	Solid Impact	1.) Secondary head is controlled by next recognized gfx. 2.) On Octane, the SI board with a TRAM module must be installed in the top graphic board location, for proper display performance.

Table 3-6 High Speed Devices - Filesystem Names

2.3.3 Host (Octane) SCSI Devices

2.3.3.1 Host SCSI Bus Info

There are two SCSI buses used in the Octane host computer: SCSI Bus 0 and SCSI Bus 1.

SCSI Bus 0 contains the internal drive bays of the Octane host computer. There are NO JUMPERS on the system disk or optional disk sled assemblies. The optional disk is a customer purchased option for more image space. The system disk drive in the bottom drive bay is auto sensed as SCSI ID 1. The optional disk in the middle drive bay is auto sensed as SCSI ID 2. The top drive bay is auto sensed as SCSI ID 3 and is currently not used.

SCSI Bus 1 is the external SCSI bus from the Octane host computer. SCSI bus 1 contains all other SCSI and removable media devices. All devices on SCSI bus 1 have jumpers and are SCSI-1 or SCSI-2 8-bit devices.

2.3.3.2 Host SCSI Device Chart

SCSI DEVICE	OCTANE	COMMENTS
System disk partition	/dev/dsk/dks0d1s*Z*	where *Z* is the partition number: *Z* = 0,1,3,5,6,7
Scan Data Disk	/dev/dsk/dks0d2s*Z*	where *Z* is the partition number: *Z* = 0,1,2,3 for 2nd disk
Disk	/dev/scsi/sc0d1l0	Boot/Op/Apps
Disk	/dev/scsi/sc0d2l0	Scan Data
MOD	/dev/scsi/sc1d3l0	Image archive device
CDROM	/dev/scsi/sc1d6l0	LFC and CBT device
DASM	/dev/scsi/sc2d1l0	/dev/dasm1 device link

Table 3-7 SCSI Devices - Filesystem Names

The general form of the SGI SCSI devices output listing is:

disk partition as a filesystem = /dev/dsk/dks*X*d*YZ*
or
generalized SCSI device = /dev/scsi/sc*X*d*YZ*
where:
X is the **SCSI controller channel** (0 = SCSI bus0, 1= SCSI bus 1l)
Y is the **unit number** (OC disk is unit 1, MOD is unit 3 and CDROM is unit 6)
Z is the **partition ID** (filesystem s0, s1, s2,...), volume (vol), or other (l0)

2.3.3.3 `fx` Utility

The IRIX '**fx**' SCSI utility can be used to test or exercise almost any SCSI device. It checks devices like the MOD, CD-ROM, and hard drive. It does not look for DASM. To non-destructively test the system disk or the optional disk, follow the example below EXACTLY until you are comfortable with '**fx**'. This utility is safe when "*used as directed*". To be sure that you don't conflict with any application software, such as Archive, shut down CT applications software only (using the service desktop utility), and run '**fx**' tests from any IRIX shell script as 'root'.

⚠ **NOTICE**
Potential For Data Loss

THIS UTILITY IS CAPABLE OF DESTROYING ALL SOFTWARE AND DATA IMMEDIATELY ON ANY SCSI DEVICE, IF IT IS USED IN SPECIAL EXPERT MODES NOT DOCUMENTED HERE. PLEASE DO NOT EXPERIMENT WITH THIS UTILITY.

Example: Using the **FX** command

This example will READ every data block on the system disk. If there are any errors after several retries, the block in question will be remapped to a good spare sector (block), and the data will be recovered (if possible).

This example can be used to test most SCSI devices (not DASM) by using the correct ctlr# and drive# (MOD and CDROM require media installed). To test other drive types, run **scsistat** to identify the correct controller and drive number.

```
{ctuser@engbay24}[1] su
Password:
```
Comment: Must be root

```
{ctuser@engbay24}[1] fx
fx version 6.4, Sep 17, 1997
```
Comment: Enter FX Utility

```
fx: "device-name" = (dksc)
```
Comment: Use default

```
fx: ctlr# = (0)
```
Comment: Controller #

```
fx: drive# = (1)
```
Comment: Device SCSI ID

Comment: Use Default

```
fx: lun# = (0)
...opening dksc(0,1,0)
```

Comment: Disk Mounted

```
fx: partitions in use detected on device
fx: devname             seq owner   state
fx: /dev/rdsk/dks0d1s7    5 xfs     already in use
fx: /dev/rdsk/dks0d1s6    4 xfs     already in use
fx: /dev/rdsk/dks0d1s5    3 xfs     already in use
fx: /dev/rdsk/dks0d1s3    2 xfs     already in use
fx: /dev/rdsk/dks0d1s0    1 xfs     already in use
fx: Warning:  this disk appears to have mounted filesystems.
         Don't do anything destructive, unless you are sure
         nothing is really mounted on this disk.
...drive selftest...OK
```

Comment: Device Model

```
Scsi drive type == SGI     QUANTUM XP34550WLXY4
----- please choose one (? for help, .. to quit this menu)-----
[exi]t               [d]ebug/             [l]abel/
[b]adblock/          [exe]rcise/          [r]epartition/
```

Comment: Exercise Drive

```
fx> exe
----- please choose one (? for help, .. to quit this menu)-----
[b]utterfly            [r]andom              [st]op_on_error
[e]rrlog               [se]quential          [m]iscompares
```

Comment: Use Sequential

```
fx/exercise> se
```

Comment: Read only mode

```
fx/exercise/random: modifier = (rd-only)
```

Comment: Starting block number

```
fx/exercise/random: starting block# = (0)
```

Comment: Number of blocks to test

```
fx/exercise/random: nblocks = (8888543)
```

Comment: Number of passes to run

```
fx/exercise/random: nscans = (1)
random pass 1: scanning [0, 8888543] (8888543 blocks)
```

Comment: Percent complete

```
0%
```

*Comment: **CTRL-C** aborts*

```
(use 'CTRL-C' to stop the testing at any time)
----- please choose one (? for help, .. to quit this menu)-----
[b]utterfly            [r]andom              [st]op_on_error
[e]rrlog               [se]quential          [m]iscompares
```

Comment: Go up 1 menu level

```
fx/exercise> ..
----- please choose one (? for help, .. to quit this menu)-----
[exi]t               [d]ebug/             [l]abel/
[b]adblock/          [exe]rcise/          [r]epartition/
```

*Comment: Exit **fx** utility*

```
fx> exi
```

⚠ **NOTICE**
Potential For Data Loss

If '**fx**' asks you to "`update the label`", always enter '**NO**'.

Section 3.0
Networking and Communications

The system has both serial and LAN communication lines that run between the OC (Octane) and the ICE (Motorola RIP). These communication lines coordinate scanning and recon activities across the computers. Refer to Figure 3-5 to manually check the communication lines serially and halt, reboot, or reset. Refer to Figure 3-6 to manually check the LAN Communications from the OC to the ICE, and to the STC, ETC, and OBC controllers.

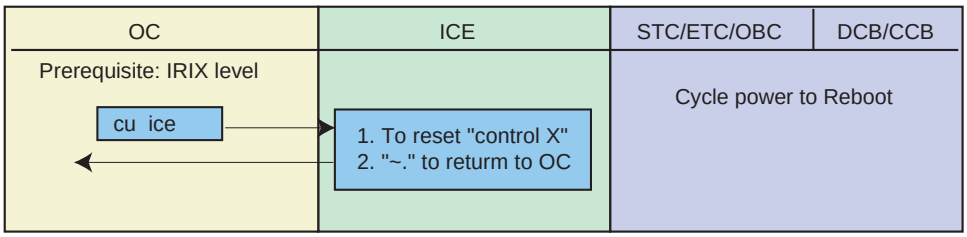

Figure 3-5 Serial Communications

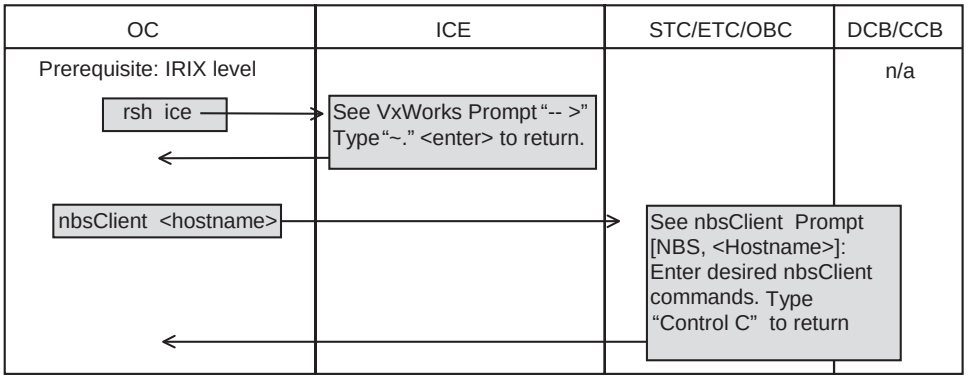

Figure 3-6 LAN Communications

3.1 Validating OC Network Connection

There are two command line executables that can be used to check OC network configuration and status: **`ifconfig`** and **`netstat`**.

3.1.1 `ifconfig` - Network interface Configuration

The command **`ifconfig`** can be used to verify that the network interface is running and is correctly configured on the system's network. The interface is defined as running when it has been probed, attached, and started by the OS (host). There are several devices that are important to host network operation. On the host side, the internal network device name is **`ef0`**. The external network device name is **`ef1`**. Use the **`ifconfig`** as follows to get configuration data about your network. At a command line on the OC, enter **`ifconfig`** followed by the device you want to inspect. Use **`ef0`** for the internal network or **`ef1`** for external network. An example of the **`ifconfig`** use follows:

Example: Check Host's internal/external networks.

```
>>ifconfig ef0
ef0:flags=1c63<UP,BROADCAST,NOTRAILERS,RUNNING,FILTMULTI,MULTICAST,CKSUM
inet 192.9.220.10 netmask 0xffffff00 broadcast 192.9.220.0
```

Comment: *IP address 192.9.220.10 is a fixed internet number assigned to the Host.*

```
>>ifconfig ef1
ef1:flags=ic63<UP,BROADCAST,NOTRAILERS,RUNNING,FILTMULI,MULTICAST,CKSUM>
inet 3.7.52.40 netmask 0xfffffc00 broadcast 3.7.55.255
```

Comment: *IP addresses (e.g. 3.7.52.40), netmask, and broadcast will depend on your own network configuration.*

3.1.2 `netstat` - Network Status

The command **`netstat`** can be used to obtain network status about your network configuration *on your system*. At a command line on the OC, enter **`netstat`** followed by the appropriate argument. Using the **`-i`** argument, you can obtain status on your system's network. Using the **`-r`** argument, you can obtain status on the devices routed by your network (such as an external suite). An example of the **`netstat`** usage initiated from the host using both arguments follows:

Example: Using the **`netstat`** command to check the network status

```
{ctuser@suite1}[1] netstat -i
Name Mtu   Network     Address      Ipkts Ierrs    Opkts Oerrs  Coll
ef0  1500  192.9.220   suite1      105044     0    46423     0     0
vd0* 4336  none        none             0     0        0     0     0
ef1  1500  3.7.52      suite1-gate  52809     0    15553     0   106
ppp0 1500  (pt-to-pt)  olc-pm1          0     0        0     0     0
lo0  8304  loopback    localhost   290542     0   290542     0     0
{ctuser@suite1}[2]

>>netstat -r
Destination     Gateway          Netmask    Flags    Refs     Use  Interface
default          medctc1us                    UG       0       0    ef1
3.1.4            medctc2us     0xfffffc00     UG       0       0    ef1
3.1.20           medctc2us     0xfffffc00     UG       0       0    ef1
3.7.52           suite1-gate   0xfffffc00      U       0       6    ef1
192.9.220        suite1        0xffffff00      U      29      77    ef0
suite1           localhost                   UGHS     186      10    lo0
```

3.2 nbsClient

The nbsClient network boot server enables you to review the Scan Control Network CPU boards statuses and activity.

Follow the list of steps below to connect to the STC, OBC, and/or ETC CPU board controllers.

At the Operators Console console:

1.) Open an UNIX shell on the right-hand display.

2.) type **`nbsClient`** ***`<controller>`*** **ENTER**

`<controller>` = **stc** or **etc** or **obcr**

CNTRL+C Logs you out of the nbsClient session.

Note: The following applies to the controllers:

- You can only access the controllers for a short time before they log you out. Get the info, then press **CNTRL+C** to exit the session.
- Staying logged into the controllers for too long a period can cause errors, keep the sessions as short as possible.

```
============================================================
List of nbsClient commands for controllers
============================================================
```

Command	Description
?	Print this list
@	Boot (Load and go)
p	Print boot params
c	Change boot params
l	Load boot file
n	Display Host/Routing Table
g adrs	Go to adrs
d adrs[,n]	Display memory
m adrs	Modify memory
f adrs, nbytes, value	Fill memory
e	Print fatal exception
a	Print value of PC
i	Print Boot Revision and GIM
r type	Reboot, type = 'soft' or 'hard'
s device [c]	Print[clear] SCA or R/SCOM driver statistics
t cmd	Run diag, cmd = led value(s) of HK tests
u TID	Print TCB info for specified TID
v TID	Summarize TCB info, TID = 0 => all
w TID	Summarize stack usage, TID = 0 => all
x TID	Print a stack trace of TID
y	Dump the error log
z	Pipe the error log to the console
#hlp	Display Flash Command Usage

Table 3-8 List of nbsClient Commands for Controllers

```
$dev(0,procnum)host:/file h=# e=# b=# g=# u=usr [pw=passwd] f=#
=============== =============
```

3.3 Networking

3.3.1 Host Network

There are two command line executables that can be used to check OC network configuration and status. They are **ifconfig** and **netstat**.

3.3.1.1 ifconfig

The command **ifconfig** can be used to verify that the network interface is running and is correctly configured on *your system only*. The interface is defined as running when it has been probed, attached and started by the OS (host). There are several devices that are important to host network operation. They are the gateway (**ef0**) and the BIT3 (**vd0**) devices. Use the **ifconfig** as follows to get configuration data about your network. At a command line on the OC, type **ifconfig** followed by the device you want to inspect—use **ef0** or **vd0**. An example of the **ifconfig** use follows:

Example: Using the **ifconfig** command to check the host network

```
>>ifconfig ef0
ef0:flags=1c63<UP,BROADCAST,NOTRAILERS,RUNNING,FILTMULTI,MULTICAST,CKSUM
inet 3.7.52.150 netmask 0xfffffc00 braodcast 3.7.52.0
```

IP addresses (e.g. *3.7.52.150*) will vary and depend on your own network configuration

```
>>ifconfig vd0
vd0:flags=8e3<UP,BROADCAST,NOTRAILERS,RUNNING,NOARP,MULTICAST>
inet 192.2.100.1 netmask 0xfffffc00 braodcast 192.2.100.255
```

3.3.1.2 netstat

The command **netstat** can be used to obtain network status about your network configuration *on your system*. At a command line on the OC, type **nestst** followed by the appropriate argument. Using the **-i** argument, you can obtain status on your system's network. Using the **-r** argument, you can obtain status on the devices routed by your network (such as an external suite). An example of the **netsat** usage initiated from the host using both arguments follows:

Example: Using the **netstat** command to check the network status

```
>>netstat -i
Name  Mtu   Network    Address    Ipkts    Ierrs   Opkts    Oerrs   Coll
ef0   1500  3.7.52     rhap25     655083   0       258478   1       141141
vd0   4336  192.2.100  ct01_oc0   19178    30      20406    53      0
lo0   8304  loopback   localhost  965831   0       965831   0       0

>>netstat -r
192.2.100   ct01_oc0    0xffffff00  U     83    195   vd0
```

3.3.2 Create or Add a Static Route to the CT System

OVERVIEW

This procedure is used to turn off the routing daemon (if it is not already off), and add a default network route (static route) on a LightSpeed system that is part of a hospital network.

This applies to all LightSpeed software version 3.6 and above. The typical application is to connect a LightSpeed system to a network that uses a router or static routing instead of RIP.

PROCEDURE

It is recommended that you discuss your site's specific needs with the Network Administrator before performing this procedure. If you need assistance performing these steps, please contact the Network Support Group at the OnLine Center.

Note: Please be aware that if this procedure is performed on a system, it will need to be performed again following a software reload. Prior to performing a software reload, ensure that changes to the files addressed in this procedure are documented.

1.) Open a UNIX shell and switch user to root:

`su` - (and enter the root password)

2.) Change directory as follows:

`cd /etc/config`

3.) Create a backup copy of the static-route.options file:

`cp static-route.options static-route.options.lfc`

4.) Determine the desired static route IP address(es) from the site's Network Administration. Add these desired static routes to the static-route.options file. It is preferred to use the "jot" text editor to modify the file, as "jot" is an X-Windows screen editor with an intuitive user interface.

`jot static-route.options`

5.) Add the desired route address(es) at the end of the file, using the following syntax:

`$ROUTE $QUIET add default www.xxx.yyy.zzz` (where this is the IP Address of the default router, provided by the site)

or

`$ROUTE $QUIET add -net www.xxx.yyy.zzz` (where this is the IP Address of the network/subnetwork, provided by the site)

or

`$ROUTE $QUIET add www.xxx.yyy.zzz` (where this is the IP Address of a specific host, provided by the site)

6.) Save the changes to the static-route.options file using the FILE pulldown menu.

7.) Exit "jot".

8.) Verify the entries made to the static-route.options file by typing:

`more static-route.options`

9.) Reboot the system for the changes to take effect.

Section 4.0
Applications and Features

4.1 Accounts

The system has several accounts. The most commonly used account is "`ctuser`," which is automatically logged in on power-up. All the accounts are listed within the `/etc/passwd` file. To display the most used accounts, enter the following:

```
ctuser@msecrp1}[7] more /etc/passwd
... (This is an abbreviated list)

root:Q87bSMq1pevEM:0:0:Super-User:/:/bin/csh
ctuser:f8QFGFmn93MaQ:100:100:Advantage Windows Home Account:/usr/g/
ctuser:/bin/csh
genesis:f8QFGFmn93MaQ:100:100:Advantage Windows Home Account:/usr/g/
ctuser:/bin/csh
insite:osDybj5bv8LjQ:101:101:Insite Account:/usr/g/insite:/bin/csh
{ctuser@msecrp1}[8]
```

On each line there are seven fields separated by a colon (:). The first field is login name, and the second field is its encrypted password. All the fields are explained in the **`man`** page for **`passwd`**. User accounts and passwords are listed in the table below.

USER	PASSWORD
`ctuser`	**`4$apps`**
`root`	**`#bigguy`**
`genesis`	**`4$apps`** or **`genesis`**

Table 3-9 Accounts and Passwords

4.2 Program Folder

On the upper left of each monitor there is a programs folder. The programs folder includes a CONSOLE shell icon, and any UNIX shell icons that were started that have been minimized (iconified).

Console shell: The CONSOLE shell logs general output (debug type messages) from processes started during Application Startups and Shutdowns.

Figure 3-7 Program Folder

The process to move the program folder forward is as follows:

1.) **ALT** + **F3** to bring the folder forward (foreground).
2.) Double click an icon to open (processes shown as icons).
3.) Click on the (o) in the upper right corner of the shell to close.
4.) Click on the (-) in the upper left corner of the shell and select exit to dismiss.

4.3 Tool Chest

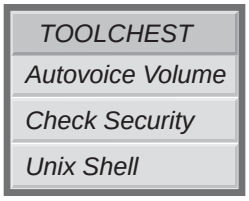

Figure 3-8 Toolchest Menu

The Toolchest menu resides in the upper right-hand corner of the desktop on both the left and right display heads. It is accessible either when the system is at IRIX level only or when Applications are up. The Toolchest has three functions: AUTOVOICE VOLUME, CHECK SECURITY, and UNIX SHELL.

AUTOVOICE VOLUME - When selected, opens up a tool for the user to adjust the volume control for Autovoice.

CHECK SECURITY - A function used to force a read of the security key to gain access to applications appropriate for that key. This is useful when installing a key after Applications are up, rather than waiting for the system (sidney process) to read the key.

UNIX SHELL - When selected, opens up a shell tool at the OC prompt for entering commands. UNIX shells are started in a X-Window environment.

Sometimes the Toolchest is in the background. You can switch it to the foreground or background windows with the key strokes **ALT+F3**.

4.4 Verify Security

The Verify Security feature reads and reports the level of security allowed by the key that is installed or not installed. This feature also reports the date the key will expire. The Verify Security function can be used to verify the system is properly reading the key.

The VERIFY SECURITY command resides in the Service Desktop, under the UTILITIES TOOLS tab. Security can also be verified by typing: **`test_check_security -v`** **ENTER** within an Unix shell.

4.5 Application Start-up/Shutdown Operation

When you power-on the console, the Host Computer (Octane) runs a selftest. After a successful selftest, it boots from its own local disk. On the OC, once IRIX is up, `ctuser` will automatically log-in and begin the auto-start of application software on the OC. A pop-up window will then appear notifying the user that he or she has five seconds to abort the auto-start.

When the system's application platform is up (refer to Figure 3-9 and Figure 3-10), the ETC, STC, and OBC are commanded to perform a hardware reset. This takes approximately 60 seconds. Next, the Host will download firmware to the ETC, STC, and OBC. Finally, firmware is downloaded to the collimator and DAS subsystem controllers.

4.5.1 Application Screens

When applications are up and running, Scan RX is the default desktop. You can show the program's folder or the Toolchest by positioning the mouse in either of the upper corners (refer to Figure 3-9 and Figure 3-10) and then pressing **ALT+ F3**. Hold down the **ALT** key and press the **F3** key at the same time. Use **ALT+ F3** as a toggle to move icons in and out of the foreground.

Figure 3-9 Application Screen (Left Monitor Head)

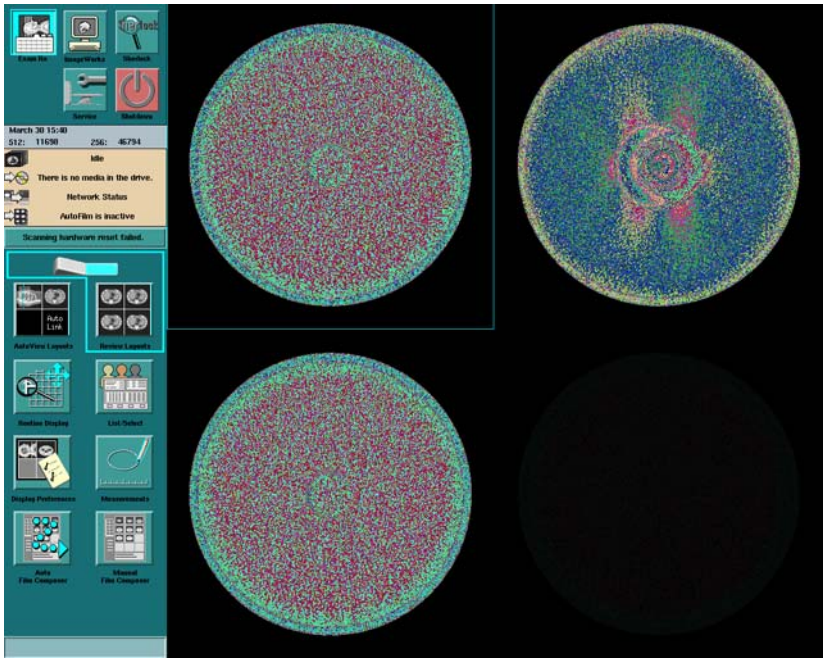

Figure 3-10 Application Screen (Right Monitor Head)

4.5.2 Applications Shutdown and Startup

4.5.2.1 Application "Only" Shutdown

To shutdown the applications platform only, and leave IRIX up on the OC, select UTILITIES and APPLICATION SHUTDOWN. This will leave you at the IRIX desktop environment. If you need to restart applications, refer to Section 4.5.2.2, on page 199. The need to shutdown applications only applies when running certain programs, such as **`reconfig`**.

Table 3-10 shows how applications processes in each of the subsystems are shut down as a result of selecting the softkeys (SERVICE DESKTOP > UTILITIES > APPLICATION SHUTDOWN).

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	Applications	Applications	Applications	Applications
Softkey Actions	SERVICE DESKTOP > UTILITIES > APPLICATION SHUTDOWN			
Final	IRIX	VxWorks	VxWorks	

Table 3-10 System Down Process Sequence

4.5.2.2 Application Startup (from IRIX level)

You must be at the IRIX desktop environment.

1.) From the Toolchest, select UNIX SHELL.

2.) Type **`st`** to start system.

Table 3-11 shows how applications processes are restarted in each of the subsystems by entering **`st`** in a shell.

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	IRIX	n/a		Firmware
User Action	Open a shell and type **`st`** **ENTER**			
Final	Apps	Apps	Apps	Apps

Table 3-11 Application Startup (from IRIX Level) Process Sequence

4.5.2.3 Halting to Boot Level (from IRIX level)

You must be at the IRIX desktop environment.

1.) From the toolchest, select UNIX SHELL.

2.) Type **`sd`** to halt system.

Table 3-12 shows how the operating systems in each of the subsystems are shut down by entering **`sd`** in a shell.

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	IRIX	n/a	VxWorks	Firmware
User Action	Open a shell> type **`sd`** **ENTER**			
Final	Prom Monitor	Prom Monitor		Firmware

Table 3-12 Halt to Boot (from IRIX Level) Process Sequence

4.5.2.4 Preventing Automatic Shutdown During Startup

Applications software can be prevented from automatically shutting down the system, if an error occurs during startup. If applications software encounters an unrecoverable error during startup, it attempts to recover. However, sometimes the error is so severe that software must terminate and shutdown the system. Thus preventing the use of tools to isolate the failure.

The procedure that follows can be used to prevent automatic shutdown.

1.) Before the system startups CT applications software, the following popup confirmation box is displayed.

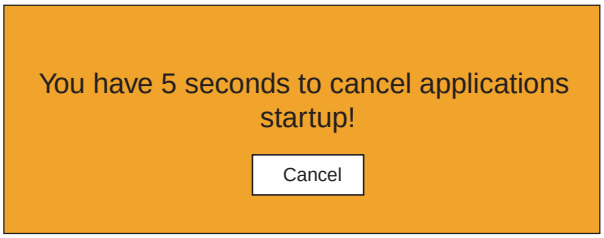

Figure 3-11 Cancel Applications Startup Screen

Using the mouse, left click the CANCEL button within 5 seconds of the window being displayed

2.) Immediately after clicking Cancel, the following popup message box appears.

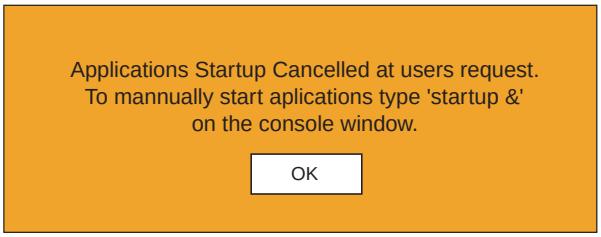

Figure 3-12 Applications Startup Cancelled Acknowledgement Screen

Using the mouse, left click the OK button.

3.) From the TOOLCHEST, use the mouse and left click on the UNIX SHELL button.

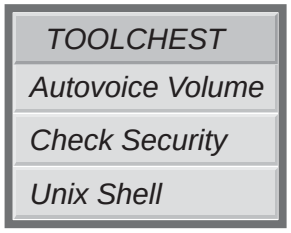

Figure 3-13 ToolChest

4.) At the prompt, in the Unix Shell, type: **`setenv NOHOSTSHUTDOWN`** **ENTER**

The above command prevents the applications startup process from shutting down if an error is encountered.

5.) Now start applications software by typing: **`startup &`** **ENTER**

Applications software will startup and not terminate if an error is encountered.

4.5.3 System Shutdown and Restart

4.5.3.1 Shutdown to Boot PROM Level (from applications)

NOTICE
Potential for loss of data

Because of the way in which the operating system software makes use of disk caching, follow the recommended shutdown procedure to give the system a chance to write any information in the cache buffers to the disk before you turn OFF power.

Use the following procedure to minimize the chance that the system leaves any files in a bad state.

1.) Select SHUTDOWN on the right head to stop scanner applications and OS software (refer to Figure 3-14).

Figure 3-14 Shutdown Button

A script starts that synchronizes the operating system file structure, and halts the operating system on the OC host computer. Table 3-13 shows the final state of each of the subsystems after selecting SHUTDOWN.

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	Apps	Apps	Apps	Apps
User Action	Select SHUTDOWN			
Final	Prom Monitor	Prom Monitor	VxWorks	

Table 3-13 System Shutdown (from applications) Process Sequence

2.) You may power off the console power switch when you see the message in Figure 3-15.

3.) You can turn off the System Mains Disconnect to remove all system power.

4.5.3.2 Restarting from a System Shutdown

Click RESTART using the mouse to bring up the operating system and applications. If you have just powered up the system, this will happen automatically. You will have an opportunity (five seconds) to stop applications autostart and remain at the IRIX desktop level.

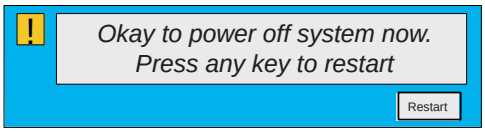

Figure 3-15 Power Off Message

4.6 Magneto-Optical Disk (MOD)

MODs labeled (formatted) for storing images have a DOS-like structure. MODs formatted for software have a UNIX structure. There are some DOS MODE commands in `/usr/g/bin` to help you view and copy files between the Image Archive media and the system. The size of DICOMDIR indicates how much space images are taking on the MOD. You must use Image Works to DETACH, then do another **`dmls`** in a shell to see an updated size.

`dmls`	list files of current directory
`dmcd <path>`	change to the directory identified by path
`dmcat props`	show content of the file props, which tells you the properties of that media
`dmcat stat`	show content of the file stat, which shows last time media was used
`dmcpin -b <dosname> <unixname>`	copy file on media to the system

4.7 Tele-radiology (Framegrabber Type) Systems

Some Genesis based systems have teleradiology (TR) systems that framegrab the Genesis GFB video (512 x 512 50/60Hz). Plus DOES NOT directly support this type of TR. The Plus RGB color display video is a much larger format at a much higher pixel frequency. GE does not promise any direct compatibility with framegrabbing TR systems (DICOM 3.0 TR systems may work depending on the DICOM implementation, but GE Healthcare does not and cannot validate all the various TRs.)

In the framegrabber case, a high quality (300Mhz bandwidth) video splitter/amplifier (as listed above) is needed to intercept and re-drive the display CRT RGB video. Composite greyscale would then be available on Green #2 (1280x1024 pixels at 72Hz). Any framegrabber hardware attempting to capture this signal must be capable of a 140Mhz pixel rate. This also involves TR system configuration parameters. The TR capture software may also need upgrading to deal with 1280x1024 and/or **crop** the signal. The TR remote display software may need upgrading to view the larger format. The image transmission times to the remote TR may be up to 4 times as long. GE Healthcare will supply all technical information necessary to assist TR suppliers in making their systems work with Plus, but GE Healthcare cannot be responsible for this third party TR equipment, software, or compatibility with Plus.

The following common parts are available from GE Healthcare:

PART NUMBER	DESCRIPTION
2237018-2	Four-way Video Splitter (BNC Converter)
2154425	BNC to BNC 7’ Splitter Cable
2142221	BNC to Octane 7’ video Cable
2256482	DB15 to Octane 7’ Video Cable
2256485	DB15 to BNC 7’ Adapter Cable

Table 3-14 Common Parts Available From GE Healthcare

4.8 User Informational Tools

CBT SOFTWARE HARD DISK SPACE REQUIREMENTS

Computer Based Training (CBT) software is provided with the system to assist the operator. By using the CBT and operator reference manual, users can quickly obtain the necessary skills to operate this CT scanner in an efficient and effective manner.

During installation, the CBT makes safe, minor changes to the system disk. The CBT creates/ modifies user information files (e.g., for bookmarks). To do this, the CBT software requires predefined hard disk area and an IRIX path name to access it. The following directory is added:

```
/usr/g/cbt
```

This directory contains the necessary cbt startup files and executables. This directory is also used and should be used to store the CBT bookmarks as necessary.

Section 5.0
Procedures and Adjustments

5.1 Setting Date and Time

If the timezone is wrong, you must run **reconfig** on the OC to select the correct one.

1.) On the Service Desktop, select **Utilities –> Shutdown Applications**.

2.) Open a UNIX Shell and become <root> in the OC window.

3.) Enter: **su**

Enter the super user (root) password, default password is **#bigguy**)

4.) Enter: **setdate**

You will now be presented with a series of date questions. Enter time specific values.

```
The month is ? <MM>
The day is ? <DD>
The hour is ? <HH>
The minute is ? <mm>
The year is ? <YYYY>
```

MM is month (01–12), ***DD*** is day (01–31), ***HH*** is hour (00–23), ***mm*** is minutes (0–59), ***YYYY*** is the year. Verify that both the OC is set to the desired time and date.

5.) Close the shell by typing: **exit**

6.) Type:**st** to restart application software.

5.2 Screen Saver Setup

You can turn the screen saver on or off, and select the screen saver that appears for the current session. To do so, open a UNIX shell and type: **ssaver**

The SGI GUI for doing this will open.

5.3 Mouse Adjustment

You can adjust the acceleration and click speed of the mouse and switch operation of the buttons. To do so, open a UNIX shell and type: **mouse**

The SGI GUI for doing this will open.

5.4 Running storelog

Storelog is run when there is insufficient disk space on the OC disk to bring up the system to Applications Level. During Applications startup, the diskmanagement process checks for adequate disk space; if there is insufficient space, **storelog** will come up automatically in a shell prompting the user. The threshold level for the OC that prompts the need for **storelog** is when the partitions approach 97-98% full.

Storelog is a tool that recovers system disk space by removing files not essential to the operation of the system. Storelog provides an option to save the files, (core, log, data) to MOD prior to removing them from the system disks. Removing these “system log” files does not add image space, but should allow the applications to startup.

The storelog tool can be run standalone in a UNIX shell by simply typing **storelog**, or from the Service Desktop select ERRORLOG, and choose STORELOG.

5.5 Running sprsnap

The use of the sprsnap is primarily intended for debugging. The purpose of the tool is to capture the state of the system prior to the system crash. This includes core files, log files and configuration files. To initiate the program, open a UNIX shell and type the following:

> sprsnap

A series of questions will appear. Save the files to MOD.

In addition to saving system information, sprsnap removes core files.

FILES SPRSNAP SAVES

Comment: Core files from the OC	`/usr/g/service/log/core*`
	`/usr/g/bin/core*`
	`/usr/tmp/core*`

Comment: UNIX kernel core files from the OC	`/var/adm/crash/*` `/usr/g/service/log` from the OC `/var/adm/*SYSLOG*` files from the OC
	`/var/adm/install*`
Comment:	*Install log files from the OC*
	`/usr/g/ctuser/logfiles/sdclog`
Comment:	*SDC log files from the OC*

Comment: ScanRx info files from the OC	`/usr/g/service/log/exam*.protocol`
	`/usr/g/service/log/exam*.scan.request`
	`/usr/g/service/log/gesys_`uname -n`.log`

	`/usr/g/queue`
Comment:	*Miscellaneous information such as disk space, process status and showprod in Queue directory.*
Comment: Scan files	`/usr/g/data_management/ex*/ex*_hdr`
Comment: SDC log from the OC	`/usr/g/ctuser/logfiles/sdclog`
Comment: Miscellaneous files from OC	`/usr/g/service/log/*.timers` `/usr/g/bin/*.timers*`
	`/usr/g/en_US/app_defaults/archive/SCSI.fol` `/usr/g/en_US/app_defaults/devices/camera.dev`

```
/usr/g/config/INFO
/usr/g/config/dataacq.cfg
/usr/g/config/dataacq.init
/usr/g/config/scan_file_mgr.cfg
/usr/g/config/scan_disk_io.cfg
/usr/g/config/scanfilemgr.init
```

5.6 Initializing a Maxoptics MOD

If you have a MOD upon which you want to put system files, this is different from image files. You prepare the MOD by making a file system on it. System State and DD File Analysis will detect this condition and prepare the MOD in the drive for you. To prep a system MOD under other circumstances, open a UNIX shell and type: **`mkfsMOD`** (formatting takes about 3-5 min).

Note: **mkfsMOD** will not work on DICOM image and options MODs.

5.7 Saving System State

To save the system configuration information, characterization, calibration, protocols, etc. to a System State MOD, perform the following tasks:

1.) Bring the system up if it is not already up.
2.) Insert the System State MOD.
3.) Click on the SERVICE DESKTOP.
4.) Click on the PROACTIVE/PREVENTIVE/PLANNED MAINTENANCE icon.
5.) Click on SYSTEM STATE.
6.) Click on ALL. This will highlight Cals, Characterization, Reconfig Info, etc.
7.) Click on SAVE.

The save will take a few minutes. Review the output for errors or missing files; the scroll bar on the right works only when the tool isn't busy performing some task, it may take a little while. If you see any missing files or failures, then refer to the note below.

8.) Click on DISMISS.

5.8 Saving and Restoring Scan Files

Saving scan files to MOD requires that the media first be formatted for a UNIX filesystem. Refer to Section 5.6 for formatting the MOD. Saving scan file function reads the scan files from the Scan Data Disk and lists them in the GUI for choosing. Saving scanfiles onto the MOD puts the scan files in the following directory path on the MOD: `/MOD/service_mod_data/SFfiles`. The scan files are saved as an `iq.<suiteid>.exam.series.scan` file, (referred to as a `.iq` file) in the `Sfiles` directory.

Restoring scan files function reads the MOD directory path: `/MOD/service_mod_data/Sfiles` and presents the files in a list/select GUI for restoring. Restoring the scan files takes a copy of `.iq` file on MOD and puts it into the scandata disk partition.

Both the Save and Restore Scan files functions reside under RECON MGMT on the top level ExamRx Desktop.

5.8.1 Saving Scan Files to MOD

Perform the following steps for Saving scanfiles to MOD:

1.) Place a formatted MOD in the drive.

2.) Bring up Recon Management main menu: Select RECONMGMT.
3.) Select SAVE SCAN DATA.
4.) Click on the Exam, Series, Scan file(s) desired.
5.) Select SAVE SELECTED FILES.
6.) When the save operation is complete, a pop-up reports "`xx scanfiles saved`"—select OK.
7.) Select QUIT.

5.8.2 Restoring Scanfiles from MOD

Perform the following steps for Restoring scan files from MOD.

1.) Place the MOD into the drive.
2.) Bring up Recon Management main menu: Select RECONMGNT.
3.) Select RESTORE SCAN DATA.
4.) Click on the Exam, Series, Scan file(s) desired to be restored.
5.) Select RESTORE SELECTED SCAN FILES.
6.) When the restore operation is complete, a pop-up comes up reporting '`xx scanfiles restored`'—select OK.
7.) Select QUIT.

5.9 Reserve/Release Scan Data

The reserve function allows you to prevent the overwriting of scan data files. The files can then be selected at a later time for future storage and reconstruction. Otherwise, eventually all of the scan data files will be overwritten with new scan data. The release function unreserves any scanfiles previously reserved, freeing that scan file to be overwritten.

5.9.1 Reserving Scan Files

Perform the following steps for Reserving scan files:

1.) From the top level ExamRx Desktop, select RECONMGMT.
2.) Select RESERVE SCAN DATA.
3.) A list of exam/series/scans currently unreserved is presented.
4.) Click on the Exam/Series/Scan(s) desired to be reserved, then select RESERVE SELECTED SCANFILES.
5.) Operation is complete when a pop-up stating "`xx scanfile reserved`" comes up. Select OK.
6.) Select QUIT.

5.9.2 Releasing Scan Files

Perform the following steps for Releasing scan files:

1.) From the top level ExamRx Desktop, select RECONMGMT.
2.) Select RELEASE SCAN DATA.
3.) A list of exam/series/scans currently reserved is presented.
4.) Click on the Exam/Series/Scan(s) desired to be released, then select RELEASE SELECTED SCANFILES.
5.) Operation is complete when a pop-up stating '`xx scanfile released`' comes up. Select OK.
6.) Select QUIT.

Section 6.0
Useful UNIX Commands

This section lists some of the most commonly used UNIX commands, including examples of use.

6.1 `pwd` - Show where you are

Displays the Present Working Directory. PWD shows exactly where you are currently in the filesystem's directory structure.

```
{ctuser@msecrp1}[2] pwd
/usr/g/ctuser
{ctuser@msecrp1}[3]
```

Notice that the user name for who is logged in and the name of the computer are shown in braces { } and the command line number is in brackets [].

6.2 `cd` - Change directory

To move to where a specific file is located, we change directory, either by the absolute address of the directory or by relative address. The absolute address specifies where it is from the root directory, and always starts with the /. This tells the shell to start at the top and go down. To change to the /etc directory, simply type "**cd /etc**" on the command line.

To get back to your home directory, just type the **cd** command without any specified directory. Relative addressing uses the current working directory. To go up one directory, simply specify the parent directory as **..**, also known as a double dot.

The sub directory names are also separated by the /. UNIX reads from left to right, so only when the / is the first character in a **cd** command string will this be read as the root directory.

```
{ctuser@msecrp1}[2] pwd
/usr/g/ctuser
{ctuser@msecrp1}[2] cd /etc
{ctuser@msecrp1}[2] pwd
/etc
{ctuser@msecrp1}[2] cd
{ctuser@msecrp1}[2] pwd
/usr/g/ctuser
{ctuser@msecrp1}[2] cd ..
{ctuser@msecrp1}[2] pwd
/usr/g
{ctuser@msecrp1}[2] cd /usr/g/service
{ctuser@msecrp1}[2] pwd
/usr/g/service
{ctuser@msecrp1}[2]
```

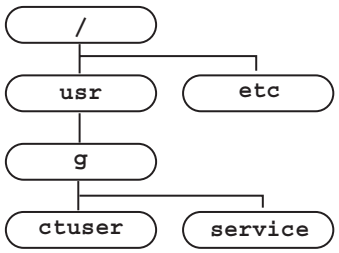

Figure 3-16 Directory Structure using the `ls` command

6.3 `ls` - List file names

Use the **`ls`** command to list all the file names in a directory. Using the **`ls`** command alone without any option, you will see a list of all the file names and subdirectories. Using the **`ls`** command alone gives you no information about the size or access fields control for each file.

Note: Some files have "s" for the 4th character (i.e., super user id bit on).

```
{ctuser@msecrp1}[3] ls
LcHostFile            denta.tar.Z*          install/
MEDAPPS.VERSION*      film/                 logfiles/
Prefs/                get_ivi_key*          messages/
QA.tar.Z              get_sdc_key*          nav.tar.gz*
SMPTE.tar             get_vxtl_key*         scripts/
app-defaults/         gunzip.Z*             set_start_vox.edit
bin/                  image_comb/           vxtl/
catalog_message_sdc/  imcomb.tar.Z*         vxtl.tar.Z*
{ctuser@msecrp1}[4]
```

Some commands have extensions or options that add functionality to each command. Options are unique to each command. The **`-al`** option lists files output in long format. That means the file list contains detailed information about every aspect of the file in the directory.

```
{ctuser@msecrp1}[4] ls -al
total 12173
drwxrwxr-x   12 ctuser   informix    1024 Feb 10 06:02 ./
drwxr-xr-x   22 ctuser   informix     512 Feb  6 10:24 ../
-rw-r--r--    1 root     sys         9313 Feb  6 10:24 .4Dwmrc
-rwxr-xr-x    1 ctuser   ctuser     15319 Feb  6 10:25 .SdCrc*
-rw-r--r--    1 root     sys          159 Feb  6 16:42 .Xdefaults
......
......
drwxr-xr-x    2 ctuser   informix    1024 Feb  6 16:35 scripts/
-rw-r--r--    1 ctuser   ctuser         68 Feb  7  1996 set_start_vox.edit
drwxrwxrwx    8 ctuser   ctuser        512 Feb  6 16:42 vxtl/
-rwxr-xr-x    1 ctuser   informix 2284893 Feb  6 16:30 vxtl.tar.Z*
{ctuser@msecrp1}[5]
```

Examining the list above, the first 10 fields are the ownership and access. The first character indicates if it's a regular file (`-`) or directory (`d`). Next comes the owner access: `r` is Read, `w` is Write, and `x` is eXecute. If the “flag” is turned on, then each field position will show `rwx`. The next 3 positions are for the group; all the users who are in the same group as this user’s primary group will have access according to the rwx. The last 3 characters are for all other users on this system, not the owner or members of the group.

```
-rwxr-xr-x    1 ctuser   ctuser     15319 Feb  6 10:25 .SdCrc*
```

Reading from right to left, you see that the current directory holds a file named `.SdCrc`. The last time that file's contents were modified (`10:25 AM on February 6`) is next. The file contains `15319 bytes`. The owner (user) of the file belongs to the group `ctuser`. The owner of the file is `ctuser`. The number (in this case, `1`) indicates the number of links to this file. Finally, the dash and letters indicate which user, group, and others have permissions to read, write, and execute.

Two special files are used particularly when we change directories or want to run a program. The dot (`.`) directory is the current directory, the one you are in right now. Sometimes the name of a program is found in many different directories. To specify that you want to run a file in the present working directory, use the dot.

6.4 `df` - Disk free space

To see how much space is free on the OC system disk, use the command **`df`**, or **`df -k`** using the option **`-k`**. You will get all the reporting in standard 1024 sized blocks and kilobytes. Examine the column for `%use`. This should generally not exceed 95%. If it reaches 100%, then only the root user is allowed to save any more data in that partition.

```
{ctuser@msecrp1}[2] df -k
Filesystem         Type  kbytes     use   avail %use  Mounted on
/dev/root           efs   92884   12688   80196  14%  /
/dev/usr            efs  499521  461314   38207  92%  /usr
/dev/dsk/dks1d1s3   efs  308076   30847  277229  10%  /data
/dev/dsk/dks1d1s7   efs  723975  370081  353894  51%  /usr/g
/dev/dsk/dks1d1s5   efs 1997002   15698 1981304   1%  /usr/g/sdc_image_pool
{ctuser@msecrp1}[3]
```

6.5 `rm` - Remove files or directory

When UNIX, or any program running on the system, creates a crash, we get large core files that should be removed. The command **`rm`** is used to remove files and directories. As root user, any file on the system can be deleted. Remember that there is no undelete command for files or directories removed under UNIX. If you execute the **`rm`** command, it is gone forever when you hit the enter key.

Note: A bad mistake is executing the **`rm`** command in the wrong directory, therefore always use the **`pwd`** command to verify the proper directory.

Core files are normally found in the **`/usr/g/service/log/crashdumps`** directory. Here is what we have after a UNIX crash.

```
{ctuser@msecrp1}[8] pwd
/usr/g/service/log/crashdumps
{ctuser@msecrp1}[9] ls -al
total 247126
drwxr-xr-x    2 root     sys          512 Feb 21 16:22 ./
drwxr-xr-x    3 ctuser   ctuser       512 Feb 21 16:22 ../
-rw-r--r--    1 root     sys          104 Feb 20 14:59 README
-rw-r--r--    1 root     sys         1844 Feb 20 20:30 analysis.0
-rw-r--r--    1 root     sys            2 Feb 21 16:21 bounds
-rw-r--r--    1 root     sys         1807 Feb 20 20:30 crashlog.0
-rw-r--r--    1 root     sys            9 Feb 20 14:59 minfree
-rw-r--r--    1 root     sys          108 Feb 20 20:30 summary.0
-rw-r--r--    1 root     sys          108 Feb 21 16:22 summary.1
-rw-------    1 root     sys      3366640 Feb 20 20:30 unix.0
-rw-------    1 root     sys      3366640 Feb 21 16:21 unix.1
-rw-------    1 root     sys      3268608 Feb 20 20:30 vmcore.0.comp
-rw-------    1 root     sys      116514816 Feb 21 16:21 vmcore.1.comp
{ctuser@msecrp1}[10]
```

All the files are owned by the root user, so we will have to do a **`su -`** before we can delete files. All the files in this directory can be removed to free up space. The first crash happened on February

20th and the last crash was on February 21st. Below is the sequence for cleaning up after the crash. Notice the amount of free space recovered in the `/usr/g` partition.

```
{ctuser@msecrp1}[11] su -
Password:
msecrp1 1# pwd
/
msecrp1 2# cd /usr/g/service/log/crashdumps
msecrp1 3# ls -al
total 247126
drwxr-xr-x    2 root     sys          512 Feb 21 16:22 ./
drwxr-xr-x    3 ctuser   ctuser       512 Feb 21 16:22 ../
-rw-r--r--    1 root     sys          104 Feb 20 14:59 README
-rw-r--r--    1 root     sys         1844 Feb 20 20:30 analysis.0
-rw-r--r--    1 root     sys         1565 Feb 21 16:22 analysis.1
-rw-r--r--    1 root     sys            2 Feb 21 16:21 bounds
-rw-r--r--    1 root     sys         1807 Feb 20 20:30 crashlog.0
-rw-r--r--    1 root     sys         1447 Feb 21 16:20 crashlog.1
-rw-r--r--    1 root     sys            9 Feb 20 14:59 minfree
-rw-r--r--    1 root     sys          108 Feb 20 20:30 summary.0
-rw-r--r--    1 root     sys          108 Feb 21 16:22 summary.1
-rw-------    1 root     sys      3366640 Feb 20 20:30 unix.0
-rw-------    1 root     sys      3366640 Feb 21 16:21 unix.1
-rw-------    1 root     sys      3268608 Feb 20 20:30 vmcore.0.comp
-rw-------    1 root     sys     16514816 Feb 21 16:21 vmcore.1.comp
msecrp1 4# df -k
Filesystem        Type  kbytes     use   avail %use  Mounted on
/dev/root          efs   92884   12693   80191  14%  /
/dev/usr           efs  499521  462224   37297  93%  /usr
/dev/dsk/dks1d1s3  efs  308076   21594  286482   7%  /data
/dev/dsk/dks1d1s7  efs  723975  505569  218406  70%  /usr/g
/dev/dsk/dks1d1s5  efs 1997002   57190 1939812   3%  /usr/g/sdc_image_ool
msecrp1 5# rm *
msecrp1 6# df -k
Filesystem        Type  kbytes     use   avail %use  Mounted on
/dev/root          efs   92884   12693   80191  14%  /
/dev/usr           efs  499521  462224   37297  93%  /usr
/dev/dsk/dks1d1s3  efs  308076   21594  286482   7%  /data
/dev/dsk/dks1d1s7  efs  723975  381996  341979  53%  /usr/g
/dev/dsk/dks1d1s5  efs 1997002   57190 1939812   3%  /usr/g/sdc_image_ool
msecrp1 7#
```

6.6 `history` - History of executed commands

In the example above you see the numbers in the brackets `[]` increment. This is the history function, which remembers what you have typed before. You can repeat any command from the history list with the **`!`** or "**`bang`**" command. To repeat the last command, use the **`!!`** or "**`bang bang`**." The history function is reset every time you log out. Here is short example.

{ctuser@msecrp1}[1] **`pwd`**
/usr/g/ctuser
{ctuser@msecrp1}[2] **`cd /etc`**
{ctuser@msecrp1}[3] **`cd`**
{ctuser@msecrp1}[4] **`history`**
1 pwd
2 cd /etc
3 cd
4 history
{ctuser@msecrp1}[5] **`!2`**
cd /etc
{ctuser@msecrp1}[6]

6.7 `more` - Read a text file

You can display the contents of a text file, one page at a time, with the **`more`** command. Most files with the Read flag set are text files; if you have the access privilege, you can then view the content. On the CT system we have the INFO file, which lists most of the system specific settings. It's a long file, so here is a short cut of what you will see. The more will display 1 screen at a time, then print `more %` at the bottom left of the screen. When you press **ENTER**, you get one more line displayed. If you press the space bar, then you get the next full screen. The file we use in this example is located in the directory `/usr/g/config`.

```
{ctuser@msecrp1}[33] more /usr/g/config/INFO
setenv DICOM_ADDRESS GENNET_SuiteID
setenv HOSPITAL_NAME "G.E. Medical Systems"
.............
.............
more 47%
setenv SERVID $GATEWAY_HOSTNAME
setenv tubeType $TUBETYPE
setenv REGEN no
{ctuser@msecrp1}[34]
```

6.8 `pipe` or | - Redirect output

Most commands send the result or output to the terminal screen, and expect input from the keyboard. You can instruct the shell to redirect the input or output to another place; you could save the output to a file or send it to a printer. One great feature is to take the output from one utility, or command, and send it as input to another command. This is the job of the pipe. You separate each command with the |. This will force all the outputs from the command on the left to be sent as input to the command on the right. For instance, the list command **`ls -al`** will often scroll off the top of the screen, so by redirecting it to the **`more`** command, you will get one page at a time. Here is the syntax and a short output. Note we have defined the screen as 4 lines long.

```
ctuser@msecrp1}[2] ls -al | more
total 12177
drwxrwxr-x   13 ctuser   informix    1024 Feb 11 02:42 ./
drwxr-xr-x   22 ctuser   informix     512 Feb  6 10:24 ../
-rw-r--r--    1 root     sys         9313 Feb  6 10:24 .4Dwmrc
-rw-rw-rw-    1 ctuser   ctuser       170 Feb  6 10:25 .config_file
-More--
-rwxr-xr-x    1 ctuser   ctuser      4501 Feb  6 16:35 .cshrc*
drwxr-xr-x    3 ctuser   informix     512 Feb  6 10:27 .desktop-msecrp1/
-r--r--r--    1 ctuser   ctuser   1189321 Feb  6 16:35 QA.tar.Z
-rwxr-xr-x    1 ctuser   informix   14248 Feb  6 16:30 get_sdc_key*
--More--
-rwxr-xr-x    1 ctuser   informix   14248 Feb  6 16:30 get_vxtl_key*
-rwxr-xr-x    1 ctuser   informix   72969 Feb  6 16:30 gunzip.Z*
 -rwxr-xr-x    1 ctuser   informix 2284893 Feb  6 16:30 vxtl.tar.Z*
{ctuser@msecrp1}[3]
```

6.9 `find` - Locate file

When we need to **`find`** "the needle in the hay stack", we use the find command. This command can be used to find many different parameters, such as files by name or user id. We have to describe quite accurately to the find command what we really want. If you want to find the `Suite.cfg` file, then we can do as the example shown here:

```
{ctuser@msecrp1}[6] find / -name Suite.cfg -print
Cannot chdir to /usr/g/sdc_image_pool/lost+found
Permission denied
/usr/g/config/Suite.cfg
Cannot chdir to /data/lost+found
Permission denied
{ctuser@msecrp1}[7]
```

Here we specify where to start the search, in this case the `/` or root directory. Then we need to specify what to look for, in this case it's a file by name **`-name`**, followed by the specific name we look for **`Suite.cfg`**, and finally we need to tell the find command that we want the result printed to the screen, that is the **`-print`**. Note here we are not allowed into several directories, because the user id of ctuser has no access privilege.

6.10 `grep` - Extract information

Often you can find the file, but it has hundreds of lines of text in it, and you are only interested in a specific type, such as memory problems in an error log or DAS type in the configuration file. Here the grep command comes in handy, it will go through one or more files, line by line and only send the lines that have a specific word you specify to the screen. It will filter out only what you want to see, the rest is ignored.

To see if IRIX has had any panics lately, we can "**`grep panic`**" from the error log. Here is an example:

```
{ctuser@msecrp2}[5] grep panic /var/adm/SYSLOG
Feb 25 11:17:28 2E:msecrp2 savecore: reboot after panic: <0>PANIC: IRIX
Killed due to Bus Error
{ctuser@msecrp2}[6]
```

If you want to see all the memory problems from all the system error logs, then you could use the wild card, or the * to read all the files, like this:

```
{ctuser@msecrp2}[5] grep Memory /var/adm/SYSLO*
Jan 26 10:22:35 2E:ct02 savecore: reboot after panic: <0>PANIC: IRIX
Killed due to Memory Error
Jan 26 10:22:35 2E:ct02 unix: Memory Parity Error in SIMM S8
Jan 27 12:10:45 2E: ct02 unix: Memory Parity Error in SIMM S8
```

6.11 `su` - Switch user

The user of the root account is often referred to as the Super User. You can get access and ownership of everything on the disc by changing to the super user in a shell, if you are already logged in as ctuser. You do this by issuing the command **`su -`** (switch user) and then supply the correct password for the root account. You can also logout as ctuser and then login as root. The main difference is the direct login gives you a different user environment. You have to do this when you want to delete core files and for many system maintenance tasks. You will be logged in to the root's home account, so beware.

```
login: ctuser
Password:
IRIX Release 5.3 IP22 msecrp1
Copyright 1987-1996 Silicon Graphics, Inc. All Rights Reserved.
Last login: Wed Feb 12 05:20:32 CST 1997 by UNKNOWN@3.231.44.107
{ctuser@msecrp1}[1] su -
Password:
msecrp1 1# pwd
/
msecrp1 2#
```

6.12 ps - Process status

UNIX is a multi-user, multiprocessing system. Every time someone starts a new routine, the kernel starts a new process and gives it a unique process id. This is a number that is incremented for every new process. Process number 1 is the kernel scheduler itself. You can see your processes with the **ps** command. If you want to see all the processes running, use the option/flag **-ef** on SGI and **-aux** on the Sun.

```
{ctuser@msecrp1}[18] ps
      PID        TTY        TIME      COMD
      633        ttyq0      0:00      csh
      782        ttyq0      0:00      csh
      1118       ttyq0      0:00      ps
{ctuser@msecrp1}[19]
```

This example shows the ctuser has a process number 633, which is the c-shell we used to login with. In this example we have a 2nd shell with process id 782, which is in the background. Process id 1118 is the **ps** command we activated.

See Section 1.4.1.3, on page 172, for an example and description of processes.

6.13 kill - Terminate a process

In the example above we have two c-shell processes. Anytime you have a program or process that does not work properly, first try to terminate it in the normal mode. Only if this does not work should you use the kill command to terminate it. Here we will terminate the 2nd c-shell. The kill command has several flags; the **-15** will try to terminate any child processes the main process has started first, then terminate the main process you specify.

```
{ctuser@msecrp1}[20] kill -15 782
{ctuser@msecrp1}[21] ps
```

You should be very careful with the **kill** command. You have no guarantee that all the child processes are closed and the data is saved to the disc, but it's better than just turning off the power. If any child process is “hung” then the -15 flag will wait forever. You can issue a sure kill with the **-9** flag, which will not wait for the children to close first.

6.14 man - Manuals online

All the manuals are on the system. You can read them with the man command. First become the root user or **su** to get the correct path in the environment variables. Man pages can sometimes be too detailed, but they are the ultimate source of information. Here is the **man** page for the **df** command.

```
ctuser@msecrp1}[3] su -
Password:
msecrp1 1# man df
```

NAME

df - report number of free disk blocks

SYNOPSIS

df [-b] [-f] [-i] [-k] [-l] [file-system ...]

DESCRIPTION

df reports the number of total, used, and available disk blocks (one disk block equals 512 bytes) in file systems. The file-system argument may name a device special file containing a disk filesystem, a mounted NFS filesystem of the form hostname:pathname, or any file, directory, or special node in a mounted filesystem. If no file-system arguments are specified, df reports on all mounted file systems.

The -l flag restricts the report to local disk filesystems only. The -b flag causes df to report usage in 512-byte units, which is the default. The `-k` flag causes df to report usage in 1024-byte units. Normally, the free block information is gleaned from the file system's superblock. The -f flag forces a scan of the free block list. The `-i` flag reports the number and percentage of used inodes and the number of free inodes. The `-q` and `-t` flags are recognized but ignored. They are provided for compatibility with previous releases.

EXAMPLES

To report usage in the root filesystem, use either of the following:

```
df /dev/root
df  /
```

Report on the file system containing the current directory:

```
df  .
```

FILES

/etc/mtab

SEE ALSO

`statfs(2), fs(4), mntent(4)`

BUGS

Free counts may be incorrect, with or without the -f flag. If file-system names an NFS file in a filesystem exported with the -nohide option on the server (see exportfs(1M)), and the client mounts an ancestor of that filesystem, then df will report incorrect information.

NOTES

In previous IRIX releases, usage was reported in 1024-byte units. The proc file system (normally mounted under `/proc`) is not printed by default, but may be explicitly specified. This filesystem consumes no actual disk space, but is an interface to the virtual space of running processes. The total and free blocks reported represent the total virtual memory (real memory plus swap space) present and the amount currently free, respectively.

The `-i` option applied to filesystems of type nfs reports a free inodecount of 0. Future versions of NFS will support useful inode counts. For the proc filesystem type, -i reports the number of active process slots in the iuse column, and reports the number of available slots in the ifree column.

```
msecrp1 2#
```

6.15 `nvram` - Examine/Modify Octane Boot environment (nvram) params

Before you can change any nvram parameter, you must be logged-in as root (S4-).

In a UNIX shell, to display all nvram parameter settings, type:
`{ctuser@msecrpl}[2] nvram` **ENTER**.

To modify a nvram parameter, type a command similar to the following example:
`{ctuser@msecrpl}[2] nvram -v console g` **ENTER**.

Chapter 4
Camera

Section 1.0
Theory

1.1 DASM (Data Acquisition System Manager)

A DASM may be used as the interface between the host computer and the laser camera. The current CT system is capable of using either an “analog” or a “digital” DASM to perform this function.

1.1.1 Analog DASM

The “analog” DASM attaches to the host SCSI bus and emulates a SCSI disk drive in function. It accepts high-level commands and 512 x 512 image data from the host via the SCSI bus and sends images and control commands to the laser camera via the camera’s video input and RS-422 serial interface.

The “analog” DASM contains 4 Mbytes of on-board Data Memory, which appears to the host as a SCSI disk drive responding to the SCSI Common Command Set. Data Memory is used for image storage as well as for host command and status handshaking. The host application makes command, status and image transfers by accessing DASM Data Memory through the SCSI bus.

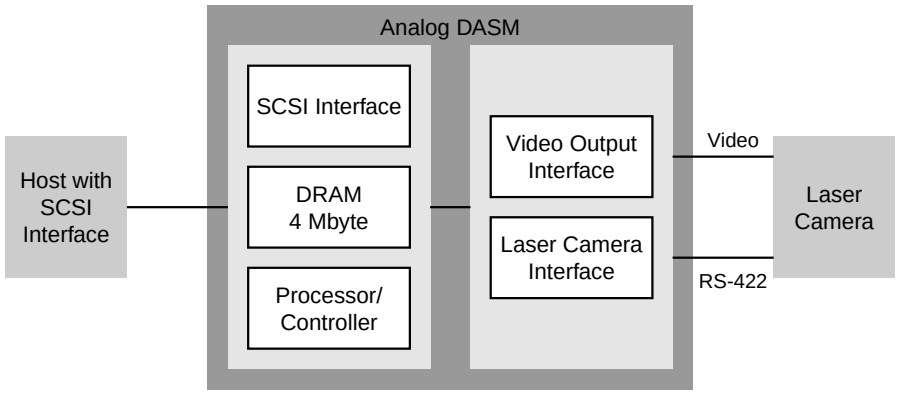

Figure 4-1 Analog DASM

1.1.2 Digital DASM

The “digital” DASM connects the host’s SCSI port to the laser camera’s control and image data ports. It attaches to the laser imager using separate data and control cables from the DIgital Data Output and Camera Control Interface of the DASM to the corresponding inputs of the laser imager.

The Digital Data Output of the digital DASM conforms to all laser camera copper connections. The DASM’s Digital Data Output has RS-485 line drivers and receivers and can be connected up to 250 feet from the laser imager, if the proper cabling is used. This distance can be extended up to 1,000 feet with a SCSI to fiber optic converter.

The DASM’s digital control output accommodates standard RS-232 and RS-422 serial port connections to the laser imager. Digital control can be used at up to 9600 baud.

1.2 DICOM

Note: The following section contains a general description of the functions supported by DICOM on LightSpeed Ultra.

1.2.1 Storage

The Service Class User (SCU) sends image data and the Service Class Provider (SCP) receives image data. The image data is formatted into Objects such as CT, MR, Secondary Capture (SC), CR, X-ray RF, X-ray US, NM, etc. See Figure 4-2.

- GE Application: MR Signa 5.4 Manual Send - User initiates the transfer of image (or series/ study of images) from the Signa to an Advantage. The Signa may also send to a non-GE device.
- GE Application: CT System Auto Transfer - Automatically transfers images to the Advantage Windows at scan. Again, it may also send images to a non-GE device.

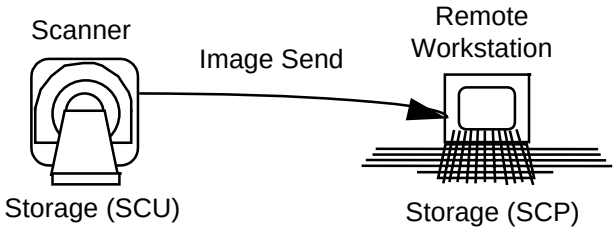

Figure 4-2 DICOM Storage

1.2.2 Query Retrieve (Q/R)

Allows a system to query another system for a list of available images (query). Also allows a system to request another system to send images (retrieve). The SCU initiates the queries and retrieval, and the SCP responds to queries with a list of available data, as well as responding to the retrieval request by sending images. See Figure 4-3.

GE Application: Pull Query - The Advantage Review-Diagnostic (ARD) user requests a list of images from the CT system. The ARD requests the scanner to send some of these images to the ARD and the scanner sends the images using the Service Class.

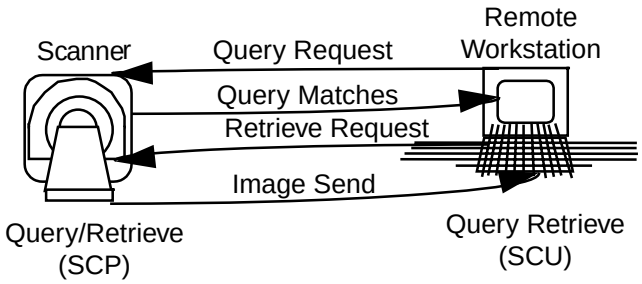

Figure 4-3 DICOM Query/Retrieve

1.2.3 Modality Worklist Management

Allows a scanner (SCU) to obtain patient requested procedure information for scheduled examinations from Information Management System (IMS). Often called the DICOM interface, however the scanner will generally not be connected directly to HIS/ RIS but to an IMS, which in turn will be connected to the HIS/ RIS. See Figure 4-4.

GE Application - A worklist is presented to the technician who simply selects the scheduled patient from the list rather than manually entering the patient demographics information. Saves typing time and avoids typing errors. Automates scheduling and information flow.

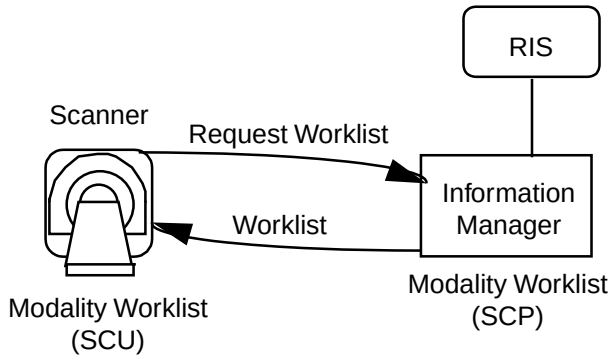

Figure 4-4 DICOM Modality Worklist Management

1.2.4 Study Component Management

Allows a modality (SCU) to keep an Imaging Information Management System (IMS) updated on the progress and completion of an examination. The associated series of form a Study Component whose actual content and status is transmitted to the Information Management system (SCP). See Figure 4-5.

GE Application - Quality management in the imaging process, automatic inputs to billing, and timely triggering of post acquisition (post processing, interpretation, ICU, etc.) events.

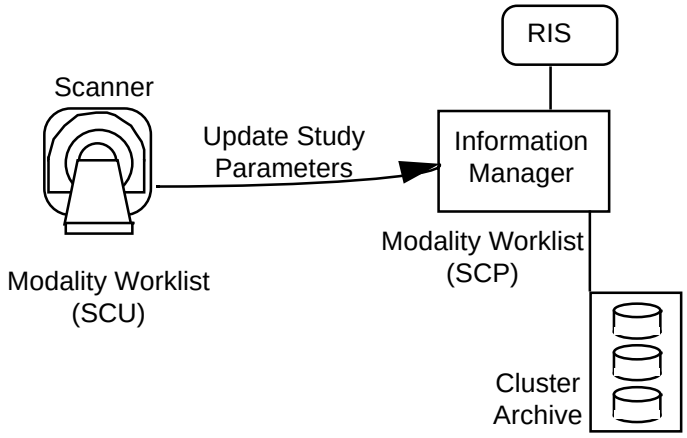

Figure 4-5 DICOM Study Component Management

1.2.5 Storage Commitment

Allows modalities (SCU) to relinquish archiving responsibility to an external device (e.g., network archive) acting as a Service Class Provider (SCP). The Storage Service Class is used in conjunction with the Commitment Service Class to transfer the images to the storage device(s). See Figure 4-6.

GE Application - (Primary Archive Node) Frees up disk space on the scanner without extensive manual archiving. Function needed on a scanner to safely work with a network manager.

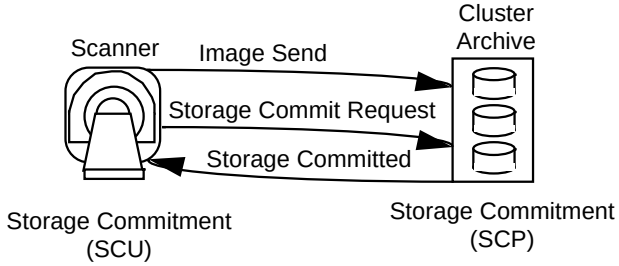

Figure 4-6 DICOM Storage Commitment

1.2.6 Results Management

Allows the radiologist reports to be retrieved by the Service Class User (SCU). See Figure 4-7.

GE Application: Reports may be viewed with the patient's images when retrieved from an Information System.

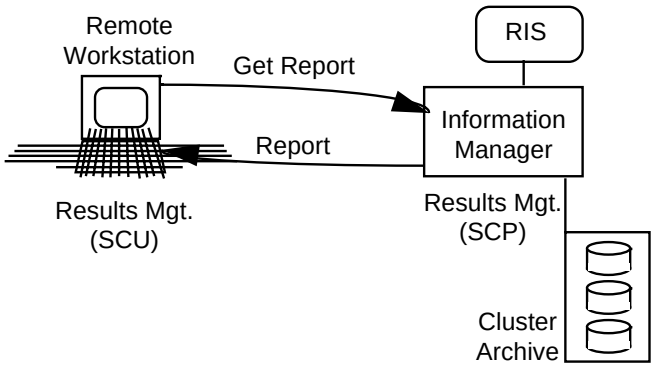

Figure 4-7 DICOM Results Management

1.2.7 Basic Print Management

Allows a workstation or scanner to send images to a printer for hard copy output. For example, a workstation (SCU) sends images to a laser camera (SCP) to be copied on film. This network interface permits workstations to share one camera interface, which can reside anywhere on the network. See Figure 4-8.

Note: Camera manufacturers are just beginning to offer DICOM products. Currently, no GE products support this feature.

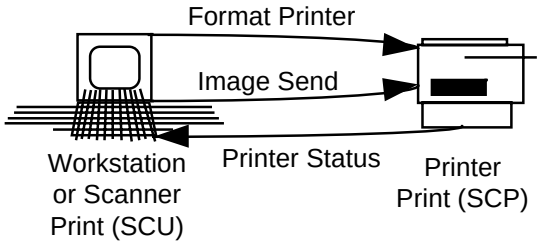

Figure 4-8 DICOM Basic Print Management

1.2.8 1.3 GB MOD Media

Standardizes the physical media (Magneto Optical Disk holding 1. 3 Billion bytes of data) and the logical format in which images are stored on the archive media. A device supporting the Media Interchange Service Class may support the following roles:

- File-Set Creator (FSC) to initialize a new piece of media and write a number of images
- File-Set Reader (FSR) to read the imaging directory and selected images stored on a media
- File-Set Updater (FSU) to read and update the imaging directory as well as images on the media

1.2.9 640 MB CD-R Media

Standardizes the physical media (Recordable Compact Disk holding 640 Million bytes of data) and the logical format in which images are stored on the archive media. A device supporting the Media Interchange Service Class may support one or more of the roles defined above.

1.2.10 Verification

Allows any system to send a test message to another system to verify the network connection.

1.2.11 Glossary of DICOM Terms

CONFIGURATION

The DICOM Print Configuration Information field is controlled by the Camera Manufacturer. It is typically used to set information on the Look-up Table to be used to convert the inputted digital image data to the hardcopy film output (since the range of valid data for the input may not match the range for the output data); however, it is not limited to this purpose. The string field is defined by the Camera Manufacturer and is currently up to 1024 bytes. The value is equivalent to working the contrast on a image monitor.

DENSITY

Density is a film term that represents the pixel value at a particular point on the film. Empty Density is the pixel representation of a blank image frame on a film. Border Density is the pixel representation of the area outside of the image frames on the film. Minimum Density is the minimum pixel representation to be used within an image, while Maximum Density is the maximum pixel representation to be used within an image. The last two values are equivalent to working the brightness on a image monitor. The range and effect of the last two density parameters are Camera Manufacturer dependent.

DICOM

Acronym for Digital Imaging and Communication in Medicine. This standard is a detailed specification for transferring medical images and related information between computers.

MAGNIFICATION TYPE

Images from the CT scanner are digitized at a low resolution and are then printed at a higher resolution. To accomplish this, images are interpolated prior to being printed. A number of techniques may be used to perform the image interpolation. The most common techniques are:

- Replication: This is the simplest method of interpolation (zero order interpolation). In this case adjacent data is used to calculate the fill data. The resultant images are typically extremely blocky and contain jagged edges.
- Bilinear: Also known as first order (linear) interpolation, this technique consists of fitting straight lines through adjacent data points to determine intermediate points. The resultant images are somewhat blurred.
- Cubic: Third order (cubic) interpolation is usually the favored technique. There are a large number of possible formulations for cubic interpolation. Each differs by the coefficients used in the process. The Camera Manufacturers use a second parameter called a Smoothing Type to set the coefficients. The implementation of the coefficient is Camera Manufacturer dependent. The cubic interpolation presents the smoothest version of interpolation when compared to replication or bilinear interpolation.

SERVICE CLASS

Represents a specific application feature by defining a set of related SOP classes (DICOM Print).

SMOOTHING TYPE

A value used in conjunction with the Magnification Type. It is only relevant when the magnification type is set to Cubic. Smoothing is used to set the coefficients for the formulation of the interpolation. The valid values and meaning of the Smoothing Type parameter are controlled by the DICOM Print Manufacturer. For example, Imation expects a smoothing factor of 0 to 15, while Agfa expects a smoothing factor of VR type 0, or falling within the range of 100 to 299.

SCP

Acronym for **Service Class Provider**. This is the Service Class server. (In the case of DICOM Print, this is the DICOM Print Camera.)

SCU

Acronym for **Service Class User**. This is the Service Class client. (In the case of DICOM Print, this is the CT Scanner.)

SOP

Acronym for **Service Object Pair**. This term is used in DICOM to specify the capabilities of a DICOM entity. The entity is defined by the union of the Information Object Definition (IOD) (e.g., CT image) and the DICOM Message Service Element (DIMSE) Services (e.g., store).

Section 2.0 Setup

2.1 Overview

The system supports either DASM Laser or network DICOM Print type cameras. Configuring the system for camera and its parameters is done from the SERVICE DESKTOP, UTILITIES menu, INSTALL submenu, and selecting INSTALL CAMERA.

Once set up, the parameters must be saved.

2.2 Filming Image Quality

Note: It is important that the camera limits are clearly understood from the camera manufacturer's Conformance Statement. Work closely with the Camera Field Engineer when setting up min and max density and configuration.

The parameters that directly affect Filming Image Quality in the camera.dev file are:

- set minDensity
- set maxDensity
- set smoothType - Used only when Mag type is set to Cubic.
- set configuration - This value sets the min & max density curve range. Camera manufacturer dependent.

DENSITY SETUP TIPS WITH BLUE FILM TYPE

The starting min and max density settings vary by camera and film type, and configuration settings.

Note: If the configuration is set to 200, and maxDensity 300, films will be quite dark. Bottomline is the higher the density and config LUT, the darker the film.

See Table 4-1 for some suggested settings for the AGFA camera. **For other camera models, refer to the camera manufacturer's conformance statement and consult with the camera FE.**

CAMERA TYPE	MEDIA TYPE	FILM TYPE	SUGGESTED STARTING	
			MINIMUM DENSITY	MAXIMUM DENSITY
AGFA Drystar 2000	Blue Film	TS Blue Base Low Speed High Density	17	185
AGFA Drystar 2000	Blue Film	TS Blue Base Fast Speed Normal Density	18	229
AGFA Drystar 2000	Blue Film	DT Blue Base Normal Speed High Density	24	300
AGFA Drystar 2000	Clear Film	TS Clear Base Low Speed High Density	5	173
AGFA Drystar 2000	Clear Film	TS Clear Base Fast Speed Normal Density	6	217
AGFA Drystar 3000	Blue Film	DT Blue Base Normal Density	23	300
AGFA Drystar 3000	Clear Film	DT Clear Base Normal Density	6	300

Table 4-1 Density Values

RECOMMENDATIONS

1.) If the Hospital already has the camera in use in laser mode, make sure you use these values as the start point. You may want to take a number of films before you change out the hardware and use them for comparison afterwards.

2.) Set up the DICOM Print Camera, and use the initial starting point. Set up to look as good as the camera FE and GE CT FE can make it.

3.) Assume that before the DICOM Print install is complete, the films have been approved by the appropriate Hospital Staff. This means some time (up to 4 hours) must be allocated for the Camera FE, CT FE and site to work together. If it is possible, the camera manufacturer can create a film with multiple contrasts for the Doctors to pick from.

2.3 DASM

A DASM Laser Camera is a camera connected to the CT system through a DASM (either Analog or Digital). The CT System connects to the DASM via the Host Computer SCSI Bus, and provides either Analog Video (Analog DASM) or Digital Video (Digital DASM) and control & command signals to the Laser Camera. Figure 4-9, below, shows an example of the required configuration parameters for a DASM Laser Camera.

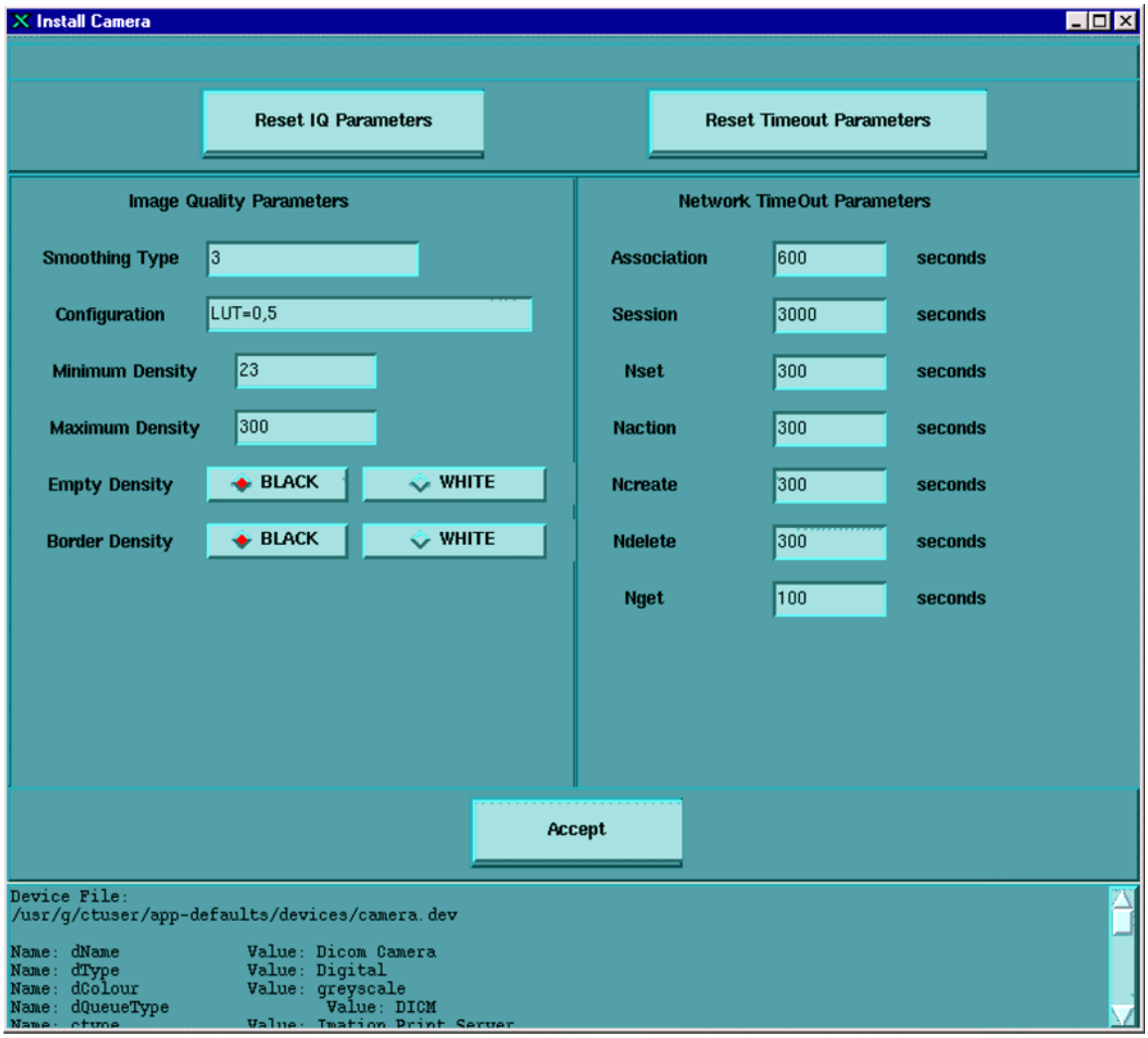

Figure 4-9 DASM Laser Camera Install Screen

1.) The **Laser Camera Type** should be selected first as this will preset all of the other parameters, with the exception of the DASM and Film. It is a good idea to verify the preset information, as camera models do change over time.

2.) Select the **DASM Interface**, either **Analog** or **Digital**, that matches your physical DASM type.

3.) Two **Options** are available with a Laser Camera: **Slides** and **Zoom**. Setting this option allows the option to be enabled or disabled at the application level. However, before selecting **Slides** or **Zoom**, be sure that the customer's camera supports these options.

4.) Camera manufacturers provide two Film resolution options for cameras. The **Smooth** resolution blurs the image, while the **Sharp** resolution makes the image "pixelly".

Recommended camera settings are as follow:

Kodak: Smooth

Dupont/Sterling: Smooth

3M/Imation: Sharp

Agfa: Sharp

If images on film are “too pixelly”, chances are that the film has been set to “sharp” — change the setting to “smooth.” The converse also applies.

2.4 DICOM

2.4.1 Applications Setup

A DICOM Print Camera is a network camera that has a hostname and IP Address connected on the Hospital Network (Ethernet Connection) from the CT System. The CT System uses TCP/IP network protocol to communicate and send DICOM Images in packets to the Camera for filming. Refer to Section 2.3.3.6 for a glossary of terms and definitions associated with DICOM Print. Figure 4-10 is an example of the required configuration parameters for a DICOM Print Camera:

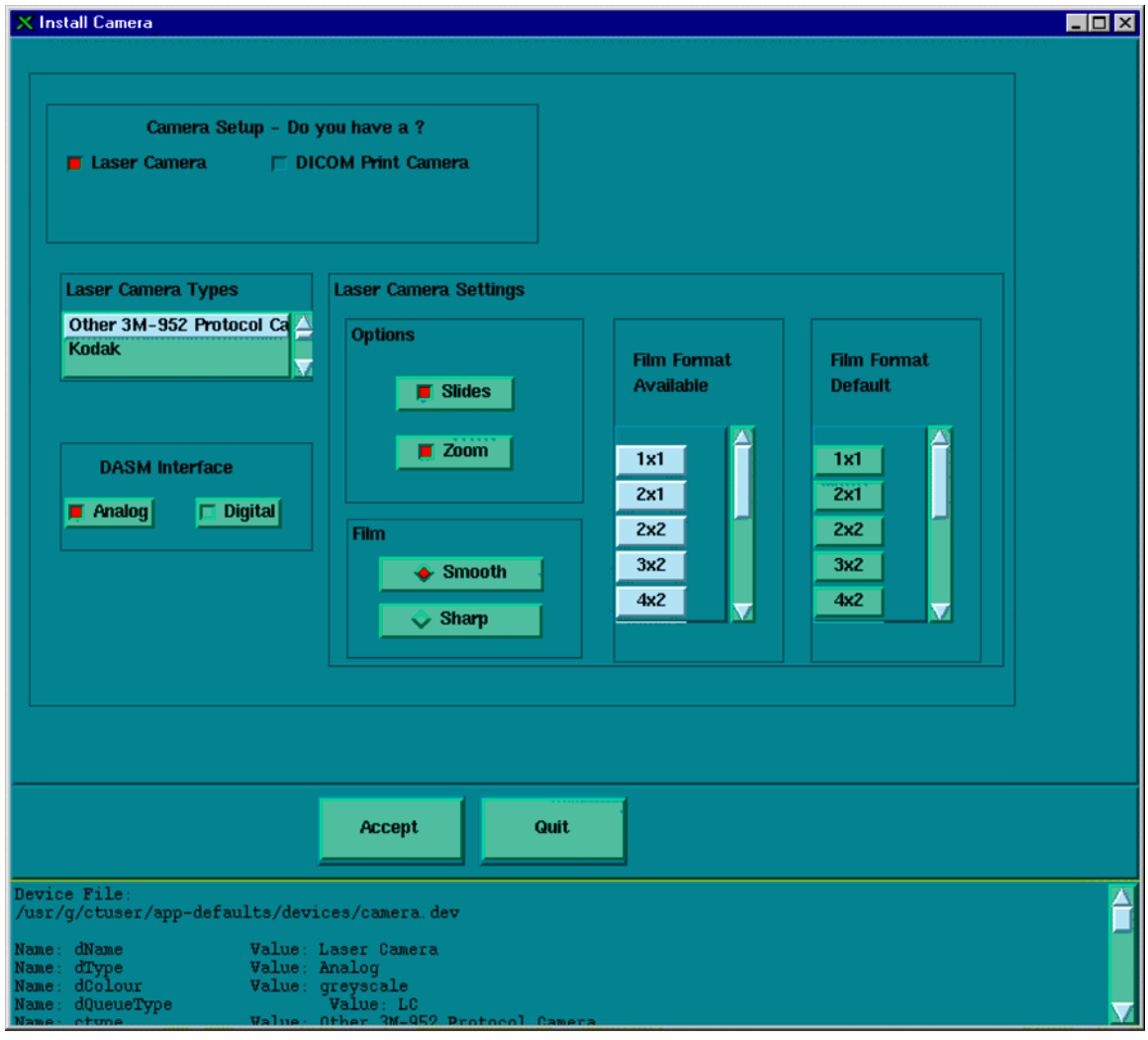

Figure 4-10 DICOM Print Camera Install Screen

1.) The **DICOM Print Camera Type** should be selected first, as this will preset all of the other parameters, with the exception of the Network Parameters. It is a good idea to verify the preset

information, as camera models do change over time.

Note: Selection of a different camera type will also clear the Image Quality parameters, as these are camera manufacturer dependent.

2.) Set up the **Network Parameters**

Note: To determine the correct DICOM Camera Network parameters (IP Address, Hostname, AE Title, Port Number, and Comments) contact the Hospital's Network Administrator.

- **IP Address** - DICOM Print Server IP Address as defined by the network.
- **Host Name** - DICOM Print Server host name as defined by the network.
- **Application Title** - DICOM Print Server Application Entity Title as defined by the server.
- **TCP/IP Listen Port** - DICOM Print Server TCP/IP Listen Port as defined by the server.
- **Comments** - (Optional) Comments to be used by the DICOM Print Server.

3.) **Destination** selects the final location for the film output, either **Magazine** or **Processor**.

4.) **Orientation** selects the film orientation; currently only the **Portrait** option is supported.

5.) **Medium Type** selects the type of film to be used, either **Blue Film** or **Clear Film**.

6.) The **Magnification Type** parameter selects the algorithm used to interpolate pixels to provide the necessary film resolution. This parameter should be set in conjunction with the camera manufacturer to make the best possible image. The settings are:

- **None** - No interpolation. This option is not supported by all camera vendors.
- **Replicate** - Adjacent pixels are interpolated, which results in images described as "pixelly". This algorithm is not usually preferred.
- **Bilinear** - A first order interpolation of pixels is used, which results in images described as blurred. This algorithm is not usually preferred.
- **Cubic** - A third order interpolation is used with a large number of possible formulations. Camera manufacturers define parameters, called smoothing type, to set coefficients used in the algorithm. Implementation of these coefficients is camera manufacturer dependent.

7.) The valid **Film Formats** are determined by the camera manufacturer (for example, IMATION does not support 4x6, 2x4, or 1x2; AGFA does not support 2x4). Also note that the DICOM Print convention is to designate film formats by column x row (e.g., 12-on-1 film is 3x4).

The Network Parameters entered in the Camera Installation GUI (including Camera Hostname, IP Address, AE Title, Port Number, and Comment) are written to **/usr/g/ctuser/Prefs/SdCPHosts** file on the OC.

The settings information entered in the Camera Installation GUI is written to **/usr/g/ctuser/app-defaults/devices/camera.dev** file on the OC.

A second screen, Figure 4-11, with image quality and timeout information parameters for filming sessions, comes up after selecting ACCEPT. Figure 4-11, below, is an example of the required image quality and timeout parameters for a DICOM Print Camera:

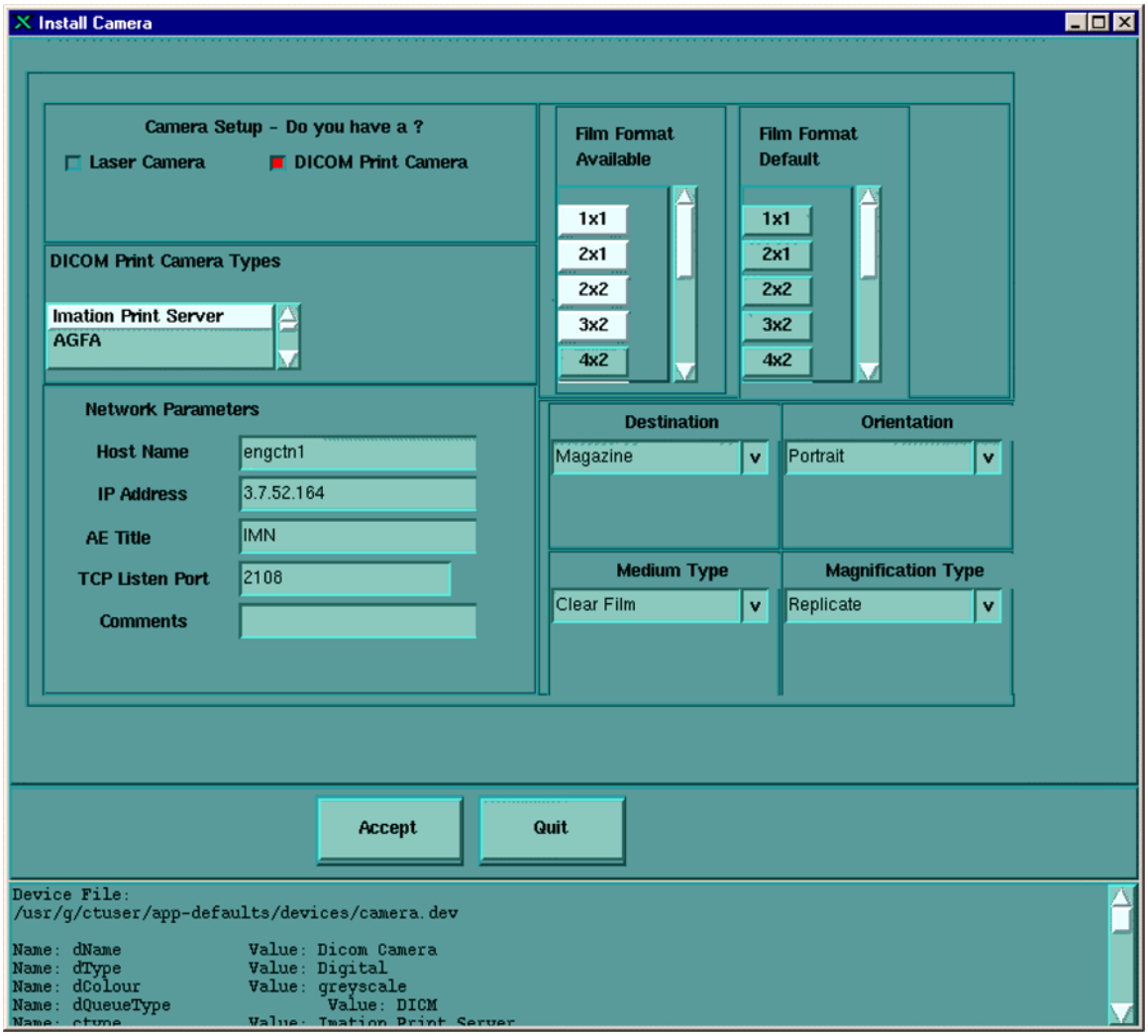

Figure 4-11 DICOM Print Camera Image Quality & Timeout Settings

The image quality parameters are saved on the OC in:

/usr/g/ctuser/app-defaults/devices.camera.dev file.

The timeout parameters are saved on the OC in:

/usr/g/ctuser/app-defaults/print/dprint.cfg file.

Note: To determine the correct camera settings, contact the Camera Service representative, and review the Camera Manufacturer's DICOM Conformance Statement. The detailed DICOM Conformance Statement for LightSpeed is available as Direction 2211216-100. You may need to refer to a copy of this document as you are working with the camera manufacturer's representative, to correctly set up the DICOM Print Camera settings.

2.4.2 Network Setup

2.4.2.1 Configuring the DICOM Network

Use the Gateway Host name for the Application Entity (AE) Title, the Gateway IP number for the DICOM Address and Port 104 for the LightSpeed scanner.

The LightSpeed DICOM configuration is set in /usr/g/config/WLdcm.cfg

WLdcm means Work List Server (software) for DICOM. Unsuccessful transfers are logged to the GE Error Log from WLServer. The most recent WLrsp.binx file with the biggest number in /usr/g/config is usually the one that failed to transfer.

2.4.2.2 Adding Stations to Network

1.) Select Network from Image Works
2.) Go to Select Remote Host from the pull down menu.
3.) Select Add.
4.) Enter the IP address, station name, network protocol you want to use.
5.) Save.

2.4.2.3 DICOM Port Number

- Genesis stations (HiLight, HiSpeed): 104
- Non-Genesis stations: 4006

This lo0 entry also must be present in file /etc/hosts or the network will not work.

```
127.0.0.1       localhost
```

2.5 Save System State

Once the camera is set up, the settings stored in the configuration files (camera.dev, sdCPHosts, and dprint.cfg) must be saved. Save these parameters to the System State MOD. Run SYSTEM STATE, and select CAMERA PREFERENCES and SAVE. For details on the save system state procedure, see Saving System State on page 206.

Section 3.0 Troubleshooting

3.1 Check Hardware

Check the camera hardware for errors. See the appropriate section of the Console chapter for details.

1.) Check the printer for paper jam or other malfunction.

2.) Check the physical connections between components.

3.) Run hardware diagnostics, as appropriate:

- **hinv**
- **showdasm** (DASM only)
- **scsistat**
- **ping** (DICOM only)

3.2 Check Error Logs

3.2.1 Filming Error and Status logs

During Laser Camera Print filming, the system writes to two camera logfiles, lclog and prslog. When a print job starts, the Laser Camera status information is logged to ~ctuser/logfiles/lclog. The print job information is logged to ~ctuser/logfiles/prslog.

---

lclog

Location

OC: /usr/g/ctuser/logfiles/lclog

Description

This logfile contains Laser Camera print filming sequence and Printer status information for the most recent print session job. Each time a new print job is performed, the status information for that latest job will overwrite the previous one.

3.2.2 prslog

Location

OC: /usr/g/ctuser/logfiles/prslog

Description

This is a running history log of print server initializations and shutdowns, and print jobs that are started and completed.

3.3 Troubleshooting DICOM Print Camera Problems

LOG OF ERROR AND FILMING STATUS

During DICOM Print filming, the system writes to two camera logfiles, dcplog and prslog. When a print job starts, the dicom information is logged to ~ctuser/logfiles/dcplog. The print job information is logged to ~ctuser/logfiles/prslog. The called AE title/host/IP/port number is taken from ~ctuser/Prefs/SdCPHosts file.

3.3.1 dcplog

This logfile contains dicom print filming sequence and Printer status information for the most recent print session job. Each time a new print job is performed, the status information for that latest job will overwrite the previous one.

1.) Printer Status Area in the dcplog report

The Printer Status area in the log report will either be NORMAL, WARNING, or FAILURE. In the event of a WARNING or FAILURE, the Status Info field attempted to identify the root cause.

NORMAL - print job was successful, no problems.

WARNING - one of three conditions can happen:

a.) The job aborts and the status info field indicates SUPPLY FULL, RECEIVER FULL, or FILM JAM. (See part 3 below for FILM JAM example.**)**

b.) The job continues and Warning is posted to the operator if Status Info field reports SUPPLY LOW.

c.) The job continues and a Warning is *not posted to the operator, but the message is put in dcplog file.*

Note: What gets reported is dependent upon the camera type and the camera server's ability to report it.

FAILURE - the print job has aborted; see Status Info field for more information.

2.) Dcplog example of a print job leading up to a Film Jam:

{ctuser@engbayXX}[17] cd /usr/g/ctusr/logfiles
{ctuser@engbayXX}[18] more dcplog
_[40;1H_[K# DICOM print_scu pid: 5463
print_scu -aIMN -hcamera -c1 -f1x1_fid -p/usr/g/ctuser/film/img21a0017f -d/usr/g/ctuser/app-defaults/devices/camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN host camera ip-addr 3.7.52.164 port 2104
EstablishAssoc: DCM_OPEN_REQ Action success
EstablishAssoc: OPEN_CONF received
Starting the print session
NgetService: Event Received : DCM_NGET_END
NgetService: Event Received : DCM_DATA

PRINTER STATUS	
SOP uid	
Instance uid	
Printer Status	**WARNING** ←
status info	FILM JAM ←
printer_name	advt
manufacturer	AGFA
model	ADVT
device serial number	123456
software version	Version 2.0
Warning	Media jam. **Failed during the print session, status -1. Job stopped here.**
CloseAssoc	DCM_CLOSE_REQ Action Success

Table 4-2 Printer FILM JAM

3.) Known error reported from Nget with Imation Cameras that should not be troubleshot:

The prslog reports:

MESSAGE from Process 2059 >> Wed Aug 19 10:03:48 1998 [PRSserver]> Print job started
Message from Process 2060 >> NgetService: N-GET response received with failure/warning Status
Message from Process 2060 >> AETitle: IMN_PrintServer
Message from Process 2060 >> Print Session successfully completed

The dcplog reports:

NgetService: N-GET response received with failure/warning Status ¨the known error.

PRINTER STATUS	
SOP uid	:
Instance uid	
Printer status	NORMAL
status info	
printer_name	IMN_LaserImager
manufacturer	Imation
model	M8700
device serial number	
software version	1.5b4
AETitle	IMN_PrintServer

Table 4-3 Imation Print Report

What Imation supports:

Imation supports the following six elements/attributes:

> (0x21100010, CS, ”NORMAL”) # Printer Status OK
> (0x21100020, CS, ””) # Printer Status Info OK
> (0x21100030, LO, ”IMN_LaserImager”) # Printer Name OK
> (0x00080070, LO, ”Imation”) # Manufacturer OK
> (0x00081090, LO, ”M8700”) # Manufacturer’s Model Name OK
> (0x00181020, LO, ”1.5b4”) # Software Versions OK

The Bug:

Nget is requesting status from these three additional elements that are not supported:

> (0x00181000, LO, ””) # Device Serial Number
> (0x00181200, DA, ””) # Date of Last Calibration
> (0x00181201, TM, ””) # Time of Last Calibration

The Fix:

Instruct Camera FE to disable the above three elements that are not supported.

4.) Communication and Network Error Troubleshooting

The most common types of network errors that can occur with DICOM Print are a:

- DCM Networkerror and
- DCM Protocol error.

DCM Network errors:

Successful network communications to the camera are dependent on a correctly configured IP Address and Port Number. Any errors associated with the network will be logged as a “DCM Network Error” in the “type” field in the dcplog report, as shown in the example below. Use ping and snoop to discover the root cause, covered in the troubleshooting steps below.

Example: DCM Network Error

Example of dcplog with a DCM Network Error:

{ctuser@engbayXX}[3] **cd /usr/g/ctusr/logfiles**
{ctuser@engbayXX}[4] **more dcplog**
_[40;1H_[K# DICOM print_scu pid: 5498
print_scu -aIMN -hcamera -c1 -f1x1_fid -p/usr/g/ctuser/film/img22a0017f -d/usr/g/ctuser/app-defaults/devices/camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN host camera ip-addr 3.7.52.164 port 2104
EstablishAssoc: DCM_OPEN_REQ Action success

Errors logged beyond this point of failure may be a result of this Error:

DCM kernel lower level error:

type = 508 -- DCM network error ¨ ERROR
code = 114 -- lost transport connection
ul_code = 52, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c line = 3051
Failed to contact printer, status 114

Steps for troubleshooting a DCM Network Error:

a.) Verify correct IP Address and Port Number are correct in the Install Camera GUI.

Note: If the IP Address and Port Number are correct, the remote application (camera server) may not be running.

b.) Verify Applications restarted after running Install Camera from Service Desktop Utilities.

c.) Verify on the OC in /usr/g/ctuser/SdCPHosts the IP Address and Port Number are correct.

Enter the following:

ctuser@bayXX}[2] **cd /usr/g/ctuser/Prefs**
ctuser@bayXX}[3] **cat SdCPHosts**
3.7.52.164camera IMN2106ctn display

d.) Ping to the camera's IP address, and check for packet loss. A successful ping indicates a good physical connection and IP Address. Port number can still be bad; proceed to next step.

Example of successful ping:

{ctuser@engbayXX}[5] ping 3.7.52.164
PING 3.7.52.164 (3.7.52.164): 56 data bytes
64 bytes from 3.7.52.164: icmp_seq=0 ttl=255 time=0.927 ms
64 bytes from 3.7.52.164: icmp_seq=1 ttl=255 time=1.079 ms
64 bytes from 3.7.52.164: icmp_seq=2 ttl=255 time=1.090 ms
64 bytes from 3.7.52.164: icmp_seq=3 ttl=255 time=1.070 ms
64 bytes from 3.7.52.164: icmp_seq=4 ttl=255 time=1.048 ms
64 bytes from 3.7.52.164: icmp_seq=5 ttl=255 time=1.073 ms
64 bytes from 3.7.52.164: icmp_seq=6 ttl=255 time=1.199 ms
----3.7.52.164 PING Statistics----
7 packets transmitted, 7 packets received, 0% packet loss
round-trip min/avg/max = 0.927/1.069/1.199 ms

e.) If you are unable to successfully ping the camera, use the snoop tool to monitor what is going on with communication packets during a print job. Snoop will read the number of responses from the server while attempting to do a print job. In Example A below, there is only one summary line being reported, (one outbound), and NO inbound response indicating the remote camera host (engctnl) cannot be reached. Refer to Snoop on page 238 for snoop and its usage.

Example: **snoop -SVta 3.7.52.164** ←where **3.7.52.164** in this case is the
Example A: camera <***IP address***>

Using device ef0 (promiscuous mode)

14:46:19.250400engbay26 -> engctn1length:58 ETHER Type=0800 (IP), size = 58 bytes
14:46:19.250400engbay26 -> engctn1length:58 IP D=3.7.52.164 S=3.7.52.151 LEN=44, ID=57050
14:46:19.250400engbay26 -> engctn1length:58 TCP D=2106 S=1192 Syn Seq=1001039841 Len=0 Win=16384

f.) If there are only two summary lines, (Example B below) one outbound and one inbound, this indicates that we can successfully ping the remote camera host, (IP Address is good) but the remote application is either not running (i.e. the machine is up, the application that acts as the print server is not running), or the wrong port number is being used. Refer to Snoop on page 238 for snoop and its usage.

Example B:

snoop -SVta 3.7.52.164 ← where 3.7.52.164 in this case is the camera <IP address>

Using device ef0 (promiscuous mode)

14:46:19.250400 engbay26 -> engctn1length:58 ETHER Type=0800 (IP), size = 58 bytes
14:46:19.250400 engbay26 -> engctn1 length:58 IP D=3.7.52.164 S=3.7.52.151 LEN=44, ID=57050
14:46:19.250400 engbay26 -> engctn1length:58 TCP D=2106 S=1192 Syn Seq=1001039841 Len=0 Win=16384

14:46:19.251971 engctn1 -> engbay26length:60 ETHER Type=0800 (IP), size = 60 bytes
14:46:19.251971 engctn1 -> engbay26length:60 IP D=3.7.52.151 S=3.7.52.164 LEN=40, ID=10027
14:46:19.251971 engctn1 -> engbay26length:60 TCP D=1192 S=2106 Rst Ack=1001039842 Win=0

Example C below shows what would be logged in the dcplog with incorrect port number problem. This is really a tcp initialization error, attempting to open an association, the remote host is up and running but the port number is wrong. Note: this same error can also be caused by the remote application (camera server) not running.

Example C:

{ctuser@engbayXX}[17] cd /usr/g/ctusr/logfiles
{ctuser@engbayXX}[18] more dcplog
DICOM print_scu pid: 2523
print_scu -aIMN -hengctn1 -c1 -f1x1_fid -p./1on1 -d./camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN host engctn1 ip-addr 3.7.52.164 port 2106
EstablishAssoc: DCM_OPEN_REQ Action success
Errors logged beyond this point of failure may be a result of this Error:
DCM kernel lower level error:
type = 508 -- DCM network error ¨ ERROR
code = 114 -- lost transport connection
ul_code = 52, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c line = 3051
Failed to contact printer, status 114

DCM Protocol Error

A DCM Protocol Error indicates a problem with calling parameters when trying to open an association. They can be caused by having an incorrect AE Title configuration. The errors

reported by a print server are only as good as the dicom implementation of that server. The Imation server will accept any called AE title. The Kodak mlp190 will accept any called AE title. The AGFA however, requires the AE to match. The following are examples of what will be reported in the dcplog, with an incorrect AE Title on an AGFA system (Example D), and what snoop is reporting (Example E).

Example D:

cd /usr/g/ctuser/logfiles
more dcplog
print_scu -aIMN1 -hengctn1 -c1 -f1x1_fid -p./1on1 -d./camera.dev
DICOM print_scu pid: 2492
print_scu -aIMN1 -hengctn1 -c1 -f1x1_fid -p./1on1 -d./camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN1 host engctn1 ip-addr 3.7.52.164 port 2106
EstablishAssoc: DCM_OPEN_REQ Action success
Errors logged beyond this point of failure may be a result of this Error:
DCM kernel lower level error:
type = 507 -- DCM Protocol error ERROR
code = 166 -- invalid pdu parameter value
ul_code = 37, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c line = 3051
DCM kernel lower level error:
type = 503 -- DCM Kernel integrity errors
code = 136 -- error with the dicom upper layer
ul_code = 22, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c line = 500
Fatal DCM error: 136
dcm_deinit: Kernel Deinit Failed
Failed to contact printer, status 166

EXAMPLE E:

The number of packets, outbound and inbound with length of ~60 and ~500 indicates that the remote application is running, but it is not allowing the scu (Service Class User, i.e. the OC) to open an association. This also indicates the IP Address and Port Number is correct.

engbay26 2# **snoop -SVta <*camera IP address*>**

Using device ef0 (promiscuous mode)

15:10:36.357083 engbay26 -> engctn1 length: 58 ETHER Type=0800 (IP), size = 58 bytes
15:10:36.357083 engbay26 -> engctn1 length: 58 IP D=3.7.52.164 S=3.7.52.151 LEN=44, ID=59135
15:10:36.357083 engbay26 -> engctn1 length: 58 TCP D=2106 S=1209 Syn Seq=1188358241 Len=0 Win=16384

15:10:36.358280 engctn1 -> engbay26 length: 60 ETHER Type=0800 (IP), size = 60 bytes
15:10:36.358280 engctn1 -> engbay26 length: 60 IP D=3.7.52.151 S=3.7.52.164 LEN=44, ID=37125
15:10:36.358280 engctn1 -> engbay26 length: 60 TCP D=1209 S=2106 Syn Ack=1188358242 Seq=1847802416 Len=0 Win=8760

15:10:36.358390 engbay26 -> engctn1 length: 54 ETHER Type=0800 (IP), size = 54 bytes
15:10:36.358390 engbay26 -> engctn1 length: 54 IP D=3.7.52.164 S=3.7.52.151 LEN=40, ID=59137
15:10:36.358390 engbay26 -> engctn1 length: 54 TCP D=2106 S=1209 Ack=1847802417 Seq=1188358242 Len=0 Win=16060

15:10:36.361533 engbay26 -> engctn1 length: 456 ETHER Type=0800 (IP), size = 456 bytes
15:10:36.361533 engbay26 -> engctn1 length: 456 IP D=3.7.52.164 S=3.7.52.151 LEN=442, ID=59138
15:10:36.361533 engbay26 -> engctn1 length: 456 TCP D=2106 S=1209 Ack=1847802417 Seq=1188358242 Len=402 Win=16060

15:10:36.412509 engctn1 -> engbay26 length: 60 ETHER Type=0800 (IP), size = 60 bytes
15:10:36.412509 engctn1 -> engbay26 length: 60 IP D=3.7.52.151 S=3.7.52.164 LEN=40, ID=37126
15:10:36.412509 engctn1 -> engbay26 length: 60 TCP D=1209 S=2106 Ack=1188358644 Seq=1847802417 Len=0 Win=8760

15:10:36.424127 engctn1 -> engbay26 length: 64 ETHER Type=0800 (IP), size = 64 bytes
15:10:36.424127 engctn1 -> engbay26 length: 64 IP D=3.7.52.151 S=3.7.52.164 LEN=50, ID=37127
15:10:36.424127 engctn1 -> engbay26 length: 64 TCP D=1209 S=2106 Ack=1188358644 Seq=1847802417 Len=10 Win=8760

15:10:36.424376 engbay26 -> engctn1 length: 64 ETHER Type=0800 (IP), size = 64 bytes
15:10:36.424376 engbay26 -> engctn1 length: 64 IP D=3.7.52.164 S=3.7.52.151 LEN=50, ID=59141
15:10:36.424376 engbay26 -> engctn1 length: 64 TCP D=2106 S=1209 Ack=1847802427 Seq=1188358644 Len=10 Win=16060

15:10:36.428902 engctn1 -> engbay26 length: 60 ETHER Type=0800 (IP), size = 60 bytes
15:10:36.428902 engctn1 -> engbay26 length: 60 IP D=3.7.52.151 S=3.7.52.164 LEN=40, ID=37128
15:10:36.428902 engctn1 -> engbay26 length: 60 TCP D=1209 S=2106 Fin Ack=1188358654 Seq=1847802427 Len=0 Win=8760

15:10:36.428975 engbay26 -> engctn1 length: 54 ETHER Type=0800 (IP), size = 54 bytes
15:10:36.428975 engbay26 -> engctn1 length: 54 IP D=3.7.52.164 S=3.7.52.151 LEN=40, ID=59143
15:10:36.428975 engbay26 -> engctn1 length: 54 TCP D=2106 S=1209 Ack=1847802428 Seq=1188358654 Len=0 Win=16060

Note: If the AE title is correct, the server may have a security feature that requires that the local host be registered on the remote host.

Image Packet Transfer, Output From snoop

This is an excerpt from a snoop output representing actual image packets, (length ~1514), being transferred to the camera:

12:19:58.436211 engbay26 -> engctn1 length: 1514 ETHER Type=0800 (IP), size = 1514 bytes
12:19:58.436211 engbay26 -> engctn1 length: 1514 IP D=3.7.52.164 S=3.7.52.151 LEN=1500, ID=38793
12:19:58.436211 engbay26 -> engctn1 length: 1514 TCP D=2106 S=1511 Ack=3095191028 Seq=1815234494 Len=1460 Win=16060

12:19:58.436256 engbay26 -> engctn1 length: 1514 ETHER Type=0800 (IP), size = 1514 bytes
12:19:58.436256 engbay26 -> engctn1 length: 1514 IP D=3.7.52.164 S=3.7.52.151 LEN=1500, ID=38794
12:19:58.436256 engbay26 -> engctn1 length: 1514 TCP D=2106 S=1511 Ack=3095191028 Seq=1815235954 Len=1460 Win=1606

3.3.2 Snoop

Snoop (snoop) is the troubleshooting tool that monitors all the communication and image packets inbound and outbound to the camera during a print job (depending on switch settings). The packet size length is important in understanding what is being transferred. A length size of < 500 indicates requests and responses between the scanner and the print server. These are from the NGET (printer status), and NCREATE (film session and film box). A series of packet lengths of about 1500 indicates an image transfer in progress. This applies to both dicom print and dicom send.

STEP	COMMENT
1. Open up a Unix shell	From Desktop, select Unix Shell
2. Become root.	**su -**
3. Start the snoop session in the shell and set it up to display outgoing and incoming packets.	**snoop -SVta <camera ip address>**
4. Send a DICOM Print job to the camera	In ImageWorks desktop, display an image and drag/drop the image into the film composer and Print it.
5. Observe the output packets of data being sent and received.	Length sizes < 500 = communication request between the scanner and the print server. Length sizes ~1500 = the image packet size being sent.

Table 4-4 Steps for Starting a Snoop Session

The following examples show common uses of snoop. See Number 3, below, for a description of snoop usage and switch descriptions. Typical use examples:

1.) How to display outgoing and in-going packets:

{ctuser@bayXX}[3] **su -**
password
bayxx 1# **snoop -SVta <camera ip address>**
Using device ef0 (promiscuous mode)
15:00:18.606959 engbay26 -> engctn1 length: 58 ETHER Type=0800 (IP), size = 58 bytes
15:00:18.606959 engbay26 -> engctn1 length: 58 IP D=3.7.52.164 S=3.7.52.151 LEN=44, ID=59593
15:00:18.606959 engbay26 -> engctn1 length: 58 TCP D=2104 S=3565 Syn Seq=1295817451 Len=0 Win=16384
15:00:18.608481 engctn1 -> engbay26 length: 60 ETHER Type=0800 (IP), size = 60 bytes
15:00:18.608481 engctn1 -> engbay26 length: 60 IP D=3.7.52.151 S=3.7.52.164 LEN=40, ID=33153
15:00:18.608481 engctn1 -> engbay26 length: 60 TCP D=3565 S=2104 Rst Ack=1295817452 Win=0

2.) How to display incoming packets only:

{ctuser@bayXX}[3] **su -**
password
bayxx 1# **snoop -SPVta <camera ip address>**
Using device ef0 (promiscuous mode)
14:58:54.506391 engctn1 -> engbay26 length: 60 ETHER Type=0800 (IP), size = 60 bytes
14:58:54.506391 engctn1 -> engbay26 length: 60 IP D=3.7.52.151 S=3.7.52.164 LEN=40, ID=14589
14:58:54.506391 engctn1 -> engbay26 length: 60 TCP D=3563 S=2104 Rst Ack=1285065404 Win=0

3.) Usage for snoop:

```
[ -a ]          # Listen to packets on audio
[ -d device ]# settable to le?, ie?, bf?, tr?
[ -s snaplen ]# Truncate packets
[ -c count ]  # Quit after count packets
[ -P ]          # Turn OFF promiscuous mode
[ -D ]          # Report dropped packets
[ -S ]          # Report packet size
[ -i file ]     # Read previously captured packets
[ -o file ]     # Capture packets in file
[ -n file ]     # Load addr-to-name table from file
[ -N ]          # Create addr-to-name table
[ -t  r|a|d ]   # Time: Relative, Absolute or Delta
[ -v ]          # Verbose packet display
[ -V ]          # Show all summary lines
[ -p first[,last] ]# Select packet(s) to display
[ -x offset[,length] ]# Hex dump from offset for length
[ -C ]          # Print packet filter code
```

For additional information, refer to the manual page for snoop. To do so, open a Unix shell, and enter the following:

su -
password
man snoop

3.4 Sample Logs

3.4.1 lclog - laser camera log

```
Successful Camera Initialization
User_Msg... CODE----> 301
#301fname = /usr/g/ctuser/film/img41a000QY
arg_copies = 1arg_format = 4x3_fidddasm952 interface was loaded...Set_Vendor_Bits...LcSyscall: cmd 30
scsisleep duration=100000000nsLcgetResponse: ready 1
Set_12_Line_Border pass...
LcSyscall: cmd a4
LcgetResponse: ready 1
Clear_Alarm...LcSyscall: cmd 85
LcgetResponse: ready 1
Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY"
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 82
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(ALI): status160->PAS
Allocate_Device OK
opening data file /usr/g/ctuser/film/img41a000QYSet_Greyscale...
LcSyscall: cmd a5
LcgetResponse: ready 1
```

Start of Print Job

STATISTICS**********START PRINTING FILM**********/usr/g/ctuser/film/img41a000QYLcSyscall: cmd 90
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(MAT): status160->PAS
LcSyscall: cmd a3
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(LUT): status160->PAS
LcSyscall: cmd 9f
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(WIM): status160->PAS
Lc_clear_all:CMI...LcSyscall: cmd 86
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(CLR): status160->PAS

Start of Image Acquisition Process

lc_load_and_acquire: img->image_sx=512lc_load_and_acquire: img->image_sy=512lc_load_and_acquire: img->image_psize=0.000000main : zoomd = 0, zoomh = 0
set_zoomd : ...set_zoomf...loading file /usr/g/ctuser/film/img41a000QYxxL952_vdbSetFormat pass...format = 12 zoom = 0.000000
set_zoomd : ...set_zoomf...L952_vdbSetFormat leavingOLD SYTLE IMAGE ACQUISITION, NO RING BUFFERINGentering rbL952_lcamStore: fname = /usr/g/ctuser/film/img41a000QY, num_imgs=12, hdrlen =632entering rbL952_lcamStore: image_sx = 512,image_sy =512, image_deep= 8rbL952_lcamStore: nbchuncks = loop_var = 16 nblocks= 512 image_size =262144ACQUIRE IMAGE... Image_ID = 1
LcSyscall: cmd 84
LcgetResponse: ready 0
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(AQU): status160->PAS
ACQUIRE IMAGE... Image_ID = 2

Comment: The above 6 steps are repeated for each succeeding Image Acquisition. Image acquisition completed, begin Printing

LcSysrep(AQU): status160->PAS
L952_vdbPrint: format = 12 print_copies = 1Define_Zone: format = 12set_zoomd : ...set_zoomf...xxDefine_Zone: format = 12 nb_zone = 4 nb_image_line 3xxDefine_Zone: set_zoomd = 0.000000 , set_zoomf = 0.000000scan_ssparam = dd
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] = 1xxDefine_Zone: images_id[1] = 2xxDefine_Zone: images_id[2] = 3Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY"
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(DZO): status160->PAS
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] = 5xxDefine_Zone: images_id[1] = 6xxDefine_Zone: images_id[2] = 7Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1

LcSysrep: resp ``STA,1,RDY"
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(DZO): status160->PAS
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] = 9xxDefine_Zone: images_id[1] = 10xxDefine_Zone: images_id[2] = 11Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY"
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(DZO): status160->PAS
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] = 13xxDefine_Zone: images_id[1] = 14xxDefine_Zone: images_id[2] = 15Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY"
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS"
LcSysrep(DZO): status160->PAS
Lc_set_up_to_print call...nbcopies= 1LcSyscall: cmd 9a
LcgetResponse: ready 1
LcSysrep: resp ``STC"
LcSysrep(STP): status160->STC
LcSysrep(STP): STC OK...
EXPOSE...
LcSyscall: cmd 8d
LcgetResponse: ready 1
LcSysrep: resp ``PTC"
LcSysrep(EXP): status160->PTC
camscan: (17:75 to 8b) 0x72 EXP 0xd 0x6 EOE 0xd & 0xa 0xb 0xc PTC 0xd & 0xa 0xb 0xc 0xa
camscan: dcr's 1
LcSysrep(EXP): DCR...print_copies = 0User_Msg... CODE----> 353
#353

Comment: *End of Print Job*

STATISTICS:******END OF THIS JOB /usr/g/ctuser/film/img41a000QY Ready To Print new*******Release_Device...LcSyscall: cmd 95
LcgetResponse: ready 1
User_Msg... CODE----> 350
#350

3.4.2 dcplog - dicom print log

dcplog Sample Output of a Successful 1on1 Film Job.

Note: The output is broken up into sections with key film session actions in bold, and an explanation indented and in italics. The dcplog includes the use of these acronyms in the following example:

SCP = Service Class Provider: The camera, a receiver of images.

SCU = Service Class User: The OC scanner, has ability to send images

calling AE title

dcm_bind: AETitle = engbay26_DCP

called AE title - hostname - IP address port number of printer

map_app_title: title IMN host engctn1 ip-addr 3.7.52.164 port 2104

Print SCU (on the OC) requests an association with print SCP (print server at camera) using the IP address, port number and AE title. The SCU proposes abstract syntaxes (in this case print service class) along with transfer syntaxes used for each syntax and PDU transfer rate.

EstablishAssoc: DCM_OPEN_REQ Action success

The Print SCP responds with an association acceptance. If the association has been accepted, the Dicom parameters (host, IP, AE, port correctly configured):

EstablishAssoc: OPEN_CONF received

The SCU sends an NGET request to the SCP for printer status:

Starting the print session

The SCP returns an NGET response status and printer status to the SCU:

Note:
- IF the SCP returns a NORMAL status to the SCU, the job continues.
- If the SCP returns an ERROR status to the SCU, the print job will fail.
- If the SCP returns a WARNING status, the job may fail or continue depending on status info. See table for list of supported status.

NgetService: Event Received: DCM_NGET_END

NgetService: Event Received: DCM_DATA

PRINTER STATUS	
SOP uid	
Instance uid	
Printer status	NORMAL
status info	
printer_name	advt
manufacturer	AGFA
model	ADVT
device serial number	123456
software version	Version 2.0
AETitle	IMN

Table 4-5 Printer Events

The SCU sends an NCREATE request to the SCP to create the film session. The Film session presentation consists of copies, priority of job, medium type, and film destination:

NcreateService: NCREATE BEG Action Success

NcreateService: DCM DATA Action Success

NcreateService: Waiting for Event

NcreateService: Event received: DCM_RETURN_BUFF

NcreateService: Waiting for Event

The SCP returns Ncreate RSP status to SCU along with instance uid for film session:

NcreateService: Event received: DCM_NCREATE_END

NcreateService: Status is : 0

film session instance uid 1.3.51.1

film session instance uid 1.3.51.1

filmbox ref sop uid 1.3.51.1

The SCU sends NCreate RQ to the SCP to create the film box. The presentation includes film format, orientation, magnification, film size:

NcreateService: NCREATE BEG Action Success

NcreateService: DCM DATA Action Success

NcreateService: Waiting for Event

The SCP returns NCREATE RSP status to the SCU along with referenced sop instance uid for film box and referenced SOP instance uids for each image box:

NcreateService: Event received: DCM_RETURN_BUFF

NcreateService: Waiting for Event

NcreateService: Event received: DCM_NCREATE_END

NcreateService: Waiting for Event

NcreateService: Event received: DCM_DATA

filmbox instance uid 1.3.51.1.1

SCU sends NSET RQ to the SCP to set the image box. The presentation includes instance uid, image position on the film, number of Rows, Columns, Bits, and image pixel data:

NsetService: Event Received: DCM_RETURN_BUFF

SCP returns NSET RSP status to the SCU along with affected sop instance uid for image box:

NsetService: Event Received: DCM_NSET_END

Image Attributes set

The SCU and SCP repeat the NSET RQ and NSET RSP for the image boxes until all images have been sent to the SCP. When all images have been sent, the SCU, it sends NACTION RQ to the SCP to print the film box with instance uid generated during the NCREATE. The SCP returns NACTION RSP to print the film:

NactionService: Event received: DCM_NACTION_END

NactionService: Event received: DCM_DATA

parse_data_set returned status 0x0

Film Box sent to printer N - Action

The SCU sends NDELETE RQ to the SCP to delete the film box with instance uid generated during the NCREATE. SCP returns NDELETE RSP to delete the film box and returns the sop Instance of the film job:

NdeleteService: Event Received : DCM_NDELETE_END

Film box instance deleted

ref SOP C uid 1.2.840.10008.5.1.1.14

ref SOP I uid 1.3.51.1.1.1.1

Print Session successfully completed

The SCU sends RELEASE RQ to the SCP to release the association:

req close assoc

CloseAssoc: DCM_CLOSE_REQ Action Success

The SCP returns RELEASE RP to release association:

close accepted

3.4.3 prslog - printer server log

LOCATION	DESCRIPTION
OC: /usr/g/ctuser/logfiles/prslog	This is a running history log of print server initializations and shutdowns, and print jobs are started and completed.
Example prslog output	
Successful print server initialization:	
MESSAGE from Process 1639>> Tue Aug 18 13:10:38 1998	[Server]> initialization in progress for port PRSserver
MESSAGE from Process 1639>> Tue Aug 18 13:10:38 1998	[Server]> ...initialization completed for port PRSserver
MESSAGE from Process 1674>> Tue Aug 18 13:11:02 1998	[PRSserver]> Hello, I'm the print server, still alive on host engbay13
Successful print jobs running:	
MESSAGE from Process 1799>> Tue Aug 18 13:15:56 1998	[PRSserver]> Print job started
MESSAGE from Process 1799>> Tue Aug 18 13:16:21 1998	Printed Ex: 1472 Se: 103 Im: 1
MESSAGE from Process 1799>> Tue Aug 18 13:16:21 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 1
MESSAGE from Process 1817>> Tue Aug 18 13:16:50 1998	[PRSserver]> Print job started
MESSAGE from Process 1817>> Tue Aug 18 13:17:16 1998	Printed Ex: 1472 Se: 103 Im: 25
MESSAGE from Process 1817>> Tue Aug 18 13:17:16 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 25
MESSAGE from Process 1825>> Tue Aug 18 13:17:41 1998	[PRSserver]> Print job started
MESSAGE from Process 1825>> Tue Aug 18 13:18:06 1998	Printed Ex: 1472 Se: 103 Im: 49
MESSAGE from Process 1825>> Tue Aug 18 13:18:06 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 49
MESSAGE from Process 1831>> Tue Aug 18 13:18:33 1998	[PRSserver]> Print job started
MESSAGE from Process 1831>> Tue Aug 18 13:18:59 1998	Printed Ex: 1472 Se: 103 Im: 73
MESSAGE from Process 1831>> Tue Aug 18 13:18:59 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 73
Print server shutdown from Applications being brought down:	
MESSAGE from Process 1639>> Tue Aug 18 14:48:34 1998	[Server]> Caught signal : 2
MESSAGE from Process 1674>> Tue Aug 18 14:48:35 1998	[Server]> Caught signal : 2.
MESSAGE from Process 1639>> Tue Aug 18 14:48:41 1998	[Server]> terminated
Successful print server initialization:	
MESSAGE from Process 1598>> Tue Aug 18 14:53:43 1998	[Server]> initialization in progress for port PRSserver
MESSAGE from Process 1598>> Tue Aug 18 14:53:43 1998	[Server]> ...initialization completed for port PRSserver
MESSAGE from Process 1636>> Tue Aug 18 14:54:09 1998	[PRSserver]> Hello, I'm the print server, still alive on host engbay13
MESSAGE from Process 1902>> Tue Aug 18 15:15:40 1998	[PRSserver]> Print job started
MESSAGE from Process 1902>> Tue Aug 18 15:16:06 1998	Printed Ex: 1476 Se: 2 Im: 1
MESSAGE from Process 1902>> Tue Aug 18 15:16:06 1998	[PRSserver]> Completed print job: Ex: 1476 Se: 2 Im: 1
MESSAGE from Process 1926>> Tue Aug 18 15:17:10 1998	[PRSserver]> Print job started
MESSAGE from Process 1926>> Tue Aug 18 15:17:35 1998	Printed Ex: 1476 Se: 2 Im: 16
MESSAGE from Process 1926>> Tue Aug 18 15:17:35 1998	[PRSserver]> Completed print job: Ex: 1476 Se: 2 Im: 16

Table 4-6 prslog Output

3.4.4 camera.dev (AGFA DICOM Print Camera)

Enter the following:

1.) {ctuser@bayXX}[5] **cd /usr/g/ctuser/app-defaults/devices**

2.) {ctuser@bayXX}[6] **cat camera.dev**

camera.dev **CONTENTS LISTING**	**DESCRIPTION**
set dName {Dicom Camera}	Sets the name that appears in manual composer and scanRx autofilm setup
set dType digital	Refers to 1 of {postscript, analogue, or digital}. For DICOM the dType is set to digital.
set dQueueType DICM	Refers to the Job type; can be {LP=postscript, LC=laser camera, or DICM} for DICOM print cameras.
set ctype {Imation Print Server}	DICOM camera type selected during Camera Installation
set dQueueName dicom	Sets the name that appears in the Filming Queue
set defaultFormat 4x3_fid	Default format for manual composer selected during Camera Installation
set dHostName agfacamera	Hostname of the print server entered during Camera Installation
set dAppTitle DRYSTAR	AE title of the print server entered during Camera Installation
set medType BLUE	Medium type selected during Camera Installation - can be one of BLUE FILM, CLEAR FILM, or PAPER - this element is sent during NCREATE of the Film Session.
set destination MAGAZINE	The destination for printed film selected in during Camera Installation. Can be one of MAGAZINE, PROCESSOR - this element is sent during NCREATE of the Film Session.
set filmOrientation PORTRAIT	The Orientation of image boxes on film selected during Camera Installation can be one of LANDSCAPE or PORTRAIT - this element is sent during NCREATE of the Film Box.
set magType CUBIC	The magnification of film selected during Camera Installation. Can be one of REPLICATE, BILINEAR, CUBIC, or NONE - this element is sent during NCREATE of the Film Box.

Table 4-7 camera.dev contents listing

camera.dev **CONTENTS LISTING**	**DESCRIPTION**
set minDensity 5 set maxDensity 300 set borderDensity BLACK set emptyDensity BLACK set smoothType 140 set configuration PERCEPTION_LUT=200	These elements are sent during the NCREATE of the Film Box and will set the following values: • sets minimum Optical Density - film and camera type dependent. • sets Maximum Optical Density - film and camera type dependent. • sets border density • sets empty image density • sets the smoothing type when magType is set to CUBIC • sets configuration info. This value differs for all camera vendors who typically define the LUT for contrast.
pformat 1x1_fid pformat 2x1_fid pformat 2x2_fid pformat 3x2_fid pformat 3x3_fid pformat 4x3_fid pformat 5x3_fid pformat 4x4_fid pformat 5x4_fid	Manual film composer and auto film formats Note: DICOM defines film format as column vs. row, as opposed to GE's Laser film format definition of row vs. column.

Table 4-7 camera.dev contents listing (Continued)

3.4.5 SdCPHosts (DICOM Print only)

Enter the following:

1.) {ctuser@bayXX}[2] **cd /usr/g/ctuser/Prefs** ENTER

2.) {ctuser@bayXX}[3] **cat SdCPHosts** ENTER

SdCPHosts **CONTENTS LISTING EXAMPLE**	**DESCRIPTION**
3.7.52.164	The IP address of the camera, entered during Camera Installation
camera	The hostname of the camera, entered during Camera Installation
PRINTSCP	The AE (Applications Entity) Title, entered during Camera Installation
2106	The TCP Listen Port number, entered during Camera Installation
ctn display	A comment entered in the network comment field of Camera Installation.

Table 4-8 SdCPHosts contents listing example

© 20006, General Electric Company.
GE Medical Systems, a General Electric Company, going to market as GE Healthcare.
3000 N. Grandview Boulevard
Waukesha, Wisconsin 53188
USA

www.gehealthcare.com

GE Healthcare

LightSpeed 2.X

Service Manual - General

OPERATING DOCUMENTATION

2243314-100
Rev 22

Book 3 of 6:

- Chapter 5 (Console)
- Chapter 6 (Table)

Pages # - 472

Effectivity

The information in this manual applies to the following GE Healthcare LightSpeed 2.X CT Scanners:

- LightSpeed Plus (SDAS)
- LightSpeed QX/i (SDAS)

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Chapter 5
Console

Section 1.0
Theory

NOTICE **The GOC3 (a.k.a. GRE Xtream Operator Console) is available as an upgrade on LightSpeed 2.X CT scanners. For service information particular to the GOC3 (GRE), please refer to Dir 2378259-800, found on CD-ROM 2384451-200.**

1.1 Console Overview

The console is divided into two functional subsystems, one is called the Host and the other the Scan Reconstruction Unit (SRU). The Host subsystem consists of the following hardware:

- Host computer
- Mouse, keyboard, trackball & monitors
- System disks
- MOD
- CDROM
- Network devices (switches and converters)
- Serial I/O (input/output)

The Scan Reconstruction Unit (SRU) subsystem consists of the following hardware:

- ICE box
- Pegasus Image Generator
- Motorola Computer
- DIP
- Scan Data Disk

Communications between these two functional subsystems takes place via network and serial connections. Communications between the host and SRU take place primarily using network channel. Using the network channel allows sharing of resources on the host disk by the SRU (client). Serial communications are used for the downloading and “flashing” memory (PROM) in the SRU when needed.

Table 5-1 lists the key components covered in this chapter, as well as their acronyms.

COMMON NAME	ACRONYM	COMMON NAME	ACRONYM
Octane Computer	HOST	VME Chassis/enclosure and Boards	ICE Box
DAS Interface Processor	DIP	Recon Interface Processor (Motorola Board)	RIP

Table 5-1 Naming Conventions

COMMON NAME	ACRONYM	COMMON NAME	ACRONYM
Pegasus Image Generator	PIG/PEG-IG	Scan Recon Computer	SRU
Scan Data Disk	SDD	Small Computer System Interface	SCSI
System Control Interface Module	SCIM	Data Acquisition System Manager	DASM

Table 5-1 Naming Conventions (Continued)

1.1.1 Physical Organization

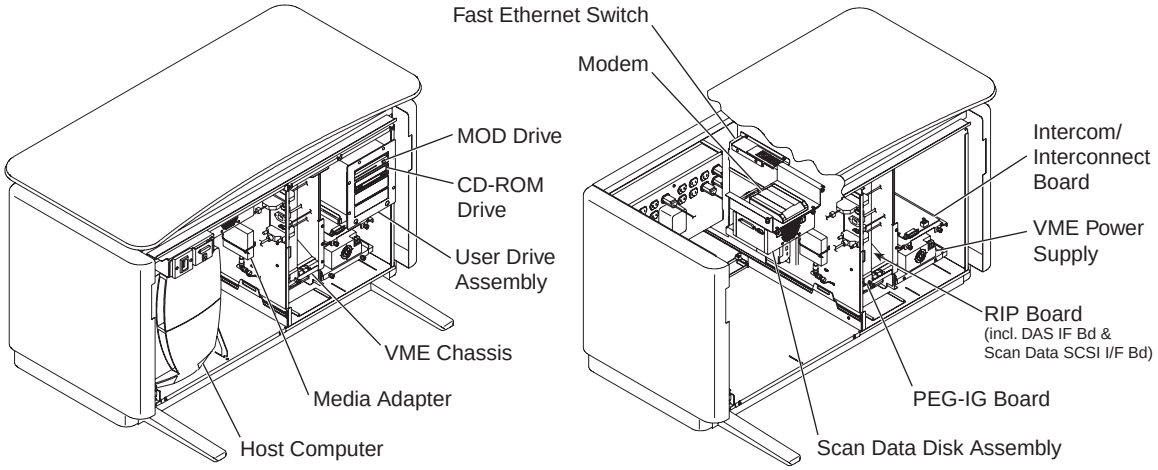


Figure 5-1 Locations of Key Console Components

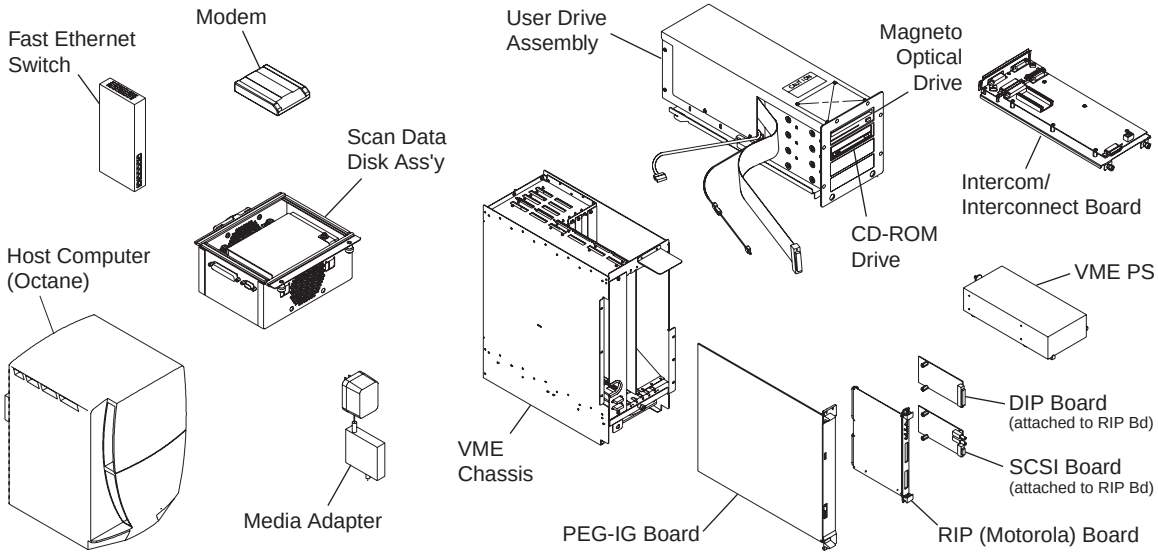


Figure 5-2 Key Console Components

1.1.2 Block Diagram

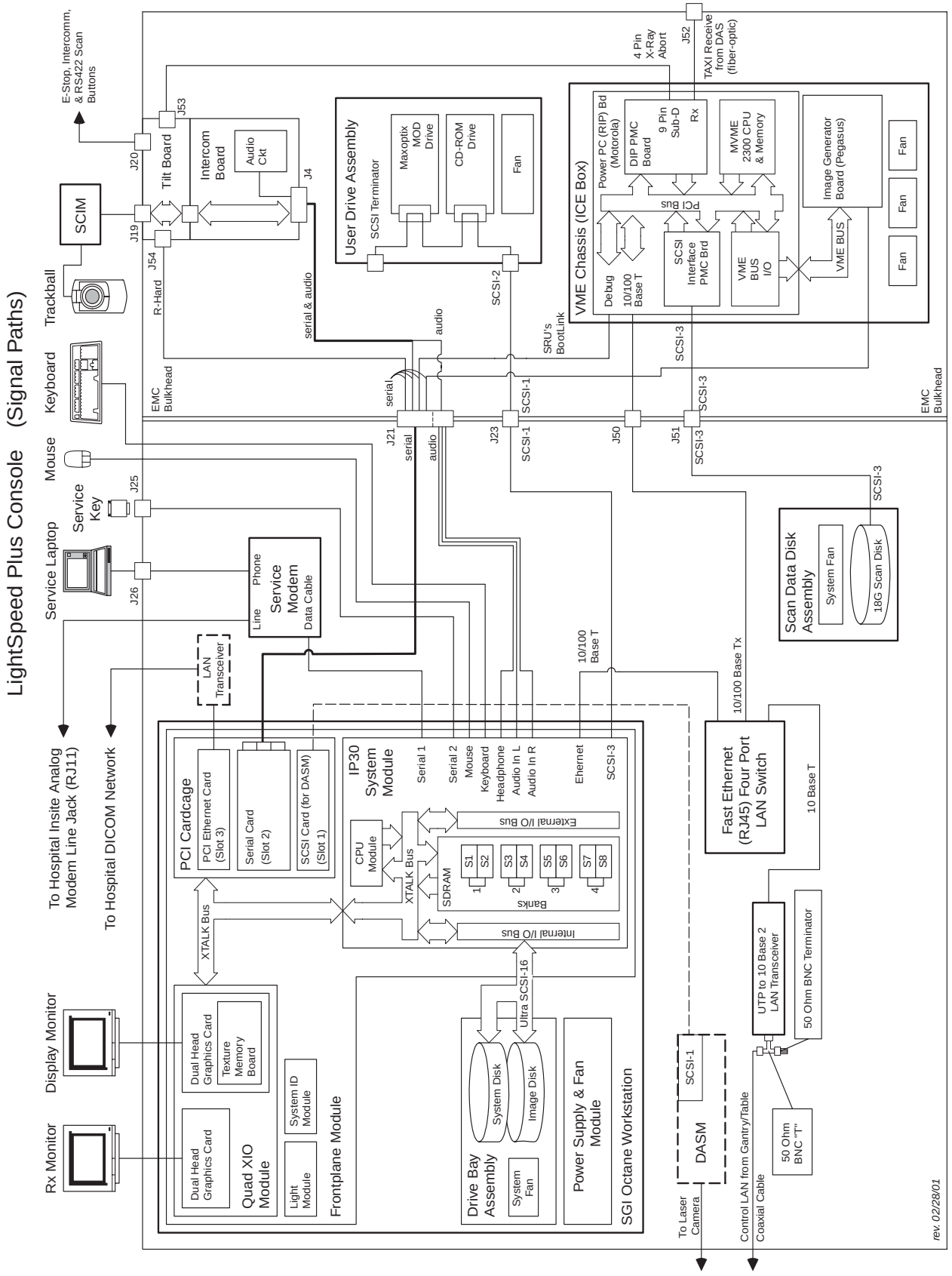


Figure 5-3 Console Block Diagram

1.2 Host Subsystem

1.2.1 System Control Interface Module (SCIM)

The SCIM provides the Scan Control (Start Scan, Pause Scan, Stop Scan, Move To Scan, Stop Move, Prescribed Tilt and Emergency Stop) and Intercom (Patient, Operator and Auto Voice) functionality. The SCIM also provides a visual X-Ray On indicator for exposures.

The SCIM is connected to the Operator Console back bulkhead at J19. The physical interface is a 1.8 meter 50 conductor cable with micro HD 50 male connectors at each end. This interface cable provides both DC power (+5, +12V and -12V) and communication (RS-422) signals using discrete paths.

Upon power-up, the SCIM performs a self test of its internal processor and memory. Upon passing all self tests, all LEDs illuminate for two seconds and then turn off. If any of the self tests fail, the LED On/Off sequence does not occur.

The microprocessor within the SCIM monitors the communication path to the Host computer for requests, and the state of the keys on the SCIM. Any time a key state change is detected, communications is sent to the host computer.

Overlays are used to identify SCIM functionality. SCIM overlays are available for different SCIM configurations and in several different languages.

The SCIM is spill resistant but not spill proof. It has been designed to withstand an accidental spill of liquids (such as coffee or soft drinks) into the enclosure. An elastomer within the SCIM routes spilled liquids to drain holes on the underside of the unit. Over-current protection has also been incorporated into the SCIM, in the event liquid does reach internal electronic components. Allow the SCIM to drain and dry, if liquids enter the enclosure.

There are NO serviceable parts within the SCIM, keyboard or cable.

1.2.2 Video Display Monitors

This product uses energy efficient (1 Watt deep sleep mode) conventional Cathode Ray Tube (CRT) computer monitors. Both monitors' CRTs used in this CT scanner are manufactured by the Sony Corporation. Each features a flat faced trinitron tube with a viewable area of 19.8 inches and a dot pitch of 0.24mm. The CRT has a 39% face plate transmission and an AR/AS coating. The monitors support a full set of user definable settings. Color temperature (9300K, 6500K, 5000K) is selectable via a nine language on-screen display (OSD). See Section 2.1.1.3, on page 304 for complete setup instructions.

Figure 5-4 Display Monitors

1.2.2.1 Signal Input Parameter

- Horizontal 30-121 kHz
- Vertical: 48-160 HZ
- Input connector:HD 15 D-Sub
- Video: Analog RGB, 0.700Vp-p, positive, 75 OHM
- Sync: Separate HD/VD, TTL Polarity Free or External Composite, TTL Polarity Free

1.2.2.2 Power Specifications

- 100-120/220-240 VAC; 50/60Hz (Auto Sensing)
- Meets EPA Energy Star, VESA DPMS & NUTEK 803299

1.2.2.3 Agency Approvals

- Safety: UL, EN60950 (TUV, GS Mark)
- Marking: CE
- EMI: FCC Class B, IC B, CISPR22B, VCCI Level II
- X-Ray: DHHS, DNHW, PTB
- Human factor: MPR2, ZH1/618, ISO 9241-3 & 8, TCO-99

1.2.2.4 Mechanical Specifications

- 491mm x 498mm x 478mm (HxWxD) - Tilt swivel included
- 32 kg (70.4 lbs)

1.2.2.5 Timing Characteristics and Video Levels

The following tables define the video signal timing for the image and operator display video outputs. Both channels are 1280 x 1024 RGB color at 72HZ, 1 Volt peak-to-peak video at 75 ohms.

DISPLAY MONITOR - VIDEO CHARACTERISTICS	
Parameter	72 Hz
Active Pixel Format	1280 x 1024
Field/Frame	non-interlaced
Refresh Rate	72.239 Hz
Pixel Clock Freq, Period	129.25 MHz, 7.737 ns
Horizontal Freq, Period	12.998 usec, 1680 pixels
Horizontal Active	9.903 usec, 1280 pixels
Horizontal Front Porch	0.232 usec, 30 pixels
Horizontal Sync	1.083 usec, 140 pixels
Horizontal Back Porch	1.780 usec, 230 pixels
Horizontal Blanking	3.095 usec, 400 pixels
Vertical Freq, Period	13.843 msec, 1065 lines
Vertical Active	13.310 msec, 1024 lines
Vertical Front Porch	38.99 usec, 3 lines
Vertical Sync	38.99 usec, 3 lines
Vertical Back Porch	454.93 usec, 35 lines
Vertical Blanking	532.92 usec, 41 lines
Equalization Pulses	yes (@horiz rate)
Serration Pulses	no

Table 5-2 Display Monitor Video Characteristics & Timing

VIDEO OUTPUT	VIDEO LEVEL	SYNC LEVEL	BLANKING LEVEL
Red	0.714 Vp-p	none	0.054 volts
Blue	0.714 Vp-p	none	0.054 volts
Green	0.714 Vp-p	0.286 volts	0.054 volts

Table 5-3 DASM Red/Green/Blue Output Level Specifications

1.2.2.6 Splitting Video Signals

Only use a high quality video signal splitter. If the display signal is used to drive multiple monitors, only use a commercial, high quality splitter (e.g., Black Box Corp. #RGBSplit-2, or Inline Corp. #IN3012). You should also use high quality (low loss) 75 ohm video cables. Splitters are also available from GE Healthcare (B7530RC).

1.2.3 LCD Monitor

1.2.3.1 Overview

The 1850X is a high performance 18.1" LCD (Liquid Crystal Display) monitor capable of over displaying 16 million colors. It is manufactured by NEC™ and "Ambix" Technology, which is a dual input technology allowing both analog and digital inputs off of one connector.

The monitor is setup and configured for use through using its on-board menu system (OSM). Please see Section 2.1.2, on page 309 for help using the OSM. For further information on this monitor, consult the NEC website: ***http://www.necmitsubishi.com.***

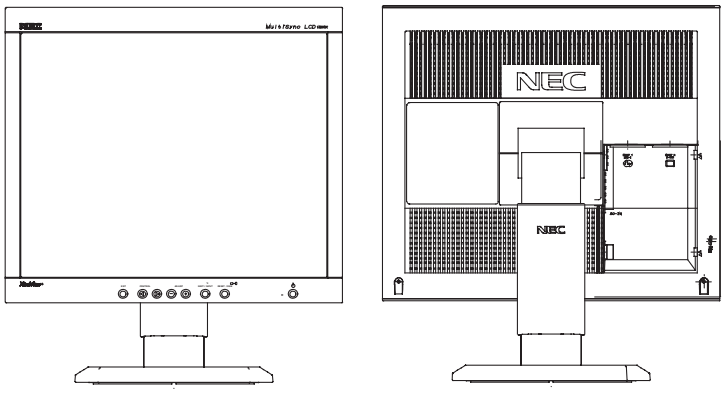


Figure 5-5 LCD Monitor (NEC 1850x)

1.2.3.2 Description

LCD:	a-Si active matrix thin-film-transistor (TFT)	
Effective display size:	(Landscape) 14.14"(H) x 11.31"(V) / 359.04mm(H) x 287.232mm(V)	
	18.1" / 46cm diagonal	
Viewing angle:	Up 85 deg. / down 85 deg. / right 85 deg. / left 85 deg. (Typical)	
Net Weight (Excluding stand):	12.1lbs / 5.5Kg	
Total Power Consumption:	65 watts (typical) in "ON" mode and less than 3 watts in power saving mode.	
Operating Environment:	Temperature	+41 to +95 deg.F / +5 to +35 deg.C
	Humidity	30% to 80%
	Altitude	0 to 10,000 Feet / 3,048m

1.2.4 Octane (Host) Computer

1.2.4.1 Overview - Hardware Features

The Host Computer is a Silicon Graphics Inc. (**SGI**) computer. Two versions of this computer can be used in this product: Octane or Octane2. Physically, they appear the same, except the Octane2 has blue covers (the original Octane has teal). Some key performance and service features include:

- A “slide-out” System Module, which contains the CPU(s)/bricks
- R12K Single or Dual (Direct-3D Option) brick processor
- Peripheral Device Support through an integrated chassis.
  - PCI expansion bay for three 32 or 64-bit wide PCI devices
  - Three 3.5-inch Ultra SCSI drive bays
- 512MB’s (non-D3D) or 1.5GB (D3D) upgrade-able DIMM Memory
- Powerful graphics subsystem that supports dual [head] monitors. Octane2 uses a V12 graphics XIO card/subsystem, with dual channel display (DCD) daughter card.
- A Unique System ID module (NIC Chip) containing system Ethernet number (which gets imprinted on option MODs)
- A slide-out Power Supply
- Dual 9GB, high speed (10k rpm), Small Computer System Interface (SCSI) disk drives. Slide-out internal hard drives with slot dependent SCSI IDs. The bottom slot being assigned SCSI ID1, the one above SCSI ID2, and the top slot for SCSI ID3, if installed.

Figure 5-6 Octane2 (left) and Octane (right) Host Computers

For additional information on Silicon Graphic’s Octane or Octane2 computer, please visit the manufacturer’s web site at ***http://www.sgi.com***.

1.2.4.2 System Module

The Silicon Graphics Octane/Octane2 workstation is powered by the 64-bit MIPS R12000A processor, with out-of-order execution, large flexible caches, and superscalar design. It features:

- R12KS-360 (single) or R12KS-400 (dual) MHz Processor(s)
- 4-way superscalar, 64-bit architecture
- Out-of-order instruction execution
- 5 separate execution units
- MIPS 4 instruction set
- 32KB two-way set-associative on-chip instruction cache
- 2MB fast L2 (secondary) cache

1.2.4.3 Peripheral Component Interconnect (PCI) Support

The host contains a Peripheral Component Interconnect (PCI) expansion chassis, which is connected to the main crossbar/crossbow bus within the Octane, and is capable of communicating at 266 MB per second. This bus is used to communicate with the Hospital's Ethernet network using a 10/100BT second ethernet PCI card. In addition, the PCI chassis contains a SCSI and serial.

PCI card cage contains 3 PCI-64 slots (2 full-height and 1 half-height) for either PCI-32 or PCI-64 cards. This card cage is inserted into the back of the Octane/Octane2 system.

The host computer configures the devices in the card cage during boot-up. The IRIX operating system assigns and configures at boot-up those devices it recognizes. Support for devices is either built into the kernel (e.g., SCSI support) or added later as device drivers (software). Device drivers (e.g., Serial expander PCI card) are added and loaded outside of the kernel.

The SGI Part Number is PCI-CARDCAGE

Figure 5-7 PCI Support Module

Fast Ethernet (100Base-TX) Adapter

The fast ethernet adapter provides a second 10/100Base-T port for the host computer. It is a one-port card that auto-negotiates between Fast Ethernet and Ethernet. The card also provides half and full duplex and auto-negotiates between the two. The port supports Category 5 unshielded twisted pair (UTP) wiring via an RJ45 connector. In addition to providing the additional Fast Ethernet port, the card also has one mouse and keyboard port. The SGI Part Number is PCI-FE-TX-MK

Figure 5-8 Fast Ethernet (100Base-TX) Adapter

SCSI PCI Card

This card fits into the PCI card cage. This single-ported card supports transfer rates up to 40Mb/S and can handle up to 6,000 I/Os per second, depending on system configuration and I/O transfer size. This PCI SCSI card supports active termination and has a 68-pin, high-density SCSI connector. The card is backward compatible with SCSI 1 and SCSI 2 devices. The SGI Part Number is PCI-SCSI-Q-SE-1P.

Serial Expansion PCI Card - Digi ClassicBoard

The Digi ClassicBoard is a high-performance 32 bit serial communications card. Manufactured by Digi International, it's available in multiple output port configurations. The card used in this product supports communication to 4 serial ports, through a DB78 connector. Internally, the board supports auto configuration of all PCI interrupts and speeds up to 460.8 Kbps. There are no user selectable jumpers or switches, and it occupies one slot in the host computer's PCI card cage.

Figure 5-9 Digi ClassicBoard Serial Port Expander Card

The board communicates electrically to the host (SGI) computer using the PCI bus. Software drivers designed for the board are loaded during OS/Apps installation and used to control and establish communications between hardware.

The Digi ClassicBoard is not manufactured for or distributed by SGI. For additional product information, visit Digi International's WEB site at ***http://www.digi.com.***

1.2.4.4 Dual In-line Memory Modules (DIMM)

The Octane host computer uses DIMM (Dual In-line Memory Module) memory. Octane's system memory is made up of DIMMs that use synchronous DRAM (SDRAM) technology—the fastest memory currently available. Each DIMM fills one of two slots in a bank. Memory must always be added in increments of two. A non-direct 3D system has one (1) pair of DIMMs, totalling 512MB of memory installed. A system with direct 3D (dual processor) has 1.5 GB (1536MB) system memory and three (3) pairs of DIMMs installed. DIMMs must always be of the same type and density throughout the system module.

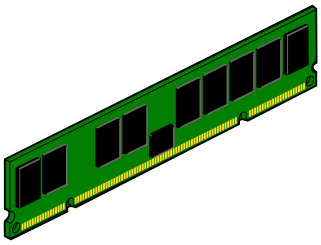


Figure 5-10 DIMM Memory

1.2.4.5 Octane2 Graphics Subsystem

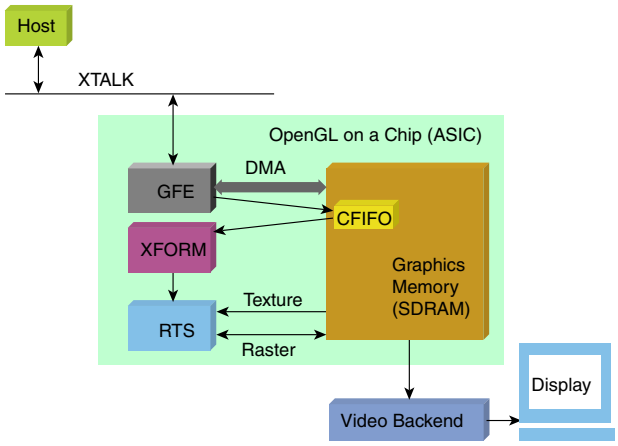
The Octane2 graphics subsystem differs from that found in the original Octane. It features a a V12 graphics XIO card/subsystem, with dual channel display (DCD) daughter card.

VPRO (V12) Graphics Card

OVERVIEW

Figure 5-11 V12 Graphics Subsystem (w/o DCD card)

The VPro (V12) is a high performance XIO graphics subsystem. It contains two primary ASICs: one for transformation and rasterization, and another for back end –video that goes to the DACs. Utilizing a ASIC containing OpenGL; transformation, lighting, texturing, clipping, and the image pipeline management is handle efficiently. The OpenGL ASIC interfaces to the display back end chip via a dedicated onboard bus and to the rest of the system via a 16-bit 800MB-per-second bidirectional XTALK interface. See Figure 5-12.



CFIFO: Deep command FIFO to buffer command streams
GFE: Graphics front end to process OpenGL graphics instructions
XFORM: Transform engine
RTS: Rasterization, texture, and shading engine

Figure 5-12 VPro (V12) Block Diagram (shown w/o DCD card)

The graphics subsystem utilizes a large and highly configurable memory for display. All buffers, texture memory and CFIFO memory are allocated from a single large graphics memory pool, as shown in Figure 5-13. Unlike the graphics subsystem used in Octane, texture memory is contained on the V12 graphics card. No additional texture memory card is required.

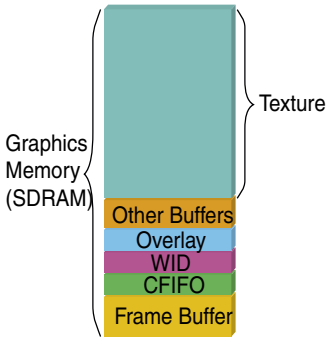


Figure 5-13 VPro (V12) Graphic Memory Organization

FEATURES

- Up to 128MB graphics memory including 104MB texture memory capacity.
- Hardware acceleration of OpenGL® 1.2 core features and imaging extensions.
- Hardware-accelerated specular shading.
- Advanced texture management with asynchronous texture download capability.
- 48-bit (12-bit per component) RGBA.
- 96-bit hardware-accelerated accumulation buffer for depth of field, full-scene anti-aliasing, motion blurs, and other effects.
- Perspective-correct textures and colors.
- High-performance hardware clipping.
- No user serviceable parts, jumpers or switches.

Dual Channel Display (DCD) Card

The Dual Channel Display (DCD) card is a daughter card that attaches to the V12 graphics card. With the DCD, the viewing area is expanded across two monitors. With the DCD installed, the left and right monitors are connected to it two output connectors. The output connector on the V12 is not connected/used when using the DCD card.

Figure 5-14 Dual Channel Display (DCD) Card

1.2.4.6 Small Computer System (Integral) Interface

The host contains three SCSI interfaces. Two of the interfaces are integrated into the computer's main system boards and the other is an add-on card found in the PCI card cage. Together, these SCSI interfaces talk to devices both inside and outside the computer's chassis.

The Hard disk drives internal to the computer's chassis are driven by one of the integral SCSI controllers. Another integral SCSI controller talks to the external CDROM and MOD devices. The third controller, in the PCI card cage, talks any attached SCSI device (i.e, DASM).

`Controller 0: ->` SCSI card for SGI Internal Hard Disk Drives

`Controller 1: ->` SCSI card for CD-ROM and MOD

`Controller 2: ->` SCSI card for DASM

SCSI device IDs are position dependent inside the computer's drive bay. Device ID zero (0) is assigned to the integral SCSI `controller 0` itself. During boot, the computer attempts to boot the OS from SCSI device ID 1 on `controller 0.` SCSI device ID 1 is assigned to the drive in the lowest slot of the computer's internal drive bay. Thus, it's important to keep the internal disk oriented correctly. The boot drive must always be keep in the lowest slot.

1.2.5 Magneto Optical Drive (MOD) - MaxOptix T5-2600, Sony SMO-F551-SD

1.2.5.1 Overview

Figure 5-15 MaxOptix T5-2600 Star (enclosure not included) & Sony SMO-F551-SD MODs

MOD drives are a combination of magnetic (magneto) and laser (optical) technologies. They are used to record data on read/write removable disks. High performance with reading speeds up to 4.6MB/sec can be realized.The MOD drive s a 5.25" half height format drive without an external enclosure, as shown inFigure 5-15.

Each removable MOD disk holds all of the image data. This versatile format allows desktop users to read and write data files, just like a high capacity hard disk, with the major added benefit of keeping a separate disk for each project or client.

Key system benefits include:

- user's files can be more easily organized
- unlimited capacity - add another disk when one gets full
- disks can be used easily for reliable archive back-ups
- transfer large amounts of data is simple & reliable
- secure sites can easily lock up their data at night

The drive also support a "write-once" format disk providing the ultimate in data security - once data is written, it cannot be altered.

1.2.5.2 Features

Reliability

Since the disks are read and written with a non-contact optical head, there is never a head crash like hard disk drives. The disks are made of high strength poly carbonate plastic, the same material as “bullet-proof” glass. The data layer is kept safe between a sandwich of poly carbonate. Also the disks are rated for more than 50 year data storage life, far longer than hard disks and magnetic tape.

Immunity to Stray Magnetic Fields

A MOD disk isn't affected by stray magnetic fields because data is written with a combination of laser and magnetic power - without this combination, data cannot be altered.

Support for Worldwide Standards

The Maxoptix & Sony optical disks and drives comply with the ISO (International Standards Organization) standards. Compliance with these standards assures that any ISO disk can be used with anyone's ISO drive. This feature:

- Eliminates reliance on single source suppliers
- Guards against premature obsolescence
- Enables users to exchange data and disks with greatest confidence of compatibility

The Maxoptix T5-2600MO drive supports four industry standard formats: 650MB, 1.0GB, 1.2GB, and 2.3GB. The Plus Applications Software, however, only allows storage of images to either the 1.2 or 2.3GB disks.

The Sony SMO-F551-SD is compatible with the following 5 ¼” (130 mm) Magneto Optical Disks:

Compatibility		Type	Description	ISO Standard
Read	Write			
		8x R/W	5.2GB 2048 bytes/sector	ISO/IEC 15286
		8x R/W	4.8GB 1024 bytes/sector	
		8x R/W	4.1GB 512 bytes/sector	
		8x WO	5.2GB 2048 bytes/sector	
		8x WO	4.8GB 1024 bytes/sector	
		8x WO	4.1GB 512 bytes/sector	
		4x R/W	2.6GB 1024 bytes/sector	ISO/IEC 14517
		4x R/W	2.3GB 512 bytes/sector	
		4x WO	2.6GB 1024 bytes/sector	
		4x WO	2.3GB 512 bytes/sector	
		4x DOW	2.6GB 1024 bytes/sector	
		4x DOW	2.3GB 512 bytes/sector	

W/R : Rewritable, WO : Write-Once, DOW : Direct Overwrite

Table 5-4 Sony MOD (SMO-F551-SD) compatible media

Compatibility		Type	Description	ISO Standard
Read	Write			
		2x R/W	1.3GB 1024 bytes/sector	ISO/IEC 13549
		2x R/W	1.2GB 512 bytes/sector	
		2x WO	1.3GB 1024 bytes/sector	
		2x WO	1.2GB 512 bytes/sector	
		1x R/W	650MB 1024 bytes/sector	ISO/IEC 10089
		1x R/W	594MB 512 bytes/sector	
		1x WO	650MB 1024 bytes/sector	ISO/IEC 11560
		1x WO	594MB 512 bytes/sector	

W/R : Rewritable, WO : Write-Once, DOW : Direct Overwrite

Table 5-4 Sony MOD (SMO-F551-SD) compatible media (Continued)

Minimal Maintenance

Because the data in an MO disk is well protected under the disk's near-indestructible poly carbonate surface, it isn't affected by contamination, except for a periodic head cleaning every few years.

1.2.5.3 What gets the MOD Drive into the CT system?

The operating system must see an operational drive during boot up to include the driver support for the MOD. The entries in `/hw/scsi/` and `/hw/rdsk` are created during boot-up and MOD permissions are defined in the `/etc/ioperms` file. Initially the permission for the MOD is only read and write for 'root'. Therefore device setup is done by 'root'.

The script `~/install/install.mod` calls `~/install/install.ars`, which calls `~/bin/scsistat` program.

`~/install/install.mod` Takes care for the needs of the high level parts of system = `~/.SdCrc`

`~/install/install.ars` Takes care of `/etc/ioperms`, `~/app-defaults/archive/SCSI.fol` and `~/Prefs/SdCArchiveDevice`. The data that feeds this task comes from `~/bin/scsistat`.

`~/bin/scsistat` Loops through SCSI device ports from 0 to 63 to locate devices. Device 12 is controller 1 target 4 (8*1+4=12). This is an important tool for SCSI buss and device testing. This program is a "superprocess" so that probing all SCSI ports can be done by mortals. `scsistat` performs a SCSI "INQUIRY" command to the devices. Repeated execution of this program can help to get the attention of a non-responsive device.

1.2.5.4 GE Healthcare MOD Disk Media

GE Healthcare supports Optical Media Recording technology for image archive. Because of technology evolution, a number of different Application Data Formats "ADF" used across different

CT scanners. As a result, each ADF is associated with a specific physical medium. The following charts shows these ADF profiles.

ADFNAME	DRIVE MFG.	TYPE	MEDIA	ISO #	FILE SYSTEM	LOGICAL FORMAT
“GWORM”	PIONEER	WORM	DEC502	10089 “B”	DOROFILE	GENESIS
“GMOD”	PIONEER	MO	DEC702	10089 “B”	ODRP	GENESIS
“GMOD2”	Maxoptix	MO	1.2GB (512)	13549	ODRP	GENESIS
“GMOD4”	Maxoptix	MO	2.3GB (512)	14517	ODRP	GENESIS
“DMOD”	Maxoptix	MO	1.2GB (512)	13549	DOS “FAT”	DICOM
“DMOD2”	Maxoptix	MO	2.3GB (512)	14517	DOS “FAT”	DICOM
“YMOD”	PIONEER	MO	DEC702	10089 “B”	KPAR	YMS
“HYMOD”	HITACHI	MO	650MB (1024)	Private	KPAR	YMS
“HYMOD2”	Maxoptix	MO	2.6GB (1024)	14517	KPAR	YMS

Table 5-5 MOD Application Data Formats (ADF)

DEFINITIONS

ADFName

A name of the standard “profile” associated with the total Application Data Format for the media including the media, the file system format, and the logical data encoding format.

Drive Mfg.

The name of the primary vendor of the drive and the media used in the ADF profile.

Type

The fundamental recording technology of the physical media. WORM stands for Write Once Read Many which is an ablative technique that burns pits into the surface of the media to cause a loss of reflectivity. WORM media can only be written once and not reused. MOD is Magneto Optic use heat of the laser to change the curie point of the magnetic domain so that a magnet can change the angle of the reflectivity of the media. MOD can be reused by reLABELing.

Media

This is a vendor ID number of the media that identifies the physical media. There are five different physical media standards that have been used in the GE Healthcare products. Though there are five physical media, they are supported by two specific and independent drives. The PIONEER uses a “sampled servo” recording format and the other drives use a “tracking servo” with the latter being the winner in the standard’s acceptance competition.

ISO

The International Standards Organization (ISO) standard specification of the physical media.

File System

There is commonly a storage of data into a dataset that has a “name” and a length and a location on the media. The File system is a defined way in which the properties of a “dataset” is recorded on the media so that the “dataset” (file) can be listed and selected. There are four different file systems used by GE Healthcare systems.

Logical Format

This is the data encoding of the internal stored datasets (files).

1.2.6 Console Intercom Board (2167014)

The Intercom board provides two functions: 1) voice messaging and control, and 2) communications feed-through.

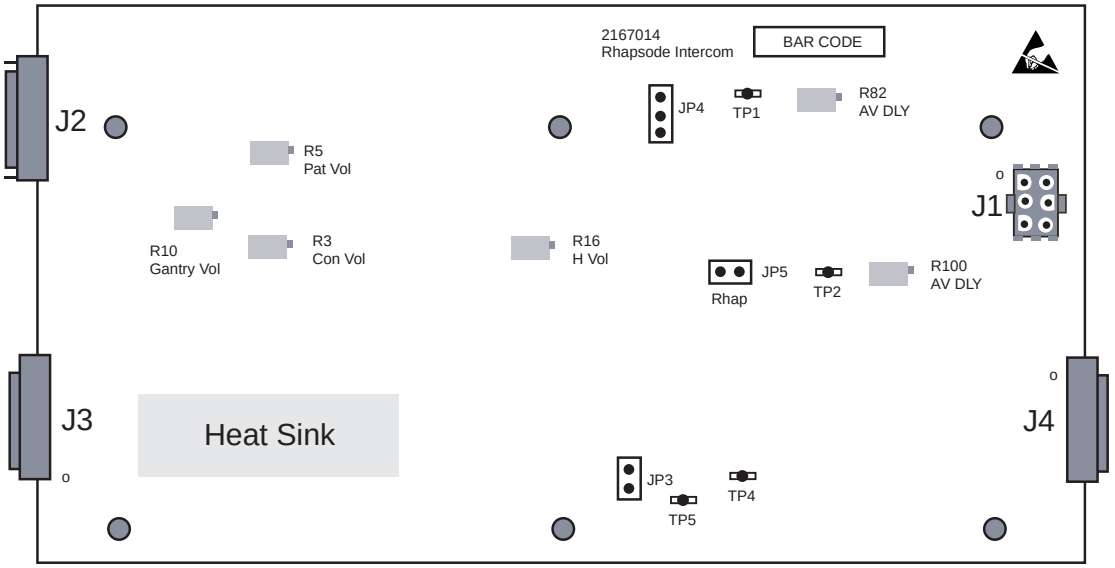


Figure 5-16 Console Intercom Board (2167014) Physical Layout

1.2.6.1 Autovoice Theory of Operation

Autovoice messages are sent simultaneously to the gantry and table speakers and the console speaker, except when the talk button is depressed. The gantry microphone is disabled during autovoice. The user at the operator's console is always able to talk to the patient via the intercom. The patient on the table can hear the operator at the console when the operator depresses the talk button. The autovoice message is disconnected when the talk button is depressed.

The user at the operator's console is always able to hear the patient on the table through the intercom, even at the lowest volume setting, except when the talk button is depressed or while autovoice is being played. A volume control knob is provided at the console to regulate the sound volume of Autovoice messages played back to the gantry or table. The autovoice volume at the console is controlled by a graphical user interface tool on the computer screen. In addition, two other volume control knobs for the intercom system shall be provided to adjust sound level for the speakers at the gantry/table and the console.

Computer based training (CBT) audio playback is available at the console only. Volume is controlled on screen. CBT audio cannot be played if the talk button is depressed or when autovoice is playing.

Gantry Microphone Input

Patient voice signals from the Gantry Intercom circuit are supplied to the Console Intercom board, using differential line driver amplifiers. This helps eliminate common mode noise, which may be induced in the interconnection cables. To complete the signal to noise improvement process, the differential voice signals are received by a differential input amplifier that discriminates against any common mode signal.

Two sections of module U14 are used for impedance matching to the inputs at J3-11 and J3-30, and for establishing a local ground reference. Module U8 is the differential amplifier that provides conversion from differential mode to single ended mode. Module U8 provides more than 70 dB of differential to common mode signal discrimination. A third section of U14 provides a gain of 2.2 and impedance matching to drive the High side of the console 5k ohm volume control potentiometer through J2-11.

AutoVoice Right

AutoVoice signals at J4-3 are processed by three sections of U17, with unity gain to drive TP2 and the switching matrix.

AutoVoice Left

AutoVoice signals at J4-2 are processed by three sections of U18, with unity gain to drive the High side of the 5k ohm AutoVoice volume control through J2-5 as signal AVVOLPOT. A section of U11 provides a gain of 3.2 as signal AV_VOL.

The AV_VOL signal is fed into an active peak detector circuit formed by two sections of U11. The discharge time constant is adjusted by potentiometer R100. The resulting DC voltage is amplified by a third section of U11 to produce the “No Signal” = –5VDC, or the “600mv Signal” = +5VDC, control signal found at TP3. The DC signal is shifted by U7 to provide 5 volt drive for NOR gate U9, which provides a Low signal OC_CNTL to the switching logic.

Control Logic

The normal state is:

- OC_CNTL High on U16, pin 5. Closes the signal path from patient’s speech into the console power amplifier.
- AV_CNTL High on U16, pin 6. Closes the signal path from the AV_RIGHT autovoice amplifier U17 pin 14 into the console power amplifier.
- CON_CNTL Low on U16, pin 16. Opens the signal path from the “Patient Volume Control” (PATVOLWIPER) into the patient power amplifier.

When AutoVoice appears:

- OC_CNTL goes Low on U16 pin 5,. This opens the signal path from patients speech into the console power amplifier.
- AV_CNTL stays High on U16 pin 6. This closes the signal path from the AV_RIGHT autovoice amplifier U17 pin 14 into the con sole power amplifier.

  AV_CNTL High also drives U16 pin 15 High. This closes the signal path from the (AVVOLWIPER) autovoice volume control into the patient power amplifier.
- CON_CNTL Low on U16 pin 16. This opens the signal path from the “Patient Volume Control” (PATVOLWIPER) into the patient power amplifier.

When the Talk button is pushed, the N.O. Talk_Button signal between J2-3 and J2-4 Is supplied, limited and protected by resistors R14, R15,CR6 and CR7 on schematic sheet 5. The signal is then sent to Schmidt trigger U4. The output of U4 drives two sections of NOR gate U10. The out puts from these NOR gates provide drive

- OC_CNTL goes Low: This drives U16 pin 1 low, which opens the signal path from the gantry speech amplifier (OCVOLWIPER) into the console power amplifier. This prevents “audio feedback” through the patient microphone.
- AV_CNTL goes Low: This drives U16 pin 6 low, which opens the signal path from the AV_RIGHT autovoice amplifier U17 pin 14 into the console power amplifier. It also drives U16 pin 15 low, which opens the signal path from the (AVVOLWIPER) autovoice volume control into the console power amplifier and the patient power amplifier.
- 3.4.3.3 CON_CNTL goes High: This drives U16 pin 16 High, which closes the signal path from the “Patient Volume Control” (PATVOLWIPER) into the patient power amplifier. This signal is supplied to the top of the PVC by amplifier U2 pin 14.

Console Microphone Pre-Amplifier

Voice signals from the Operator Console microphone are brought to the input of module U2 through J2-14, J2-15 and J2-16. The signal amplitude at J2-15 is multiplied by ten in amplifier U2 at Pin 8, for input to U13. Microphone Pre-amplifier U13 provides variable signal gain and compression to reduce variation in patient volume as the console operator moves around the console microphone.

Another section of U2 provides impedance matching at Pin 14, to drive the 5k ohm Patient Volume Control through J2-8. A third section of U2 provides impedance matching at Pin 7 for driving Balanced line driver U3 with output on pins on 1 and 8. VR1 is a +5 volt voltage regulator that determines the break point for signal compression in U13.

Power Amplifier

Signals coming from the volume control wipers are switched by U16 and appear as inputs to the power amplifier section formed by U15 and U12. TP4 is connected to the output of U15 pin 1 and provides an opportunity to monitor the voice signals being sent from the patient. TP5 is connected to the output of U15 pin 7 and provides an opportunity to monitor the voice signals coming from the console. Both of these signals are imposed on the input terminals of power amplifier chip U12.

Signal OCSPK from U2 pin 4 drives the console speaker through J2-17. Signal PSPK from U12 pin 6 drives the patient speaker through J2-12.

Power Supply

Power for the board is obtained through connector J1. J1 pins 2 and 3 are connected to Analog ground. Pin 1 is connected to Logic ground. Pin 4 supplies +12 vdc. Pin 5 supplies + 5 vdc. Pin 6 supplies –12 vdc. Module U1 is a voltage regulator that derives + 6 vdc, for Microphone bias, from the +12 vdc supply.

1.2.6.2 "Point to Point" Feed-Through

Connectors J2, J3 and J4 provide for interconnection of a number of circuits that have little or no functional relationship to the intercom feature. These interconnection paths from connector to connector are continuous conductors that can be checked by continuity measurement.

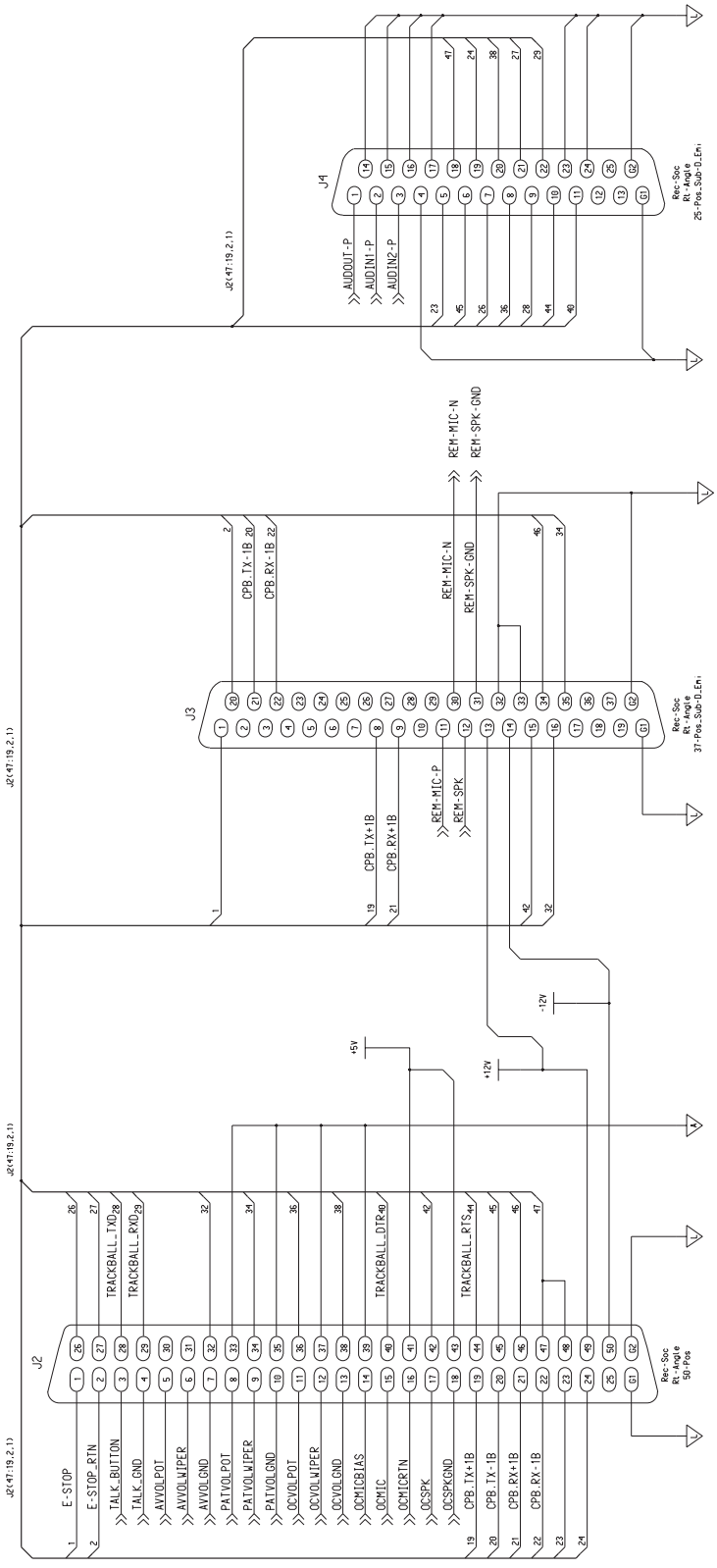


Figure 5-17 Intercom Board - Schematic

1.2.7 Media Adapter (AT-MC15, Allied Telesyn)

For additional product information, see Allied Telesyn. web site at ***www.alliedtelesyn.com***

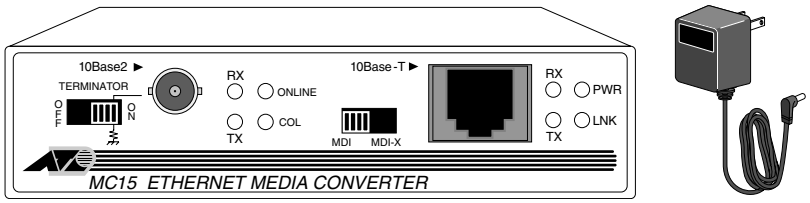


Figure 5-18 AT-MC15 (Allied Telesyn)

1.2.7.1 Overview

The AT-MC15 (Figure 5-18) is a thin-net/twisted pair converter providing a 10Base-2 BNC connection. It converts Ethernet signals from twisted pair cable to thin-net cable and vice versa. An external power supply serves as its power source.

1.2.7.2 Power Requirements

The AT-MC15 draws power from a wall-mount type AC-DC power adapter, which attaches at AT-15's DC jack. TUV/UL/CSA compliant, the AC power adapter supplies an unregulated output of 12 VDC at 1A. The power required for the AT-MC15 is 12Vdc, 500 mA.

1.2.8 Fast Ethernet Switch (AT-FS705, Allied Telesyn)

For additional product information, see Allied Telesyn web site at ***www.alliedtelesyn.com.***

Figure 5-19 AT-FS705 Front Panel

1.2.8.1 Overview

The AT-FS705 (Figure 5-19) is a twisted pair five-port, Fast Ethernet switch. It has five auto-negotiable 10BaseT/100 Base-TX ports. Port 5 can be used as a MDI or MDIX port for simple connection to other hubs and switches. The AT-FS705 series are fully compliant with IEEE 802.3u standards for 100 Mbps baseband networks.

1.2.8.2 Power Requirements

The AT-FS705 series switch uses an internal switching power supply with 100 to 120 VAC, 50/60 Hz input rating. Maximum power consumption is 50W.

1.2.9 Data Acquisition System Manager (DASM) Video

1.2.9.1 DASM Timing Characteristics

ANALOG DASM VIDEO TIMING CHARACTERISTIC	60 HZ	50 HZ
pixel frequency:	24.192 Mhz	24.192 Mhz
pixel period:	41.336 nsec	41.336 nsec
horiz line freq:	33.6 Khz	33.6 Khz
horiz line width:	720 pixels	720 pixels
horiz active:	544 pixels	544 pixels
horiz blanking:	176 pixels	176 pixels
horiz front porch:	26 pixels	26 pixels
horiz sync:	76 pixels	76 pixels
horiz back porch:	74 pixels	74 pixels
vert frame freq:	60 Hz	50 Hz
vert frame time:	560 lines	672 lines
vert active:	524 lines	524 lines
vert blanking:	36 lines	148 lines
vert sync:	3 lines	3 lines
vert back porch:	30 lines	86 lines
vert front porch:	3 lines	59 lines
scanning format:	non-interlaced	non-interlaced

Table 5-6 Analog DASM Video Timing Specifications

1.2.9.2 DASM Display Formats

ANALOG DASM VIDEO DISPLAY FORMAT	
visible field:	544 pixels by 524 lines
image field:	512 pixels by 512 lines
grayscale field:	32 pixels by 16 level gray bar on left side of image
grayscale:	software selectable on/off
grayscale off value:	0 (black)
initial grayscale:	255 (white) at upper left corner
border field:	12 lines at bottom of visible field
border field value:	any 8-bit value, software programmable

Table 5-7 Analog DASM Video Display Formats

1.2.9.3 DASM Serial Ports

ANALOG DASM HOST COMMUNICATIONS/CONTROL SERIAL PORT (ANALOG INTERFACE ONLY*)	
interface:	RS422
25D conn pinout:	pin 8 (RX+), pin 21 (RX-), pin 9 (TX+), pin 22 (TX-), pin 7 (GND)
baud rate:	1200 baud
word length:	8 bit, 1 start bit, 1 stop bit
parity:	even
type:	asynchronous

Table 5-8 Analog DASM Host Communications/Control Ports

Note: The LightSpeed digital DASM/LCAM serial control is standard RS232 on pins 2, 3, and 7. Some cameras may require a NULL MODEM cable and/or adapter.

1.2.9.4 Filming Interface Specifications (Video & Serial)

Analog DASM VIDEO OUTPUT

ANALOG DASM VIDEO OUTPUT (MEASURED INTO 75 OHMS AT BNC OUTPUT)	
amplitude:	1 volt peak-to-peak
video:	0.643V ±10%
setup:	0.071V ±10%
sync:	0.286V ±10%
DAC resolution:	8 bits
diff linearity:	± 1 LSB max
glitch area:	80 picovolt-seconds max, for any step size
rise/fall times:	> 10 nsec, 10%–90%
FS settling time:	7.5 nsec typical to 1 LSB
transfer func:	guaranteed monotonic
noise level:	> 5.0 millivolt peak-to-peak, combined sync/async noise
DC offset:	± 1VDC referenced to ground

Table 5-9 DASM Video Output Specifications

Analog DASM PIXEL CLOCK OUTPUT

ANALOG DASM PIXEL CLOCK OUTPUT	
logic family:	F series TTL
output low level:	0.8VDC max
output high level:	2.0VDC min
output period:	41.336 nsecs ±10%
transition times:	10 nsec max, 10%-90%

Table 5-10 Analog DASM Pixel Clock Output

1.3 Scan Reconstruction Unit Theory

The Scan Reconstruction Unit (SRU) consists of the following components:

Scan Data Disk (SDD)	The SDD is the raw DAS data save media and can hold 2000, 4-slice rotations of data.
Reconstruction Interface Processor (RIP)	The RIP is responsible for coordinating the save operation and moving the data from the DIP to the scan data disk.
DAS Interface Processor (DIP)	The DIP is responsible for receiving data from Slip Ring Communications (SRC), decoding the FEC CRC and buffering it for saving by the RIP.
Pegasus Image Generator (PEG-IG)	The PEG-IG is responsible for correcting and calibrating the DAS data (after it has been saved onto the SDD), and then making an image from the corrected view data.

For SRU component interconnection information, see the Console block diagram (page 261).

1.3.1 Scan Reconstruction Unit Overview

1.3.1.1 X-ray Abort

The DAS Interface Processor (DIP) contains a 24V X-ray Abort relay. This normally open relay must be closed to enable X-ray exposure. If the SRU detects that it is unable to save uncorrupted scan data to non-volatile memory, then it will open the X-ray Abort relay, halting any further X-ray exposure. See Figure 5-3, on page 261.

1.3.1.2 Scan Data Flow

DATA TRANSFER	984 HZ	1405 HZ	1968 HZ
DAS Interface	61.40 Mb/s	87.67 Mb/s	122.80 Mb/s
Scan Data Save	6.14 Mb/s	8.77 Mb/s	12.28 Mb/s

Table 5-11 Scan Data Flow Rates

The Forward Error Correction (FEC) algorithm implemented in DIP hardware will add an additional 10% to the scan data rates. All data received through the DAS Interface must be saved in non-volatile memory. One super view size (including header) is 6,240 bytes.

1.3.1.3 Scan Data Capacity

LightSpeed requirement 2000 rotations:

- 984 Vws/Rot x 4 Rows/Vw x 768 Ch/Row x 2 B/Ch = 6.05MB / Rot - Scan Data
- 984 Vws/Rot x 24 Wds/Hdr x 4 B/Wd = 94.5 KB / Rot - Header
- 2000 Rotations x 6.14 MB / Rotation = 12.28 GB.
- Scan Data Disk is currently an 18GB capacity disk, and holds only the Scan Data (views).
- OC host computer holds Scan Header Data.

1.3.1.4 Reconstruction Data Flow

DATA TRANSFER	3.0 SECONDS
Scan Data Restore	3.0 MB/s
Prep to FBP to Image Pull	2.34 MB/s

Table 5-12 Reconstruction Data Flow Rates

1.3.1.5 Reconstruction Performance

Time-to-First-Image reconstruction time, T1st, is measured from the point the software function, DIP Control, receives the first “Data Available” interrupt from DIP hardware, to the point where the software function, Image Create, pulls the reconstructed image from the PEG-IG board.

T1st assumes the following functional flow.

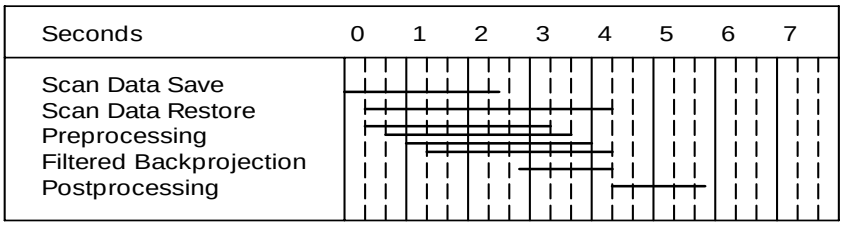


Figure 5-20 Time to first Image (assuming 0% overhead)

Preliminary study of Helical Reconstruction processing estimates that the time to first image including overhead is 7 seconds. Case study features 3:1 pitch, 2x Z-over-sampling, 3.0 second recon, and continuous images. The system requirement measured from start scan button pushed until image displayed is 10 sec. for helical and 6 sec. for axial scans.

Image-to-Image reconstruction time, TImg, is measured from the point where the software function, Image Create, pulls a reconstructed image from the PEG-IG board to the point where Image Create pulls the next reconstructed image from the PEG-IG board.

TImg assumes the following functional flow.

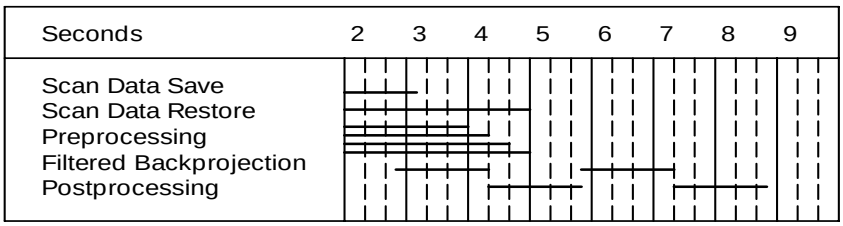


Figure 5-21 Image to Image Time (assuming 0% overhead)

TImg assumes Filtered Backprojection (FBP) and Postprocessing are the determining functions. FBP takes approximately 1.60 sec. and Postprocessing is 0.70 sec., i.e. total time = 2.30 Seconds. IBO adds 0.80 sec. to Postprocessing.

1.3.1.6 Preprocessing

Preprocessing is performed on the PEG-IG Board. The data is received from the RIP and DAS interface processor Board.

1.3.1.7 Filtered Backprojection (1.60 Seconds)

Convolution operates on projections the same way: 8 DSP's filter 8 projections simultaneously. However, the filter time is approximately 13ms. per iteration. Thus, the total filter time is approximately 123 x 13ms = 1.60 seconds.

Backprojection hardware operates simultaneously on 8 projections per pixel scan. The time to back-project these 8 projections is 5.24ms. per 5122 image or 1.31ms. per 2562 image. The image back-projection time is based on number of views divided by 8 and multiplied by the respective pixel scan time. For example: 984 projections P 8 = 123 iterations x 5.24ms = 0.64 seconds for 5122 images.

Backprojection hardware operates on projections n through n+7. Convolution operates on projections n+8 though n+15. The filtered backprojection time is based on the longer of these two functions.

1.3.1.8 Postprocessing (0.7 Seconds)

Ring-fix takes 500ms, and clip, scale, and round take 200ms to complete.

1.3.2 Scan Reconstruction Unit Hardware Theory

The SRU has three inter-bus connections and one external control signal: 1) SDAS (via RF Slip Ring), 2) UIF Sub-system (Host Computer), 3) Scan Control, and 4) X-ray Abort (to PDU).

The SDAS-SRU connection utilizes TAXI transmitted from the DAS Control Board (DCB) and received by SRU's DIP Card. The Host-SRU connection utilizes Ethernet-TCP via 100BaseTX. The SRU-Scan connection (3) utilizes Ethernet-UDP via 10Base2. X-ray Abort (4) is a 24V, normally-open relay that controls the X-Ray ON function. See Figure 5-3, on page 261.

There are four major intra-bus connections: 1) PMC - PCI Mezzanine Card, 2) Ultra SCSI - Small Computer System Interface, 3) 100BaseTX-Ethernet, and 4) VME - Versa Modulo Euro-card. These bus structures must support data and control flow for a 4 row, 0.7 second scanner and scalable to support 0.5 second scanning.

There are two logical sections to the console chassis. One section contains the Host Computer (Octane Computer) with System Disk, Ethernet and Serial Interfaces, and the Scan Data Disk. The other section is integrated into the console hardware and contains a VME Backplane, Recon Interface Processor with piggy-backed PMC Scan Data SCSI Interface and PMC DIP Interface boards, and Pegasus Image Generator Board. The entire VME Chassis is commonly termed the Image Chain Engine (ICE).

The Octane Host performs functions for scan control, and the RIP performs functions for recon control, and scan data acquisition. The PEG-IG, under the control of the RIP, performs functions for preprocessing, filtered backprojection, iterative bone option, and postprocessing. The Octane Host-VME connection utilizes Ethernet-TCP via 100BaseTX.

Recon Interface Processor (RIP) - or Motorola POWER-PC Computer performs Recon Control functions. It is the central "hub" for all logical connections between sub-systems in the ICE. Its processor is RISC and contains adequate memory to support Control and Image Chain functions. It connects to the scan data disk and performs the Scan Data Save and Restore functions. The RIP can communicate with the rest of the ICE through the VME Backplane, and with the OC Host Computer through its 100BaseTX-Ethernet Interface.

Scan Data Disk (DD or SDD) serves as a buffer for the Image Chain's data flow architecture and a temporary storage facility for the scan data required for reconstruction (header data for the scans is stored on the OC Host's disks). This disk sub-unit must support 4 row, 0.7 second scanning, i.e. 8.61 MB/s Scan Data Save and 2.60 MB/s Scan Data Restore and be scalable to support 4 row, 0.5 second scanning, i.e. 12.06 MB/s Scan Data Save and 2.60 MB/s Scan Data Restore. Save and Restore operations must be partitioned or interleaved to minimize Time to First Image (T1st) and allow scan and recon simultaneity.

LAN Switch & HUB interconnect two 100BaseTX and one 10Base2 Ethernet ports. The ethernet switch isolates the 100Mb/s transmissions from the 10Mb/s transmissions. The ethernet hub converts UTP to thin coax media for communication with the Gantry.

DAS Interface Processor (DIP) is a bus medium translator. It guarantees a continuous flow of DAS data from the 125Mb/s TAXI to the 132MB/s PMC-bus. This board connects directly to the RIP as a PCI-PMC Card. It has adequate data buffers to support the Scan Data Save operation. Forward Error Correction will be applied to the data stream to increase the errors/bit rate to approximately 10-14. The DIP will count the occurrences of forward error corrected scan data during an exposure. If Scan Data cannot be corrected, then an abort condition exists. The RIP software will record the FEC correction count on a per scan basis. Its TAXI design can be easily upgraded to support 175Mb/s transfer rate (i.e., 4 row, 0.5 second scanning). The DIP also contains the 24V normally-open relay that contributes to the X-ray On function.

Pegasus Image Generator (PEG-IG) performs **Scan Data Correction**. The **Scan Data Correction** portion of the PEG-IG performs the Image Chain's preprocessing, calibration, and scout imaging functions. It receives Scan Data from the RIP and transmits Projection Data and Scout Images to the board's Image Generator.

Pegasus' Image Generator performs the Image Chain's Filtered Backprojection and Postprocessing (including Iterative Bone Option, IBO) functions. It receives Projection Data from the RIP and transmits Scout, Axial, Cine, or Helical Images to the RIP for transfer to the OC Host.

POWER SUPPLY

The following chart identifies power requirements of the external power supply used for the Scan Data Disks and the VME Chassis:

EXTERNAL POWER REQUIREMENTS	+ 3 VOLTS	+ 5 VOLTS	- 12 VOLTS	+ 12 VOLTS
Scan Data Disks		1.0 A	3.6 A	
Recon Interface Processor	+	4.0A +	0 mA +	0 mA +
Pegasus Image Generator		12.0 A		500 mA
Total = 134.2 Watts		17.0 A	3.6 A	0.5 A

Table 5-13 Scan Reconstruction Unit Power Supply Requirements

Note: Up to 15 Watts additional power may be drawn by the two PMC cards (DIP and SCSI) attached to the RIP Board.

Care must be taken to provide the proper in-rush current necessary to accelerate the disk drive motors to specified RPMs.

1.3.3 Scan Data Disk Assembly

SEAGATE P/N »	ST318404LW		ST318452LW	
Formatted capacity:	18.352 Gbytes		18.4 Gbytes	
Max. data blocks:	35,843,670 (222EE56h)		35,843,670 (222EE56h)	
Cylinders and heads (user accessible):	14,100 / 6 heads		18,497 / 4 heads	
Disc rotation:	10,000 rpm		15k rpm	
Operating voltages:	+5V	+12V	+5V	+12V
Typical operating current:	1.00A	0.95A	0.88A	0.79A

Table 5-14 Scan Data Disk Drive Characteristics

1.3.4 Recon Interface Processor (RIP) - Motorola Board

The Motorola POWER-PC based processor board used in LightSpeed systems performs the function of Reconstruction Interface Processing. The board (MVME2308) utilizes a 333 MHz MPC 604R PPC processor, contains 128 Mbytes of main memory, and has both a SCSI PMC daughter-card and a DIP PMC daughter-card.

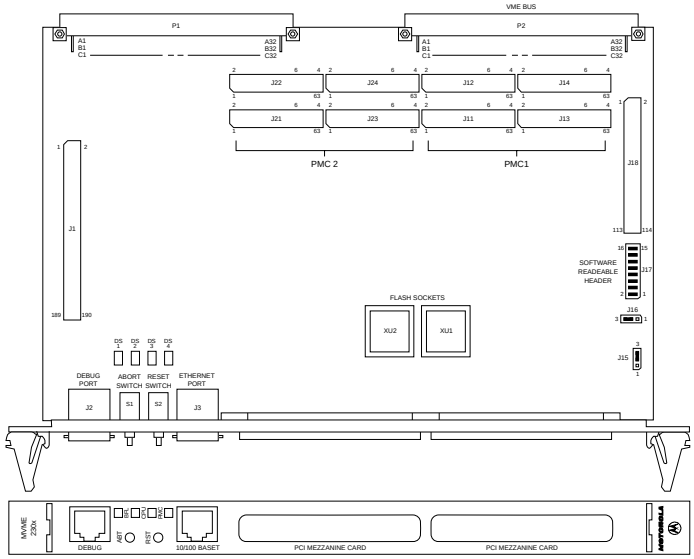


Figure 5-22 Recon Interface Processor Board Layout (MVME230x is shown)

The MVME230x is a VME processor module equipped with a PowerPC 604 microprocessor. Features include:

- Ethernet and debug ports
- Boot ROM
- Flash memory
- DRAM
- Interface for two PCI Mezzanine Cards (PMCs)

Four standard buses are supported:

- PowerPC Processor Bus
- ISA Bus
- PCI Local Bus
- VMEbus

The MVME230x interfaces to the VMEbus via the P1 and P2 connectors. It also draws +5V, +12V, and -12V power from the VMEbus backplane through these connectors. The +3.3V power, used for the PCI bridge chip and possibly for the PMC mezzanine, is derived onboard from the +5V power.

Two RJ45 connectors on the front panel provide the interface to 10/100Base-T Ethernet, and to a debug serial port.

Figure 5-84, on page 332, illustrates the placement of the switches, jumper headers, connectors, and LED indicators on the MVME230x.

Items that can be configured manually on either board include:

- Flash memory bank A/bank B reset vector (230x: J15; 240x: J8)
- VMEbus system controller selection header (230x: J16; 240x: J9)
- General-purpose software-readable header (230x: J17; 240x: S3)

These boards have been factory tested and are shipped with the configurations described in Section 2.2.4. The factory-installed debug monitor, PPCBug, operates with those factory settings.

1.3.5 PMC SCSI Card - SBS Technologies (2265396)

The PMC-UltraSCSI Card provides a high performance UltraWide SCSI (Fast-40) adapter solution for a PMC carrier board in VME-based systems. It is an ideal module for disk, tape, CD-ROM or other storage media and SCSI peripheral applications. The module supports single-ended or differential signaling for asynchronous or synchronous SCSI operations. Flexible physical I/O access is available via a 68-pin SCSI-III front panel connector or the PMC back panel P4 connector.

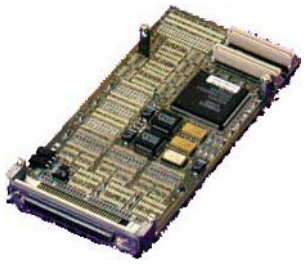


Figure 5-23 PMC-UltraSCSI Card (SBS Technologies)

The PMC-UltraSCSI features the LSI Logic SYM53C875 UltraWide SCSI (Fast-40) controller, with SCSI SCRIPTS processor support. It allows bus transfer rates up to 40 MB/sec synchronous across a 16-bit bus. In addition, 4KB of on-chip static RAM is available for SCSI SCRIPTS instruction storage to control the SCSI device.

The PMC-UltraSCSI supports DMA with 536 bytes of FIFO. The FIFO has burst length of up to 128 transfers to allow maximum bandwidth. Interrupt is supported via PCI pin INTA#. VxWorks, LynxOS, and Windows NT device drivers are available for the PMC-UltraSCSI (single-ended signaling only). The module is compliant with standard single-wide PMC specifications IEEE P1386.1 and PCI Specifications.

KEY FEATURES

- Supports UltraSCSI (Fast-20), SCSI-I, SCSI-II, and SCSI-III
- Features LSI Logic SYM53C875 SCSI controller
- Synchronous SCSI data rates up to 40 Mbytes/sec, asynchronous up to 20 Mbytes/sec
- Front-panel or back-panel I/O access (via order options)
- Single-ended or differential SCSI bus support (via order options)

Support for VxWorks, LynxOS, and Windows NT (single-ended only)

1.3.6 DAS Interface Processor (DIP)

1.3.6.1 Overview

The DIP is the main interface between the DAS and the SRU Subsystem. It receives high-speed serial data from the slip ring, buffers it, and sends an interrupt to Scan Data Save process in the RIP. The RIP then saves data to the Scan Data Disk (SDD). The interface between Scan Data Acquisition and the SRU is drawn at the serial interface of the DIP. The DIP board is a plug-in mezzanine adapter card, with a PCI-standard interface, to the RIP board.

The DIP board also contains the SRU portion of a “wired and” interface to the scan abort relay. Access to the relay is achieved via a registered write on the PCI bus, via the RIP board.

The DIP board also contains the SRU input to the RHARD reset interface to the scan control hardware in the STC, ETC, and OBC. Access to the relay is achieved via a registered write on the PCI bus, via the RIP board.

There’s no built-in self test on the DIP Board. The DIP board does provide data loopback capability in diagnostics.

Inputs

FROM SLIP RING

High-speed serial data, on fiber optic media, received via a connector on the faceplate of the DIP board. Data can be either:

- Offset Data Views prior to scan start and containing a Forward Error Correction (FEC) CRC
- Scan Data Views after scan start and containing a Forward Error Correction (FEC) CRC

FROM RIP, VIA THE PCI BUS

- PCI board configuration control, via a set of configuration registers
- PCI board base address, via a set of configuration registers
- Data transfer configuration, via a register set
- X-ray Abort line control, via a command register
- RHARD line control, via a command register

Outputs

TO RIP

- Interrupts when a configurable amount of DAS data is buffered and ready for saving OR when one of several data integrity errors has occurred. Per the PCI Spec v2.1, the DIP only uses INTA_N in the PCI bus.
- A block of DAS data, via Direct Memory Access (DMA) memory read

TO PDU

Wired “AND” relay connection for X-ray abort

TO SCAN CONTROL HARDWARE

RHARD relay connection for resetting the scan control hardware

1.3.6.2 Data Paths

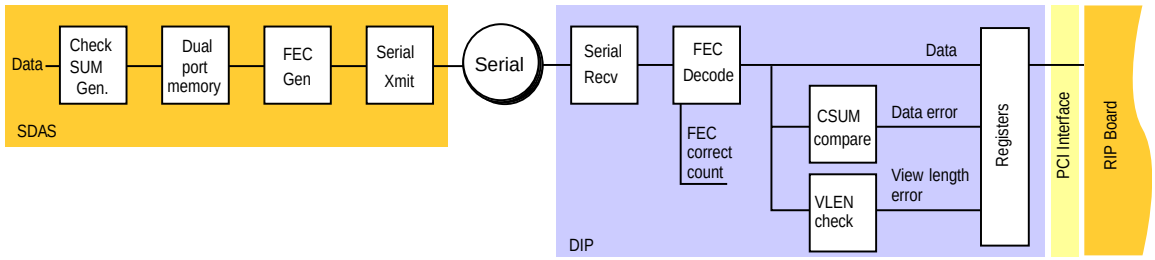


Figure 5-24 DAS/DIP Data Path

SRC Data Path

The Scan Data Interface to the DAS scan data buffers is the primary DAS data path, within the DIP. The data path is 16-bits wide and is timed off of the serial data receive clock, running at 16.667 MHz. Therefore, the bandwidth is 33.33 Mbytes / second. Of this, only 25 Mbytes / second (including FEC) are used.

When reading and writing in burst mode, the SDRAM bus is capable of transferring eight 32-bit data words at 66.6676 MHz in 15 clock cycles. This provides a bandwidth of 142 MB/s. The SDRAM bus provides a margin of 43 MB/s when it is being fully utilized by the Serial and PCI Interfaces.

PCI Data Path

This PCI Data Path connects the RIP's PCI interface with the SDRAM Data Buffers. The data bus is 32 bits wide while the address bus is only 24 bits. All functions on the bus appear as a memory map, with respect to the RIP. All transactions are 32-bits long word-wide timed off of the PCI board clock, running at 33 MHz. Therefore, the bandwidth of the bus is 132 Mbytes / second in burst mode. However, the DIP is only capable of transferring a 32-bit long word of data every two clock cycles in burst mode. Therefore, the bandwidth limit on the DIP is 66 Mbytes / second.

1.3.6.3 Interfaces

Scan Abort Line

The abort line interface is the gateway for the SRU subsystem to abort scanning in the event of a fatal error condition that cannot be terminated through normal scan control communication messages. Error conditions can include CPU failures, communication failures, and DAS data errors. A relay that normally forms a closed loop with the PDU is connected to a male, 9-pin, Sub-miniature D connector on the DIP faceplate. The relay opens to abort a scan. The interface is designed to be safe upon reset. This means that the relay is normally open and must be closed by writing a logical "1" to the DIP command register before X-rays can be turned on. Abort line status is available to the RIP via the DIP status register. See Figure 5-26.

RHARD

The RHARD interface is the gateway for the SRU subsystem to reset the scan control hardware (STC, ETC, and OBC) in the event of a controller lockup error condition that cannot be reset through normal scan control communication messages. A relay that normally forms a closed loop with the STC and ETC is connected to the same male, 9-pin, Sub-miniature D connector on the DIP faceplate as the Abort Line Interface above. The relay opens to reset the scan control hardware. Reset relay status is available to the RIP via the DIP status register. See Figure 5-26.

Scan Data Interface

The Scan Data Interface function is responsible for the following: (See Figure 5-26)

- Controlling the Transmit function. Transmit only occurs when diagnostic mode is active.
  - Reading the Test Data FIFO, when non-empty
  - Setting up the data to be transmitted to the Transmit function and creating the write enable
- Controlling the Loopback function. Loopback mode can only be enabled when diagnostic mode is active.
- Controlling the Receive function.
  - Detecting an incoming data byte stream and reading it from the Receive function
  - Checking byte parity errors and feeding those errors back into FEC for increased error detection and correction
  - Detecting modem violations and FEC CRC errors from the Receive function
  - De-multiplexing the incoming byte stream into 32-bit words

- Checking the header for data type and magic number to recognize view length errors. There are two magic numbers, one for an offset views and one for scan data views. The upper 16-bits of the first word of each view is compared to the values written into the BMR. If there is a match, the lower 16-bits are considered the length of the view and are loaded into a counter. When the counter expires, it is assumed to be at the start of the next view and the word is checked again. If there is not a match, a view length error is assumed.

- Controlling the DAS Buffer Crossbar and writing DAS data words to the DAS Data Buffer
- Making interrupt requests to the PCI Interface function

PCI Interface

The DIP is considered a target-only PCI board. All registers and buffers on the DIP are mapped into memory Unix memory space. See Figure 5-25. Registers and buffers can be accessed through programmed I/O by the CPU or through DMA by any device on the PCI bus. PCI I/O space accesses are not allowed. All registers and buffers are accessed with 32-bit transfer only and both single and burst mode transfers are supported.

The PCI Interface function is responsible for controlling the PCI bus transactions:

- Providing board level plug-n-play and configuration
- Providing address decodes for all board registers and memory devices
- Providing transaction sequencing for all access modes
- Providing system interrupt capability for reporting all error conditions

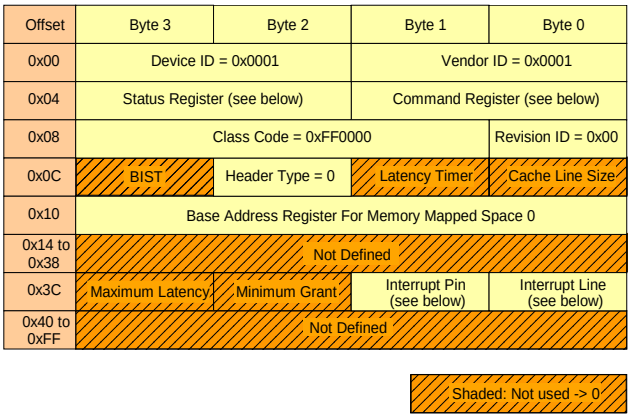


Figure 5-25 DIP Board Configuration Space Header (CSH) Memory Map

TEST DATA FIFO (MEMORY MAPPED SPACE)

The Test Data FIFO function buffers data from the PCI Interface that is to be looped back through the transmitter. The purpose is to provide a means of testing the data paths, functionality, and memory on board the DIP and to provide a stand-alone development environment.

This FIFO is a 256-word x 32-bit synchronous memory, within the DIP control FPGA. The primary purpose of this memory is to provide a diagnostic data path for testing functionality on the DIP. Data paths and PCI interface functionality, and DAS data buffer integrity can be tested. The FIFO is mapped within the DIP's address space. FIFO data are written only by the PCI interface and read only by the Scan Data Interface and are written / read in sequential order. An error interrupt will be sent to the PCI if a write to a full FIFO or a read from the FIFO is attempted.

GLOBAL REGISTERS (MEMORY MAPPED SPACED)

GLOBAL BUS MEMORY

PCI Data Path address decode is performed by a gate array that monitors the PCI address during the address phase of a transfer and either creates read and write strobes or passes the address to the SDRAM data buffer.

BOARD COMMAND REGISTER (BCR)

This write / readable register controls the board level operation of the DIP. It contains commands for controlling X-ray Enable, scan data transfers, and diagnostic modes. All bits are active high Processing.

BOARD STATUS REGISTER (BSR)

This read-only register contains board level status information. Values in this register are not latched and reflect the current status of the functional blocks.

OFFSET MAGIC NUMBER REGISTER (OMNR)

This write / read register sets the magic numbers to be checked by the Scan Data Interface.

BOARD INTERRUPT STATUS/MASK REGISTER (BISR)

This lower 16-bits of this register contain status information about the scan data transfer, including error conditions. A logic “1” in one, or more, of the bit positions indicates that an event has occurred.

The upper 16-bits of this register contains the interrupt enable. Writing a logical “1” to bit N, causes the interrupt corresponding to bit N-16 to be enabled. By disabling then re-enabling an interrupt, the ISR can test whether or not the error condition still exists.

BOARD INSITE REGISTER SET (BIR)

This is a set of two 32 bit-wide registers, each with its own base address, that implements the InSite ID. The two registers must be read one at a time. For a complete definition of the InSite ID, see the InSite PAL Format Standard, Rev C, in the Electrical Engineering Design Guide.

DATA STATUS REGISTER (DSR)

This read-only register contains status information on received data, including number of FEC blocks corrected and number of SERIAL DATA modem violations. Values in this register reflect current counts.

DAS DATA BUFFER CONTROL REGISTER (DDBCR)

This write / read register controls the amount of data that will be written into each DAS data buffer before a DAS data buffer ready interrupt will be generated.

DAS DATA BUFFER STATUS REGISTER (DDBSR)

This readable register reports the amount of data that was written into the last used DAS data buffer when a DAS data buffer ready interrupt was generated. The buffer size value read from this register is in 32-bit long words and is equal to the number of words -1.

VIEW MAGIC NUMBER REGISTER (VMNR)

This write / read register sets the magic numbers to be checked by the Scan Data Interface.

LOOPBACK TEST DATA FIFO (TDF)

This FIFO is a 256-word x 32-bit synchronous memory, within the DIP control FPGA. The primary purpose of this memory is to provide a diagnostic data path for testing functionality on the DIP.

DAS DATA BUFFER (DDB)

The DDB is a 16 M-word, 32-bit Synchronous Dynamic RAM (SDRAM) block, pseudo-double buffered so that data can be written by the Scan Data Interface and read by the PCI Interface simultaneously.

1.3.6.4 DIP Board Processing

The DIP acts as the main interface between the DAS and the SRU Subsystem. It is responsible for receiving data from the slip ring, buffering it, and sending an interrupt to Scan Data Save to have it save to the Scan Data Disk (SDD). The interface between Scan Data Acquisition and the SRU is drawn at the interface of the DIP. The DIP board is a mezzanine adapter card, with a PCI-standard interface, to the RIP board. See Figure 5-26 for a block diagram of the DIP PWA.

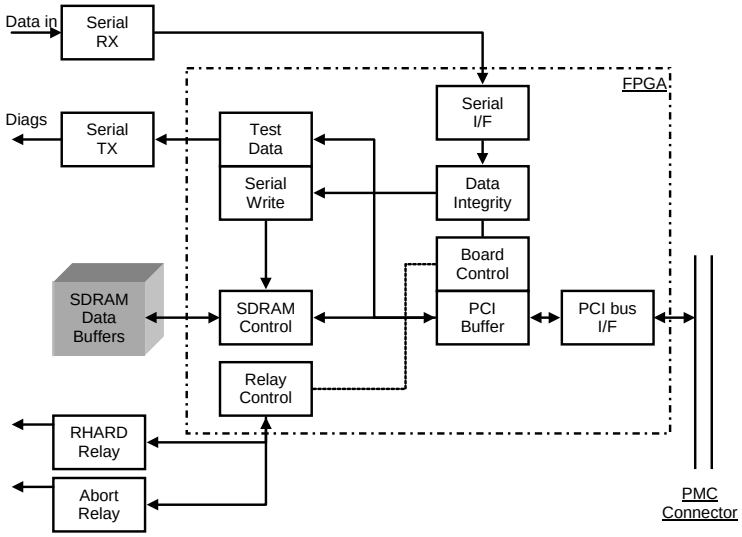


Figure 5-26 DIP Block Diagram

The only processing that is performed on the DIP is data integrity checking. Each view record, sent by the DAS contains the following information:

- Header, with a Unique (Magic) ID
- Channel Data
- Checksum of the header and the channel data

In addition, the DAS breaks up the view record into several blocks, called message blocks, and adds a Forward Error Correction (FEC) CRC to each block immediately prior sending the them to the DIP. Based on known error patterns, this CRC allows on 1 in 1015 errors not to be corrected and 100% of error to be detected.

As data are received from the interface by the DIP, a new FEC CRC is computed for each message block and is compared to the CRC that the DAS added. This CRC is used to detect and correct errors in the message block. Corrected message blocks are handed off to a second function in the DIP that validates data integrity and buffers the data.

View data integrity is checked for corruption, length, and type errors. Corruption errors would occur, if FEC either did not detect an error or did not correct an error. Computing a checksum on the received view record and comparing it to the checksum in the view record check corruption. View length errors would occur if a data output indicator was missed or double clocked and one or more data bytes were dropped or added. View length is checked by assuming that the first word of every view contains a Unique ID word. The correct Unique ID's are configured in the DIP in a register, with one Unique ID for offset views and a second Unique ID for scan views and two enable flags, one for each type of Unique ID. The DIP looks for this word at the beginning of each view and flags a length error if there is no Unique ID. View type errors would occur if the DAS were sending scan views during offset collection or offset views during scanning. Comparing both the Unique ID's to the Unique ID in the view record and flagging an error that the wrong type is received checks view type.

The DIP provides double buffering scheme for DAS data movement into the PCI interface. Buffer size is set, based to optimize the transfer of data to the disk controller. Current buffer size is set to 16M words/ buffer. The process for transferring the data from the DIP to the RIP is as follows. See Figure 5-27.

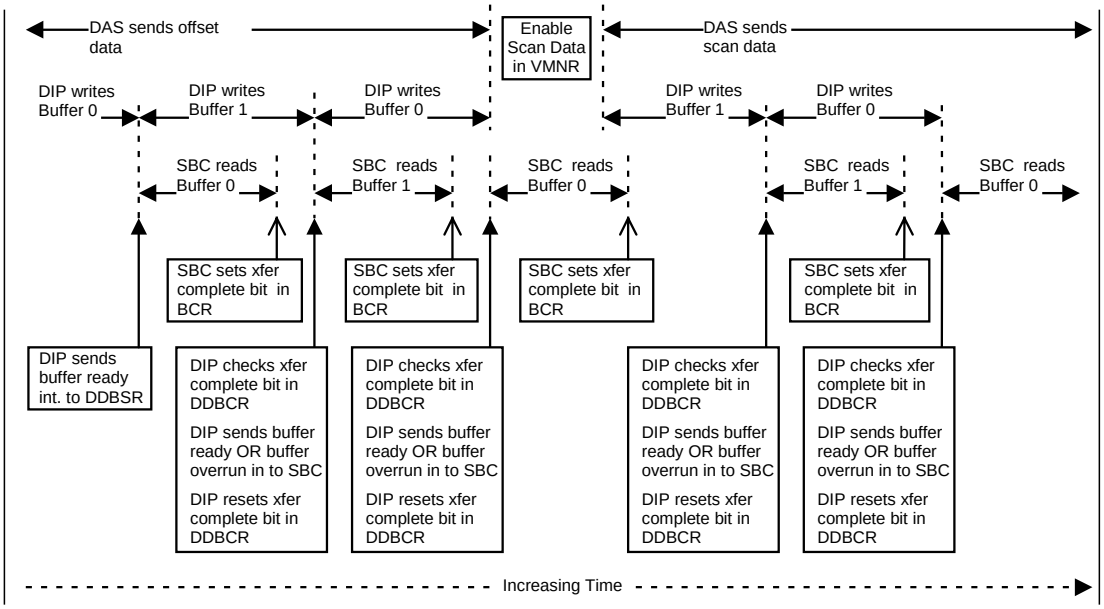


Figure 5-27 DIP Processing Sequence

SETUP

The RIP sets up the DAS data buffer transfer size, in words, in the DIP command register. This transfer size is the number of 32-bit words -1 that will be written into one of the two DAS Data Buffers before the DIP will interrupt the RIP.

The RIP sets up the DIP magic number register for both the offset and scan views, but only sets the enable bit for the offset views.

The RIP sets up the DIP command register to enable FEC and data receive and waits for interrupts from the DIP indicating that there are buffers of offset data ready for save.

OFFSET VIEWS

The first buffers of data to be written are offset views. Once enough offset data has been written to a DAS data buffer to equal the DAS buffer transfer size, the DIP will switch the Scan Data Buffer crossbar to the other buffer and interrupt the RIP.

The DIP ISR on the RIP will read the DIP interrupt status register, see that the interrupt was for a buffer ready, kick off the transfer, and wait for completion. A resource on the RIP then performs PCI 32-bit memory access reads of the Scan Data Buffer until the block has been transferred. When the RIP gets the completion message, it sets the transfer complete bit in the DIP command register.

The RIP then waits for the next interrupt to repeat the process until all offset data blocks, except for the last, have been transferred.

The last offset view to be sent from the DAS has a flag in the Unique ID word of the header indicating that this is the last offset to be sent. This indicates to the DIP that the last DAS data buffer is a partial buffer. When the DIP has written this last partial buffer, it interrupts the RIP with a different bit set in the DIP interrupt status register. The DIP ISR that reads the DIP interrupt status register detects this and performs a read of the BSR to determine the size of the last transfer. It then sets up the last transfer and kicks off the transfer.

When offsets are complete, the RIP sets up the magic number register to disable offset views and enable scan views.

SCAN VIEWS

The process for collecting scan data views is identical to collecting offset data views

1.3.6.5 Power Requirements

The DIP uses 2 of the available power supplies provided by the PCI backplane. Power dissipation on the DIP for each supplied used is shown in Table 5-15.

ELEMENT	MAXIMUM POWER
+5V	2 watts
+3.3V	7 watts
+12V	Not Used
-12V	Not Used

Table 5-15 DIP Power Requirements

1.3.7 Pegasus Image Generator (PEG-IG) Board Theory

Refer to the Pegasus schematic (2216467SCH) for this section. Figure 5-28 is the block diagram of the Pegasus board.

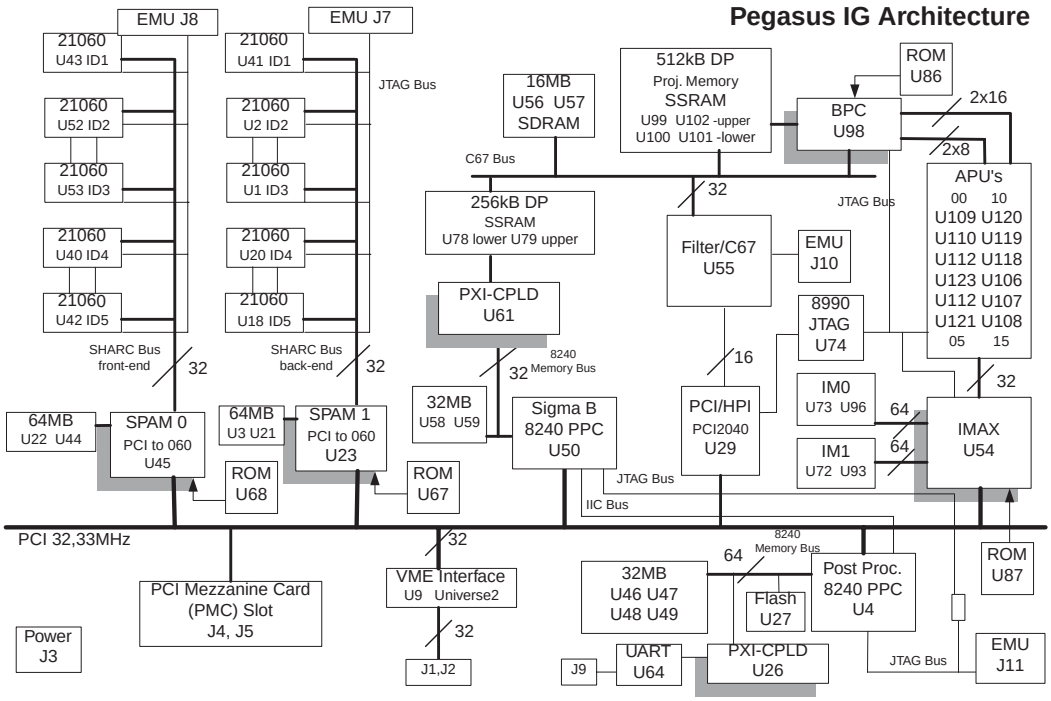


Figure 5-28 Pegasus Image Generator Board Block Diagram

The Pegasus Assembly is a complex circuit board that converts raw image data into a viewable image. There are thirteen microprocessors, as well as twelve custom ASICs that all work in parallel to perform this task. The following is a short description of each major section of the board.

1.3.7.1 Power Supply Overview

The Pegasus board gets all its power from the VME 5V supply. There are three local power regulators (page 11 of the schematics) that supply 1.9V, 2.6V, and 3.3V power for the board. The comparators on page 11 are for the purpose of power sequencing. Specifications for the TI and Motorola microprocessors requires that, to prevent damage to the processor, the 3.3V supply may only come up after the core voltage is up (1.9V and 2.6V), and must come down before the core voltage comes down.

There are three power supply LEDs near the center backplane connector:

DS14 - Goes on when the 5V power is up.

DS15 - Goes on when the on-board 2.6V regulator is up.

DS16 - Goes on when the on-board 1.9V regulator is up.

These LEDs only give an approximate indication of the power status, i.e. they do not indicate whether or not the supply is out of tolerance.

1.3.7.2 Clock Overview

There are six main clock distribution networks (pages 21-21B, and page 64 of the schematics) on the Pegasus board. These networks distribute the PCI clock (CLK33 - 33 MHz), CLK40 (40MHz - for 21060 SHARC processors), CLK64 (64Mhz - for the back-projector), CLK80 (actually 83.33MHz - for the SPAM SDRAM banks), CLK80 (80MHz - for the dual port SSRAM on the C67 bus), and TCK16 (16MHz - for the JTAG test bus) to multiple destinations on the board.

Each clock distribution tree fans out the clock using equal-length traces, so that clock skew is minimized at the destinations. Clock skew between any two same-frequency clocks is less than one nanosecond.

The following table details the various clocks on the Pegasus board.

SOURCE	DESTINATION	FREQUENCY	DUTY CYCLE	DESCRIPTION
U26-35	U64-1	16 MHz	45% ¾ 55%	UART
U61-35	U90-10	16 MHz	45% ¾ 55%	Back-projector JTAG
Y1-3	U50-AD21	33 MHz	40% ¾ 60%	Post Processor
Y2-3	U69-24	40 MHz	40% ¾ 60%	SHARC processors
Y3-3	U91-24	64 MHz	40% ¾ 60%	VME & Back-projector
U55-AD17**	U80-24**	80 MHz	45% ¾ 55%	Filter's Sync SRAM
U55-AE20**	U56-38**	80 MHz	45% ¾ 55%	Filter's Sync DRAM
U4-D1	U49-38	100 MHz	45% ¾ 55%	Post's Sync DRAM
U50-E1	U71-24	83 MHz	45% ¾ 55%	Sigma-B DP SSRAM

** Must be enabled by the C67 software after boot-up.

Table 5-16 Clock Frequency and Duty Cycle Values

1.3.7.3 VME Interface

The Pegasus board uses a Tundra Universe II chip for the VME interface (located on pages 26-32 of the schematics). This chip is a “single chip” VME interface solution, with the exception of the discrete buffers needed between the Universe and the VME bus connectors.

In addition to providing a generic VME interface, the board's master PCI hardware reset is also driven from the Universe chip.

1.3.7.4 Motorola 8240 PowerPC “Post” Processor

The Motorola 8240 PowerPC chip at U4 is dubbed the “Post” processor because its main job in the application software is to do the post back-projector processing.

This processor section (pages 76-80 of the schematics) includes the processor chip (U4), 32 megabytes of SDRAM (U46-49), a FLASH ROM chip (U27), an RS-232 UART port (U26,U702,U64,U83,J9), and status LEDs (U24, DS12,DS13,DS21-28).

The 8240 has a 603 PowerPC core that runs at 250Mhz internally. It also has an integrated SDRAM controller and an internal DMA engine. On Pegasus, the SDRAM is configured to operate at a 100MHz external bus clock.

This processor is the main processor on the board in that it has the bootrom FLASH chip, it contains the PCI arbiter, and it connects to the serial port, which is used to download firmware and provide a diagnostic interface to the board.

1.3.7.5 Motorola 8240 PowerPC “Sigma B” Processor

The Motorola 8240 PowerPC chip at U50 is dubbed the “Sigma-B” processor because of the application software task that it performs.

This processor section (pages 53-56 of the schematics) includes the processor chip (U50), 32 megabytes of SDRAM (U58-59), and status LEDs (DS29-36).

At power-up or hardware reset, it boots from the Post processor FLASH chip across the PCI bus.

1.3.7.6 Analog Devices 21060 SHARC DSP Processors

There are a total of ten 21060 SHARC digital signal processors from ADI, in two clusters of five, on the Pegasus board. (The “front end” cluster is on pages 35-42 of the schematics; the “back-end” cluster is on pages 45-52.) Each cluster is connected together on a common SHARC bus, where each SHARC chip can transfer data to any other SHARC chip.

Each SHARC chip is a specialized processor that runs at 40MHz, with 512KBytes internal SRAM, and DMA I/O capability. Each SHARC on the Pegasus board has one software programmable LED. Each cluster has a JTAG bus that is primarily for the purpose of SHARC emulator hardware for software development.

See the ADSP-2106x SHARC User's Manual for more information.

1.3.7.7 SPAM Bridge FPGAs

The SPAM (SHARC to PCI And Memory) chips are custom designed bus bridges implemented in Xilinx FPGAs. There are two SPAM bridges on the Pegasus board: one for each cluster of 5 SHARC chips. (The “front end” SPAM is on pages 33-34 of the schematics; the “back-end” SPAM is on pages 43-44.) Each of these SRAM-based FPGAs get configured on each power-up or board RESET from a serial EPROM.

Each SPAM chip controls 64MBytes of SDRAM, and allows memory-mapped access from PCI bus masters and SHARC chips. In addition to SDRAM access, the slave-only PCI interface on the SPAM chip allows access to each SHARC chip's host port on the SHARC bus.

The SPAM chip allows access to the SDRAM from the SHARC bus by two methods: through normal SHARC bus transfers, and also through “handshake” DMA cycles. The handshake DMA mode uses SHARC DMA in conjunction with specialized DMA circuitry in the SPAM chip to achieve the full bandwidth of the SHARC bus (160MBytes/sec.) between SHARC chips and SDRAM.

See the SPAM document (2261143PDL) for more information.

1.3.7.8 Texas Instruments C67 DSP Processor

The Texas Instruments 320C6701 chip is a high performance 160MHz DSP chip capable of 1 GFLOPs. This processor is dubbed the “filter” processor because it runs the filtering algorithms in the software application.

This processor section (pages 58-65 of the schematics) includes the processor chip (U55), 16MBytes of SDRAM (U56-57), and six dual port SSRAM chips organized in two banks (projection memory: U99-102, and view memory: U78-79).

The C67 chip does not have any ROM; it is booted & controlled by the Post processor through a host port interface chip (U29).

1.3.7.9 Back-Projector Controller FPGA

The BPC (Back-projector Controller Chip) is a custom designed Xilinx FPGA. It is an SRAM-based FPGA, which gets configured on each power-up or board RESET from a serial EPROM (U86). Its

main function is to control the APU ASIC back-projector, and provide an interface between them and the dual port SSRAM (view memory).

See the BPC document (2261139PDL) for more information.

1.3.7.10 APU ASICs

There are twelve APU (Attenuation Pipeline Unit) chips on the Pegasus board. The APU chip is a custom designed GE Healthcare ASIC.

See the BPC document (2261139PDL) for more information.

1.3.7.11 IMAX FPGA

The IMAX (Image Memory & Accumulator Xfer) chip is a custom designed Xilinx FPGA. It is an SRAM-based FPGA, which gets configured on each power-up or board RESET from a serial EPROM (U87).

The image memory section of the board (pages 73-75 of the schematics) includes the IMAX chip (U54), and two banks of ZBT SRAM (U72/U93, and U73/U96). The basic function of the IMAX chip is to receive the attenuation data that comes from the APU section, and accumulate it into one of two banks of ZBT SRAM. After a complete image has accumulated into one of the image banks, it gets pulled out by the Post processor via the PCI bus.

The data coming from the APU section, as well as the ZBT bus interfaces, are synchronous with respect to the 64MHz clock.

See the IMAX document (2261138PDL) for more information.

1.3.7.12 PMC Interface

Connectors J4 and J5 are PMC connectors that are for the purpose of adding a (future) daughter card to the Pegasus board.

1.3.7.13 Miscellaneous

The Pegasus board also has four temperature sensing chips; one in each quadrant of the board. These are used to monitor the temperature of the board, and alert the user to an over-temperature condition (possibly due to malfunctioning fans).

The microprocessors are connected to JTAG emulator interface headers. These are for the purpose of development only, and are not used during scanner or diagnostic functions.

1.3.7.14 Programmable Devices

This circuit board requires specific devices pre-programmed before in-circuit testing.

Port-X Interface (PXI)

The components located at U61 and U26 must be programmed prior to the circuit board assembly process. These components are manufactured by Altera (GE Healthcare p/n 2247492, Altera p/n EPM7032AE-4). The program file is maintained by GE Healthcare-CT (GE Healthcare p/n 2261140PDL).

Sharc to PCI And Memory FPGA (SPAM)

Each of the two SPAM FPGAs have a serial PROM that is used to configure the logic at power-up or board Reset. SPAM 0 (U45) is configured by U68; SPAM 1 (U23) is configured by U67. These PROMS are manufactured by Xilinx. The program file is maintained by GE Healthcare-CT (GE Healthcare p/n 2261143PDL).

Back-Projector Controller FPGA (BPC)

The BPC FPGA (U98) has a serial PROM (U86) that is used to configure the logic at power-up or board Reset. This PROM is manufactured by Xilinx. The program file is maintained by GE Healthcare-CT (GE Healthcare p/n 2261139PDL).

Image Memory & Accumulator Xfer FPGA (IMAX)

The IMAX FPGA (U54) has a serial PROM (U87) that is used to configure the logic at power-up or board Reset. This PROM is manufactured by Xilinx. The program file is maintained by GE Healthcare-CT (GE Healthcare p/n 2261138PDL).

FLASH ROM

The FLASH ROM (a 48 pin micro-BGA, 16Mb Flash Memory component) is located at U27. It contains code that is executed by both Motorola PowerPC 8240 processors. (The Sigma B processor at U29 boots from this chip through the PCI bus.) The FLASH ROM component is manufactured by Advanced Micro Devices (GE Healthcare p/n 2246050, AMD p/n AM29LV160BB70R) and must be programmed prior to the circuit board assembly process.

The program file is maintained by GE Healthcare-CT (GE Healthcare p/n 2287989PDL). This file contains the boot monitor program. The boot monitor resides in a single 64K sector, and is used to download a kernel into other sectors of the FLASH chip. The specific 64k sector occupied by the boot monitor (sector 19, address 0xFFF00000 - 0xFFF10000) is not likely to ever need to be erased or re-written.

1.3.8 Scan Reconstruction Unit Cabling

1.3.8.1 Power and Ground

The LAN electronics contain their own power supplies and will receive 110VAC power from the Console “PDU”. The Scan Data Disks and the VME backplane will receive their +5VDC and +12VDC power from a power supply shared with the “User Drive Assembly” of the console.

1.3.8.2 DAS Data Receive

Connects the Stationary Communication Board (SCOM) or the Slip Ring’s Buffer Board on the stationary side and the DIP Board via 62.5/125 um Glass Fibre with ST connectors, where the typical application is 35m. The DIP Board uses an AMP Fibre Optic receiver. The data is serially encoded using 11 bits per byte in a 4B/5B NRZI format per the AMD TAXI specification. The maximum data rate is 118 Mbaud (10.8 MB/s).

1.3.8.3 X-ray Abort

Connects the Power Distribution Unit (PDU) to the DIP Board via a cable with DB9 Connectors; the typical application is 35m. The DIP design uses a 4-pin Mate-n-Loc connector. The following chart shows the pin definitions. The sense pins are shorted when a cable is present, resulting in a logic “HI.” If the cable is disconnected, the resulting logic level is “LO.” This state can be read by the host computer via the Status or Interrupt Registers.

This four pin format must be converted to mate with a 9-pin Sub-D AMP205204-4 connector before leaving the console. This connector adaptor can be placed on the console’s bulkhead.
See Table 5-36, on page 335.

1.3.8.4 Serial Port

There is one serial port connection. It is between the Host Computer and the RIP. The Host connector is of type RJ45. The RIP connector is of type RJ45. They comply with the RS232 specification. These ports function as a backup connection to the RIP in the event that the processor unit does not properly initialize (Boot Link). It is also dedicated to performing Scan and Recon inter-processor communications during system operation.

1.3.8.5 Ethernet Switch

All external and internal Ethernet connections between the SRU and Scan Control components must be made through an Ethernet Switch. This switch isolates the 100Mb/s traffic of the Host Computer and RIP board from the 10Mb/s traffic between the Host and Patient Handling Sub-system (PHS). These connections to the switch use Category 5 Un-shielded Twisted Pair (UTP) cable with RJ45 connectors. The 10Mb/s media is converted from 10BaseT to 10Base2 before leaving the console.

1.3.8.6 Ethernet

Connects the Scan Control Subsystems (10Base2) to the OC Host Computer (10BaseT). The media conversion takes place in the console via a powered converter. The cable from the Ethernet switch to the Ethernet converter is a Category 5 Un-shielded Twisted Pair (UTP) cable; maximum length 6m. The cable from the powered transceiver to the Scan Control Subsystems is Thin Coax. The typical application is 35m.

1.3.8.7 Fast Ethernet

Connects the UIF Host Computer, and Image Chain Engine (ICE) using a Category 5 Un-shielded Twisted Pair (UTP) cable. The connection to the RIP is a standard 100BaseTX Ethernet (RJ45). Maximum length 6m.

1.3.8.8 External SCSI

Connects RIP to (1) Scan Data Disk using high density 68 pin cable as defined by the ANSI SCSI-3 (Wide Ultra SCSI) Standard for 16bit - 40MB/s buses. Maximum length 0.75m.

1.3.8.9 Technical Specifications

Serial

Table 5-17 shows cable pin-out assignments for the serial ports.

PIN	ASSIGNMENT	DESCRIPTION
1	DCD	Data Carrier Detect
2	RD	Receive Data
3	TD	Transmit Data
4	DTR	Data Terminal Ready
5	SG	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request to Send
8	CTS	Clear to Send
9	RI	Ring Indicator

Table 5-17 Serial Port Pinout Assignments

Ethernet 10-Base T/100-Base T

Table 5-18 shows the cable pinout assignments for the Ethernet 10-Base T/100-Base T port.

PIN	ASSIGNMENT
1	TRANSMIT+
2	TRANSMIT–
3	RECEIVE+
4	(Reserved)
5	(Reserved)
6	RECEIVE–
7	(Reserved)
8	(Reserved)

Table 5-18 Ethernet 10-BASE T/100-Base T Port Pinout Assignments

SCSI

Table 5-19 shows the cable pinout assignments for the SCSI port.

PIN	ASSIGNMENT	PIN	ASSIGNMENT
1	GROUND	35	-DB(12)
2	GROUND	36	-DB(13)
3	GROUND	37	-DB(14)
4	GROUND	38	-DB(15)
5	GROUND	39	-DB(P1)
6	GROUND	40	-DB(0)
7	GROUND	41	-DB(1)
8	GROUND	42	-DB(2)
9	GROUND	43	-DB(3)
10	GROUND	44	-DB(4)
11	GROUND	45	-DB(5)
12	GROUND	46	-DB(6)
13	GROUND	47	-DB(7)
14	GROUND	48	-DB(P)
15	GROUND	49	GROUND
16	GROUND	50	GROUND
17	TERMPWR	51	TERMPWR
18	TERMPWR	52	TERMPWR
19	OPEN	53	OPEN
20	GROUND	54	GROUND
21	GROUND	55	-ATN
22	GROUND	56	GROUND

Table 5-19 SCSI Port Pinout Assignments

PIN	ASSIGNMENT	PIN	ASSIGNMENT
23	GROUND	57	-BSY
24	GROUND	58	-ACK
25	GROUND	59	-RST
26	GROUND	60	-MSG
27	GROUND	61 -SEL	28
GROUND	62	-C/D	29
GROUND	63	-REQ	30
GROUND	64	-I/O	31
GROUND	65	-DB(8)	32
GROUND	66	-DB(9)	33
GROUND	67	-DB(10)	34
GROUND	68	-DB(11)	

Table 5-19 SCSI Port Pinout Assignments (Continued)

Section 2.0
Jumpers, Switches, Adjustments, LEDs & Connections

2.1 Host Subsystem

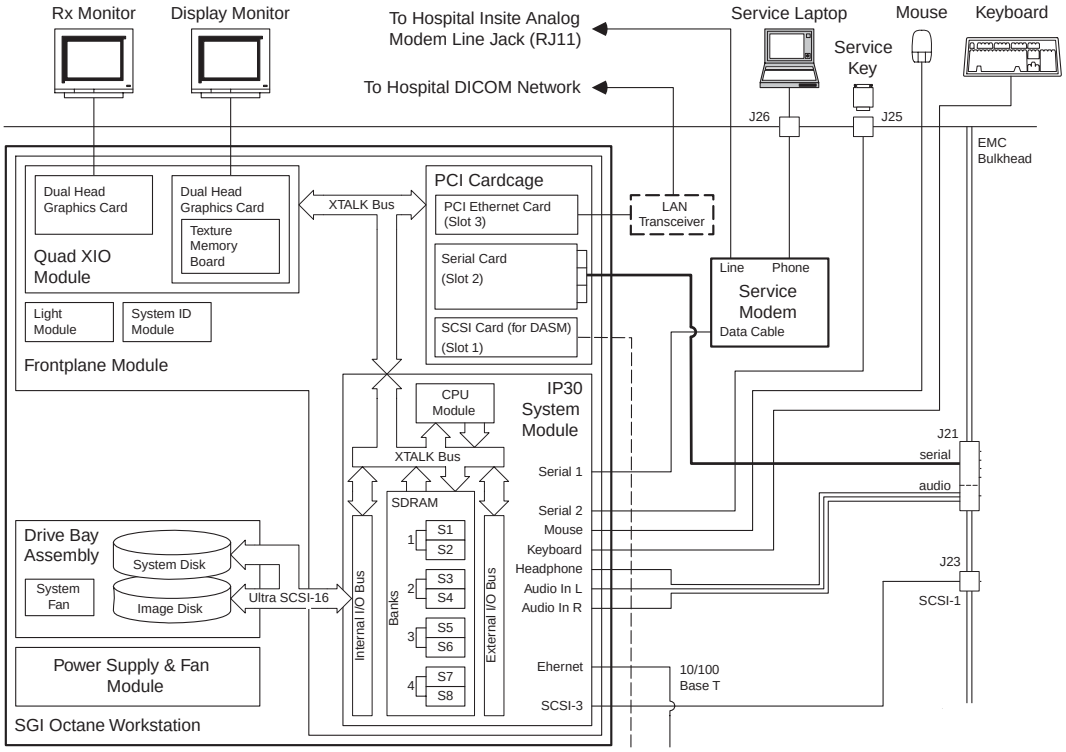


Figure 5-29 Host (Octane) Computer Block Diagram

2.1.1 Video Monitors - CRT

2.1.1.1 Connections

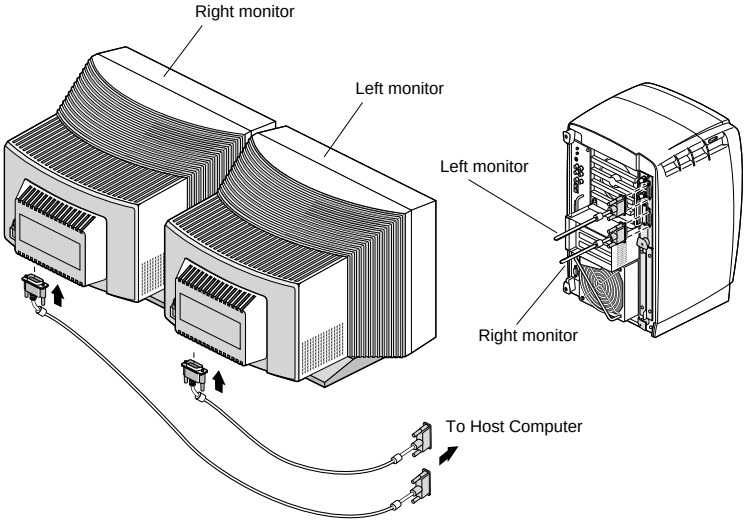


Figure 5-30 Video Monitor Connection to the Host Computer

2.1.1.2 Controls

Overview

The light output from all color monitors is lower than the output from black and white monitors. For this reason, you need to be very careful when setting up the monitor brightness and contrast. Initially, the systems are set to factory defaults, but these can be adjusted. Refer to the “Installation Manual” for details on how to adjust the Brightness and Contrast for these monitors.

The technologist may perceive that the image on the monitor is “softer” than the image on the film, (i.e. they like the film, but they would like the image on the monitor to look like their film in terms of contrast and brightness). By now, you’ve probably guessed that due to the light output of the color monitor, you need to make the adjustment for Brightness and Contrast so that the technologist can see anatomical structure (window width) at the right amount of brightness (window level).

You can type < **confidence** > in a Unix shell, then select the monitor icon to have the host help you make some adjustments to the monitor.

Sony Trinitron Artifacts (Horizontal Lines)

Due to the Sony Trinitron picture tube design used in the Display Monitors, an artifact on the display is seen as two equal distance horizontal lines.

- This artifact will NOT appear on films.
- This artifact is NOT in the image, but rather is a function of the design of the monitor.

Front Controls

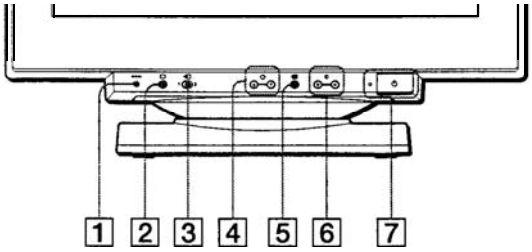


Figure 5-31 Monitor Front Parts and Controls

ITEM	DESCRIPTION
1	**Reset Button** This button resets the adjustments to the factory settings.
2	**ASC (auto sizing and centering) Button** This button automatically adjusts the size and centering of the picture. Note: Do not use the ASC function, as it does not work properly with SGI video output.
3	**Input Switch** This switch selects the INPUT 1 (video input 1 connector) or INPUT 2 (video input 2 connector) video input signal.
4	**Brightness Buttons** These buttons display the Brightness/Contrast menu and function as the ↑/↓ buttons when selecting menu items.

Table 5-20 Front Parts and Controls

ITEM	DESCRIPTION
5	**Menu Button** This button displays the main menu.
6	**Contrast Buttons** These buttons display the Brightness/Contrast menu and function as the ◒/◑ buttons when selecting menu items.
7	**Power Switch and Indicator** This button turns the monitor on and off. The power indicator lights up in green when the monitor is turned on, and either flashes in green and orange, or lights up in orange when the monitor is in power saving mode.

Table 5-20 Front Parts and Controls (Continued)

Rear Controls

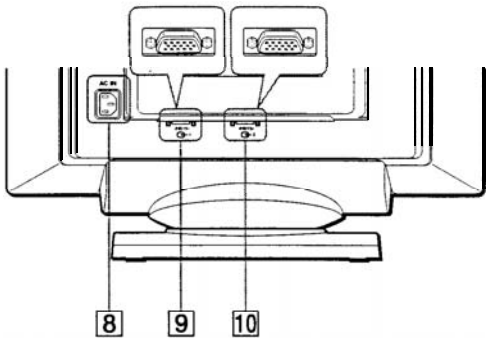


Figure 5-32 Monitor Rear Parts and Controls

ITEM	DESCRIPTION
8	**AC IN Connector** This connector provides AC power to the monitor.
9	**Video Input 1 Connector** This connector inputs RGB video signals (0.700 Vp-p, positive) and sync signals.
10	**Video Input 2 Connector** This connector inputs RGB video signals (0.700 Vp-p, positive) and sync signals.

Table 5-21 Rear Parts and Controls

2.1.1.3 Display (Customization) Setup

Selecting the On-Screen Menu Language

English, French, German, Spanish, Italian, Dutch, Swedish, Russian, and Japanese versions of the on-screen menus are available. The default setting is English.

1.) Press the menu button.

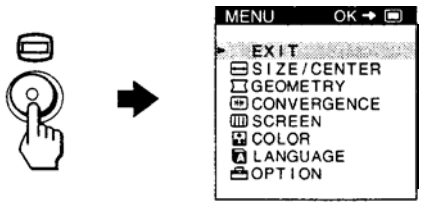


Figure 5-33 Menu

2.) Press the ↑/↓ buttons to highlight LANGUAGE and press the menu button again.

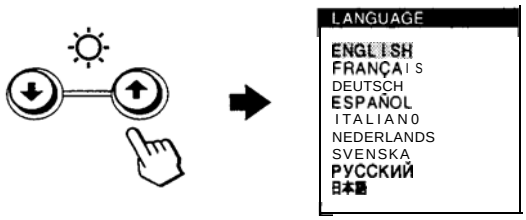


Figure 5-34 Language Menu

3.) Press the ↑/↓ buttons to select a language.

- English
- French
- German
- Spanish
- Italian
- Dutch
- Swedish
- Russian
- Japanese

4.) Press the menu button once to return to the main menu and twice to return to normal viewing If no buttons are pressed, the menu closes automatically after about 30 seconds.

Press the reset button, while the LANGUAGE menu is displayed on-screen, to reset to English.

Selecting the Input Signal

You can connect two computers to this monitor using the video input 1 and video input 2 connectors. To select one of the two computers, use the Input Signal Switch.

Figure 5-35 Input Signal Switch

Move the Input Signal Switch to select the computer. The selected connector appears on the screen for three seconds.

Note: **If no signal is input to the selected connector, NO INPUT SIGNAL appears on the screen. After a few seconds, the monitor enters the power saving mode. If this happens, switch to the other connector.**

Automatically Sizing and Centering the Picture

You can easily adjust the picture to fill the screen by pressing the auto sizing and centering button. When this button is pressed, the picture automatically fills the screen.

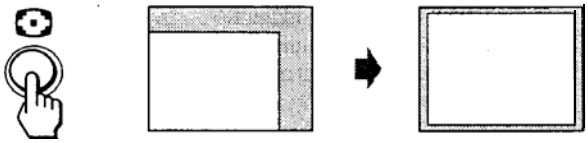


Figure 5-36 Sizing and Centering Button

This function is intended for use with a computer that provides a full screen picture. It may not work properly if the background color is dark or if the input picture does not fill the screen to the edges.

Pictures with an aspect ratio of 5:4 are displayed at their actual resolution and do not fill the screen to the edges.

The displayed image moves for a few seconds when the auto sizing and centering button is pressed. This is not a malfunction.

Customizing the Monitor

You can make numerous adjustments to the monitor using the on-screen menu.

NAVIGATING THE MENU

Press the menu button to display the main menu on the screen.

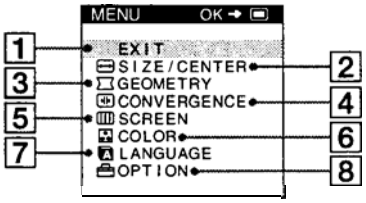


Figure 5-37 Menu Items

Use the ↑/↓ and menu buttons to select one of the following menus.

1.) EXIT. Select EXIT to close the menu.

2.) SIZE/CENTER. Select the SIZE/CENTER menu to adjust the picture's size, centering, or zoom.

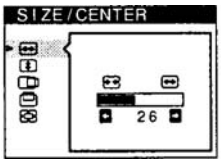


Figure 5-38 Size/Center Menu

3.) GEOMETRY. Select the GEOMETRY menu to adjust the picture's rotation and shape.

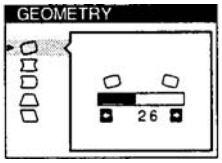


Figure 5-39 Geometry Menu

4.) CONVERGENCE. Select the CONVERGENCE menu to adjust the picture's horizontal and vertical convergence.

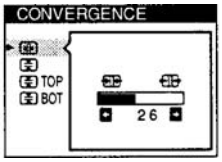


Figure 5-40 Convergence Menu

5.) SCREEN. Select the SCREEN menu to adjust the picture's quality. You can adjust the landing and moire cancellation effect.

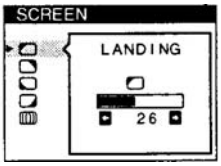


Figure 5-41 Screen Menu

6.) COLOR. Select the COLOR menu to adjust the picture's color temperature. You can use this to match the monitor's colors to a printed picture's colors.

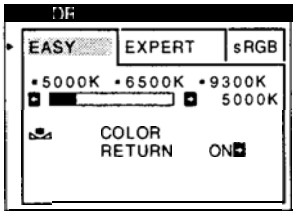


Figure 5-42 Color Menu

7.) LANGUAGE. Select the LANGUAGE menu to choose the on-screen menu's language. (See "Selecting the On-Screen Menu Language," on page 304.)

8.) OPTION. Select the OPTION menu to adjust the monitor's options The options include:

- degaussing the screen
- changing the on-screen menu position
- locking the controls

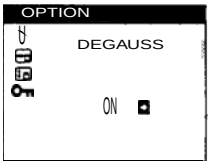


Figure 5-43 Option Menu

DISPLAYING THE CURRENT INPUT SIGNAL

The horizontal and vertical frequencies of the current input signal are displayed in the main menu. If the signal matches one of this monitor's factory preset modes, the resolution is also displayed.

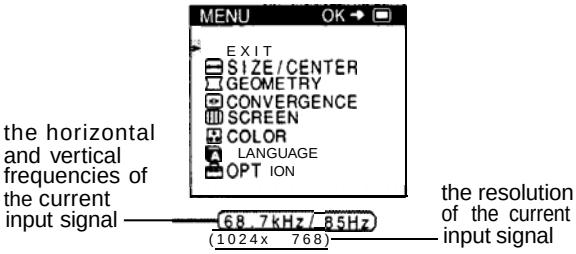


Figure 5-44 Displaying the Current Input Signal

USING THE MENU BUTTONS

1.) Press the Main Menu button to display the main menu on your screen.

Figure 5-45 Main Menu Button

2.) Press the ⟲/⟳ buttons to highlight the menu you want to adjust. Press the Main Menu button to select the menu item.

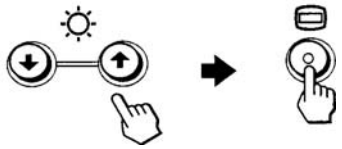


Figure 5-46 Select Menu Item

3.) Press the ⟲/⟳ buttons to select the desired adjustment item. Press the ⟲/⟳ buttons to make the adjustment.

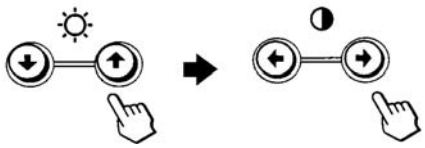


Figure 5-47 Adjust the Menu

4.) Press the Main Menu button once to return to the main menu, and twice to return to normal viewing. If no buttons are pressed, the menu closes automatically after about 30 seconds.

Figure 5-48 Main Menu Button

Press the reset button to reset the adjustments back to the factory settings.

Figure 5-49 Reset Button

ADJUSTING THE BRIGHTNESS AND CONTRAST

Brightness and contrast adjustments are made using a separate BRIGHTNESS/CONTRAST menu. These settings are stored in memory for the signals from the currently selected input connector.

1.) Press either one of the brightness or contrast buttons. The BRIGHTNESS/CONTRAST menu appears on the screen.

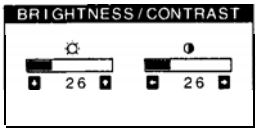


Figure 5-50 Brightness/Contrast Menu

2.) Press the ⏶/⏷ buttons to adjust the brightness and the ⮌/⮎ buttons to adjust the contrast.

2.1.1.4 Video Input Connector

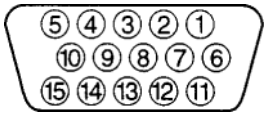


Figure 5-51 Monitor Video Pin Connector

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Red	9	DDC + 5V
2	Green (Sync on Green)	10	Ground
3	Blue	11	ID (Ground)
4	ID (Ground)	12	Bi-Directional Data (SDA)
5	DDC (Display Data Channel) Ground	13	Horizontal Sync
6	Red Ground	14	Vertical Sync
7	Green Ground	15	Data Clock (SDL)
8	Blue Ground		

Table 5-22 Monitor Video Pin Connector Assignments

2.1.2 Video Monitors - LCD

2.1.2.1 Connections

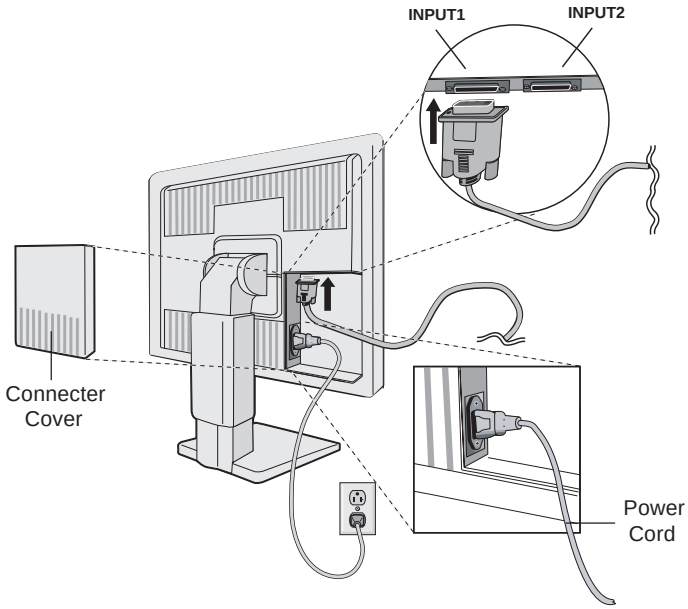


Figure 5-52 LCD Monitor Connections

VIDEOSIGNAL / DDC 1: Monitor rear side DVI-I (analog & digital)
VIDEOSIGNAL / DDC 2: Monitor rear side 15-pin D-Sub *(according to PC 99)*

Input signal connector: HD D-sub (15Pin) Connector

PIN - ASSIGNMENT OF 15-PIN D-SUB:					
1	Red Video	6	Red Ground	11	Monitor Ground
2	Green Video	7	Green Ground	12	DDC-Serial Data
3	Blue Video	8	Blue Ground	13	H-Sync.
4	No Connection	9	+5V input *)	14	V-Sync.
5	DDC-Return	10	Logic Ground	15	DDC-Serial Clock

* In case the power of the PC unit is switched off and the power of the monitor is switched on, no voltage may occur at pin 9.

Table 5-23 LCD Monitor - HD D-Sub Connector Pin-Out

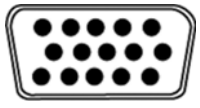


Figure 5-53 LCD Monitor - HD D-Sub Connector Pin-Out

Input signal connector: DVI Connector

PIN – ASSIGNMENT OF DVI CONNECTOR					
1	TX2-	9	TX1-	17	TX0-
2	TX2+	10	TX1+	18	TX0+
3	Shield (TX2 / TX4)	11	Shield (TX1 / TX3)	19	Shield (TX0 / TX5)
4	TX4-	12	TX3-	20	TX5-
5	TX4+	13	TX3+	21	TX5+
6	DDC-Serial Clock	14	+5V power *)	22	Shield (TXC)
7	DDC-Serial Data	15	Ground (H/V sync)	23	TXC-
8	V-Sync. (analog)	16	Hot plug detect	24	TXC+
C1	Red Video (analog)	C2	Green Video (analog)	C3	Blue Video (analog)
C4	H-Sync. (analog)	C5	Ground (analog)	--	--

* In case the power of the PC unit is switched off and the power of the monitor is switched on, no voltage may occur at pin 14.

Table 5-24 LCD Monitor - DVI Connector Pin-Out

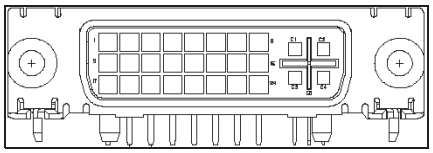


Figure 5-54 LCD Monitor - DVI Connector Pin-Out

2.1.2.2 Monitor Positioning

Raise and Lower Monitor Screen

To raise or lower screen, place hands on side of the monitor and lift or lower to the desired height. See Figure 5-55.

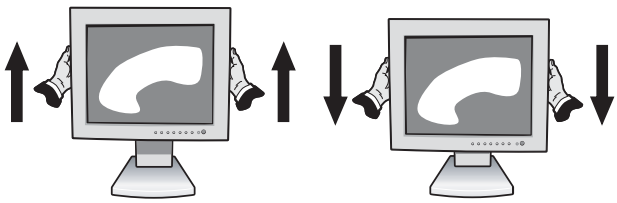


Figure 5-55 Raise or Lower LCD Monitor Screen

Tilt and Swivel

Grasp both sides of the monitor screen with your hands and adjust the tilt and swivel as desired.

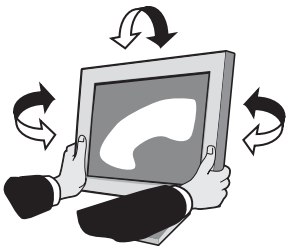


Figure 5-56 LCD Monitor Tilt and Swivel

Remove Monitor Stand for Mounting

To prepare the monitor for alternate mounting purposes:

1.) Disconnect all cables.

2.) Place hands on each side of the monitor and lift up to the highest position.

3.) Place monitor face down on a non-abrasive surface. (Place the screen on a 2-inch platform so that the stand is parallel with the surface.) Refer to Figure 5-57.

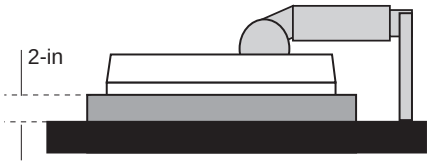


Figure 5-57 Place LCD monitor face down

4.) Remove the stand cover by sliding the top/bottom pieces off the stand. Remove the 4 screws connecting the monitor to the stand and lift off the stand assembly. The monitor is now ready for mounting in an alternate manner. Refer to Figure 5-58.

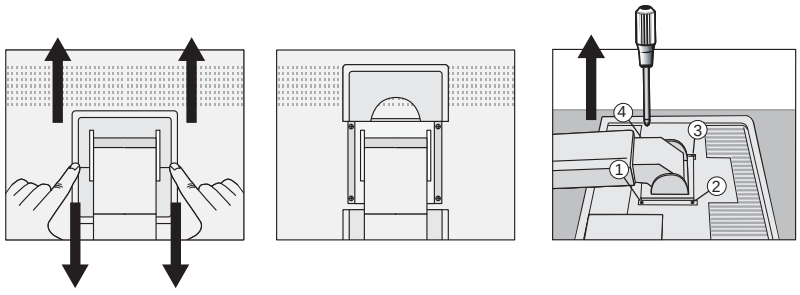


Figure 5-58 Remove stand from monitor

5.) Reverse this process to reattach stand.

Note: Use only VESA-compatible alternative mounting method.

NOTICE **Please use the attached screws (4 pcs) when mounting. To fulfil the safety requirements the monitor must be mounted to an arm which guaranties the necessary stability under consideration of the weight of the monitor. The LCD monitor shall only be used with an approved arm (e.g. GS mark).**

2.1.2.3 Controls

On-Screen Manager

OSM™ (On-Screen Manager) control buttons on the front of the monitor function as follows:

To access OSM menu, press any of the control buttons (◄, ►, –, +).

To change DVI/D-SUB signal input, press the NEXT button.

To rotate OSM between Landscape and Portrait modes, press the RESET button.

Note: OSM must be closed in order to change signal input and rotate.

	Menu
EXIT	Exits the OSM controls. Exits to the OSM main menu.
CONTROL ◄/►	Moves the highlighted area left/right to select control menus. Moves the highlighted area up/down to select one of the controls.
ADJUST – / +	Moves the bar left/right to increase or decrease the adjustment. Active Auto Adjust function. Enter the Sub Menu.
NEXT	Moves the highlighted area of main menu right to select one of the controls.
RESET	Resets the highlighted control menu to the factory setting. Resets the highlighted control to the factory setting.

Note: When RESET is pressed in the main and sub-menu, a warning window will appear allowing you to cancel the RESET function by pressing the EXIT button.

Brightness/Contrast Controls

BRIGHTNESS

Adjusts the overall image and background screen brightness.

CONTRAST

Adjusts the image brightness in relation to the background.

AUTO **AUTO ADJUST** (Analog input only)

Adjusts the image displayed for non-standard video inputs.

Auto Adjust (Analog input only)

AUTO Automatically adjusts the Image Position and H.Size settings and Fine settings.

Position Controls (Analog input only)

LEFT / RIGHT

Controls Horizontal Image Position within the display area of the LCD.

DOWN / UP

Controls Vertical Image Position within the display area of the LCD.

H. SIZE

Adjusts the horizontal size by increasing or decreasing this setting.

FINE

Improves focus, clarity and image stability by increasing or decreasing this setting.

AccuColor® Control Systems

AccuColor® Control Systems: Six color presets select the desired color setting (sRGB and NATIVE color presets are standard and cannot be changed). Color temperature increases or decreases, in each preset. **R, Y, G, C, B, M, S**: Increases or decreases Red, Yellow, Green, Cyan, Blue, Magenta and Saturation depending upon which is selected. The change in color will appear on screen and the direction (increase or decrease) will be shown by the color bars.
NATIVE: Original color presented by the LCD panel that is unadjustable.

sRGB: sRGB mode dramatically improves the color fidelity in the desktop environment by a single standard RGB color space. With this color supported environment, the operator could easily and confidently communicate color without further color management overhead in the most common situations.

Tools 1

SMOOTHING: Select one of three image sharpness settings. This function is only valid when the expanded display function (expansion function) is on.

TEXT MODE: Use this to display text clearly.

NORMAL MODE: This sharpness is between TEXT and GRAPHIC MODE.

GRAPHIC MODE: This mode is suited for images and photographs.

EXPANSION MODE: Sets the zoom method.

FULL: The image is expanded to 1280 x 1024,regardless of the resolution.

ASPECT: The image is expanded without changing the aspect ratio.

OFF: The image is not expanded.

CUSTOM (DIGITAL INPUT & RESOLUTION OF 1280x1024 ONLY): Select one of seven expansion rates.In this mode the resolution may be low and there may be blank areas.This mode is for use with special video cards.

VIDEO DETECT: Selects the method of video detection when more than one computer is connected.

FIRST DETECT: The video input has to be switched to “FIRST DETECT” mode. When current video input signal is not present, then the monitor searches for a video signal from the other video input port.If the video signal is present in the other port, then the monitor switches the video source input port to the new found video source automatically. The monitor will not look for other video signals while the current video source is present.

LAST DETECT: The video input has to be switched to the “LAST DETECT” mode. When the monitor is displaying a signal from the current source and a new secondary source is supplied to the monitor, then the monitor will automatically switch to the new video source. When current video input signal is not present, then the monitor searches for a video signal from the other video input port. If the video signal is present in the other port, then the monitor switches the video source input port to the new found video source automatically.

NONE: The Monitor will not search the other video input port unless the monitor is turned on.

DVI SELECTION: This function selects the DVI input mode. When the DVI selection has been changed, you must restart your computer.

DIGITAL: DVI digital input is available.

ANALOG: DVI analog input is available.

Tools 2

LANGUAGE: OSM™ control menus are available in seven languages.

OSM POSITION: You can choose where you would like the OSM control image to appear on your screen. Selecting OSM Location allows you to manually adjust the position of the OSM control menu left, right, down or up.

OSM TURN OFF: The OSM control menu will stay on as long as it is use. In the OSM Turn Off submenu, you can select how long the monitor waits after the last touch of a button to shut off the OSM control menu. The preset choices are 10,20,30,45,60 and 120 seconds.

OSM LOCK OUT: This control completely locks out access to all OSM control functions. When attempting to activate OSM controls while in the Lock Out mode, a screen will appear indicating the OSM controls are locked out. To activate the OSM Lock Out function, press ◄,then ► and hold down simultaneously. To de-activate the OSM Lock Out, press ◄, then ► and hold down simultaneously.

RESOLUTION NOTIFIER: This optimal resolution is 1280x1024. If ON is selected, a message will appear on the screen after 30 seconds, notifying you that the resolution is not at 1280x1024.

FACTORY PRESET: Selecting Factory Preset allows you to reset all OSM control settings back to the factory settings. The RESET button will need to be held down for several seconds to take effect. Individual settings can be reset by highlighting the control to be reset and pressing the RESET button.

Information

MODE **DISPLAY MODE**: Provides information about the current resolution display and technical data including the preset timing being used and the horizontal and vertical frequencies.

Increases or decreases the current resolution. (Analog input only)

MONITOR INFO: Indicates the model and serial numbers of your monitor.

OSM™ Warning: OSM Warning menus disappear with Exit button.

NO SIGNAL: This function gives a warning when there is no signal present. After power is turned on or when there is a change of input signal or video is inactive, the No Signal window will appear.

RESOLUTION NOTIFIER: This function gives a warning of use with optimized resolution. After power is turned on or when there is a change of input signal or the video signal doesn't have proper resolution, the Resolution Notifier window will open. This function can be disabled in the TOOL menu.

OUT OF RANGE: This function gives a recommendation of the optimized resolution and refresh rate. After the power is turned on or there is a change of input signal or the video signal doesn't have proper timing, the Out Of Range menu will appear.

CHECK CABLE: This function will advise you to check all Video Inputs on the monitor and computer to make sure they are properly connected.

NOTE: If "ⓘ CHANGE DVI SELECTION" is displayed switch to DVI SELECTION.

2.1.3 Host Computer (SGI Octane/Octane2)

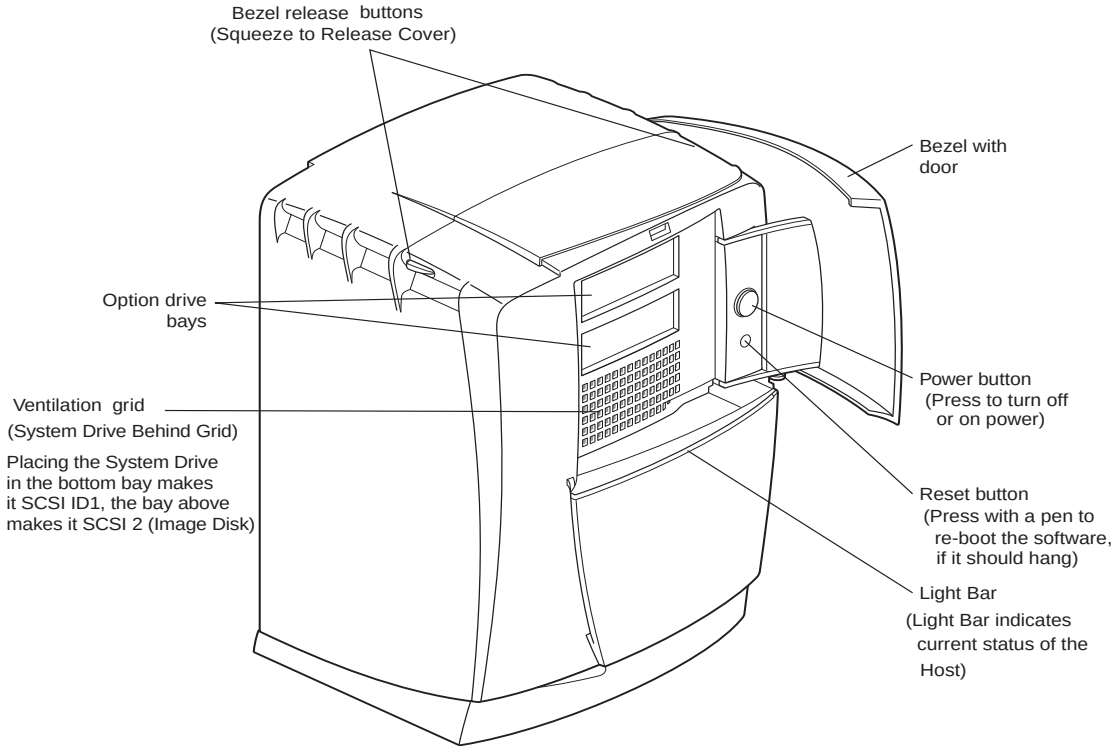
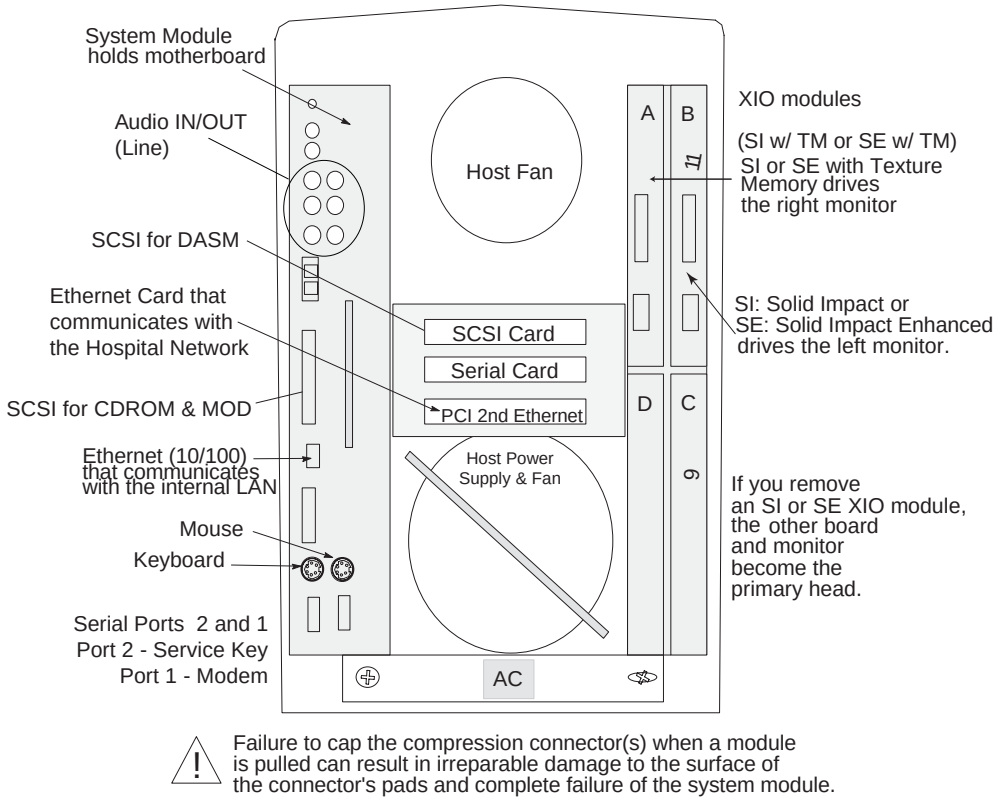


Figure 5-59 Front View of Host (Octane) Computer



Failure to cap the compression connector(s) when a module is pulled can result in irreparable damage to the surface of the connector's pads and complete failure of the system module.

Figure 5-60 Rear View of Host (Octane) Computer

2.1.3.1 Octane2 Graphics Subsystem

VPRO (V12) Graphics Card

Table 5-25 shows the V12 graphics board port pinout assignments for a 20” monitor.

PIN	ASSIGNMENT
A1	Red signal, analog
A2	Green signal, analog
A3	Blue signal, analog
1	Monitor ID bit 3, TTL
2	Monitor ID bit 0, TTL
3	Composite Sync (active low), TTL
4	Horizontal Sync (active high), TTL
5	Vertical Sync (active high), TTL
6	Monitor ID bit 1, TTL
7	Monitor ID bit 2, TTL
8	Ground
9	Ground
10	Ground

Table 5-25 20-inch Monitor Port Pinout Assignment

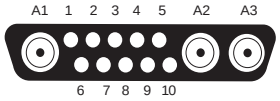


Figure 5-61 V12 Graphics Board Monitor Port

The 13W3 cover should be screwed in place when the V12’s monitor port is not in use. Such as when using the DCD card. With the cover in place, unwanted EMI is eliminated.

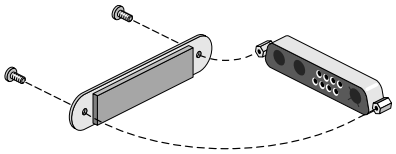


Figure 5-62 V12 Graphics Card 13W3 Cover

Dual Channel Display (DCD) Card

Table 5-26 shows the DCD board port pinout assignments for a 20” monitor

PIN	ASSIGNMENT	PIN	ASSIGNMENT	PIN	ASSIGNMENT
1	T.M.D.S. Data2-	9	T.M.D.S. Data1-	17	T.M.D.S. Data0-
2	T.M.D.S. Data2+	10	T.M.D.S. Data1+	18	T.M.D.S. Data0+
3	T.M.D.S. Data2/4 Shield	11	T.M.D.S. Data1/3 Shield	19	T.M.D.S. Data0/5 Shield
4	T.M.D.S. Data4-	12	T.M.D.S. Data3-	20	T.M.D.S. Data5-

Table 5-26 DCD Board Pinout Assignments

PIN	ASSIGNMENT	PIN	ASSIGNMENT	PIN	ASSIGNMENT
5	T.M.D.S. Data4+	13	T.M.D.S. Data3+	21	T.M.D.S. Data5+
6	DDC Clock	14	+5V Power	22	T.M.D.S. Clock Shield
7	DDC Data	15	Ground *(return for +5V, HSync, and VSync)*	23	T.M.D.S. Clock +
8	Analog Vertical Sync	16	Hot Plug Detect	24	T.M.D.S. Clock-
C1	Analog Red	C2	Analog Green	C3	Analog Blue
C4	Analog Horizontal Sync	C5	Analog Ground *(analog R, G, and B return*)		

Table 5-26 DCD Board Pinout Assignments (Continued)

2.1.3.2 PCI Support: SCSI PCI Card

SCSI CONNECTOR PINOUT

Signal Name	Pin Number	Pin Number	Signal Name
Ground	1	35	-DB(12)
Ground	2	36	-DB(13)
Ground	3	37	-DB(14)
Ground	4	38	-DB(15)
Ground	5	39	-DPARH
Ground	6	40	-D0
Ground	7	41	-D1
Ground	8	42	-D2
Ground	9	43	-D3
Ground	10	44	-D4
Ground	11	45	-D5
Ground	12	46	-D6
Ground	13	47	-D7
Ground	14	48	-DPAR
Ground	15	49	Ground
Ground	16	50	Ground
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
Reserved	19	53	Reserved
Ground	20	54	Ground
Ground	21	55	-ATN
Ground	22	56	Ground
Ground	23	57	-BSY
Ground	24	58	-ACK
Ground	25	59	-RST
Ground	26	60	-MSG
Ground	27	61	-SEL
Ground	28	62	-C/D
Ground	29	63	-REQ
Ground	30	64	-I/O
Ground	31	65	-DB(8)
Ground	32	66	-DB(9)
Ground	33	67	-DB(10)
Ground	34	68	-DB(11)

Table 5-27 Single-Ended Ultra SCSI PCI Card Connector Pinout

2.1.3.3 PCI Support: Serial PCI Card - Digi ClassicBoard

STANDARD/TRADITIONAL - DB25 PINOUT

EIA-232 SIGNAL	DB-25	EIA-232 SIGNAL	DB-25
RI	22	RxD	3
DSR	6	SG**	7
RTS	4	CTS	5
GND*	1	DTR	20
TxD	2	DCD	8

Table 5-28 Standard/Traditional - DB25 Pinout

DIGI INTERNATIONAL CLASSICBOARD - DB78M PINOUT

DB78 PIN	Signal Name	Equivalent DB25 PIN	DB78 PIN	Signal Name	Equivalent DB25 PIN
1	DTR8	8-20	40	TxD5	5-2
2	TxD6	6-2	41	RTS6	6-4
3	DTR6	6-20	42	DSR6	6-6
4	CTS6	6-5	43	DCD5	5-8
5	DSR5	5-6	44	RI5	5-22
6	DCD8	8-8	45	CTS8	8-5
7	RI8	8-22	46	RxD7	7-3
8	RxD6	6-3	47	RI7	7-22
9	CTS7	7-5	48	DCD7	7-8
10	TxD4	4-2	49	DTR1	1-20
11	TxD3	3-2	50	TxD2	2-2
12	RTS3	3-4	51	RTS1	1-4
13	DTR3	3-20	52	DTR4	4-20
14	RTS4	4-4	53	CTS2	2-5
15	RI2	2-22	54	DSR1	1-6
16	CTS1	1-5	55	RxD1	1-3
17	RxD2	2-3	56	RxD4	4-3
18	DCD4	4-8	57	CTS4	4-5
19	RI4	4-22	58	DSR3	3-6
20	RI3	3-22	59	CTS3	3-5
21	RTS5	5-4	60	RTS8	8-4
22	DTR5	5-20	61	DTR7	7-20
23	DCD6	6-8	62	RTS7	7-4
24	RI6	6-22	63	TxD7	7-2
25	CTS5	5-5	64	TxD8	8-2
26	DSR8	8-6	65	----	
27	RxD8	8-3	66	----	
28	RxD5	5-3	67	----	
29	DSR7	7-6	68	GND1	1-7
30	TxD1	1-2	69	GND2	2-7
31	RTS2	2-4	70	GND3	3-7
32	DTR2	2-20	71	GND4	4-7

Table 5-29 DB78M PINOUT to equivalent DB25 PINOUT Map

DB78 PIN	Signal Name	Equivalent DB25 PIN	DB78 PIN	Signal Name	Equivalent DB25 PIN
33	DCD2	2-8	72	GND5	5-7
34	DSR2	2-6	73	GND6	6-7
35	DCD1	1-8	74	GND7	7-7
36	RI1	1-22	75	GND8	8-7
37	RxD3	3-3	76	----	
38	DSR4	4-6	77	----	
39	DCD3	3-8	78	----	

Table 5-29 DB78M PINOUT to equivalent DB25 PINOUT Map (Continued)

2.1.4 CD-ROM Drive - Teac CD-532S

2.1.4.1 GE Specific Jumper Settings

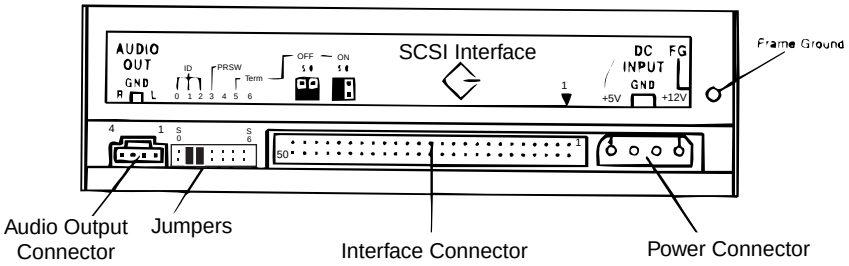


Figure 5-63 GE Specific Jumper Settings

2.1.4.2 Jumper Description

1.) S0, S1 and S2 jumpers determine the SCSI ID number.

SCSI ID	S0	S1	S2
0	OFF	OFF	OFF
1	ON	OFF	OFF
2	OFF	ON	OFF
3	ON	ON	OFF
4	OFF	OFF	ON
5	ON	OFF	ON
6	OFF	ON	ON
7	ON	ON	ON

Table 5-30 Strap Jumper Settings

ON: Jumper blocked

OFF: Jumper block removed

2.) S3: Parity Check

- Strap jumper ON — The drive does NOT perform parity check.
- Strap jumper OFF — The drive performs parity check.

3.) S4: Logical Block Size
- Strap jumper ON The drive operates at 512 bytes per logical block.
- Strap jumper OFF The drive operates at 2048 bytes per logical block.

4.) S5: Terminator
- Strap jumper ON Terminator is activated.
- Strap jumper OFF Terminator is NOT activated.

5.) S6: Factory
Reserved for Factory Use Only (always OFF)

2.1.5 Magneto Optical Drive (MOD) - MaxOptix T5-2600 (2260734-2)

2.1.5.1 GE Specific Switches and Jumpers

The location of the jumpers on T5-2600 is shown here. There is a single 40-pin Berg connector on the T5 Model, and a 24 pin Berg connector and a mini-dip switch pack on the T5 Star Model.

Note: 'ON' refers to the on position as indicated on the dip-switch bank. 'ON' is equivalent to being closed or having a jumper installed.

The Drive is configured with a SCSI ID of 3. Refer to Figure 5-64 to help identify the pin numbers. Jumpers should be as follows:

1 - 2 ON
3 - 4 ON The first three jumper settings make a SCSI ID of 3.
5 - 6 OFF
7 - 8 ON This Enables Write Verify

All Other Pins - OFF - No jumpers

SW1 DIP Switch Settings - All 1 - 8 positions should be OFF

2.1.5.2 Jumper Descriptions

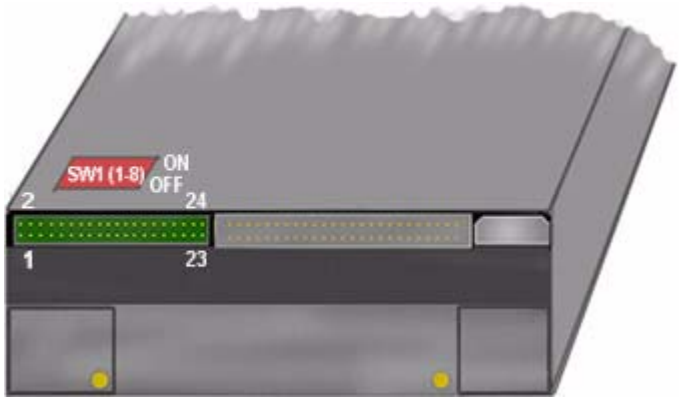


Figure 5-64 MOD Drive (Maxoptix T5-2600 Star)

PIN NUMBER	DESCRIPTION	DEFAULT	FUNCTION
1 & 2	SCSI ID bit zero	installed	enable
3 & 4	SCSi ID bit one	installed	enable

Table 5-31 Functional Switch Connector Pin Assignments

PIN NUMBER	DESCRIPTION	DEFAULT	FUNCTION
5 & 6	SCSI ID bit two	removed	disable
7 & 8	Write with verify	installed	enable
9 & 10	Active termination	removed	disable
11 & 12	Drive supplied term power	removed	disable
13 & 14	SCSI bus supplied term power	removed	disable
15	AC eject	Jukebox operation	Reserved
16	LED pipe	Jukebox operation	Reserved
17	PwrDnReq	Jukebox operation	Reserved
18	PwrDnAck	Jukebox operation	Reserved
19	AC error	Jukebox operation	Reserved
20	Cart in drive	Jukebox operation	Reserved
21	AC reset	Jukebox operation	Reserved
22	Cart loaded	Jukebox operation	Reserved
23	GND	Jukebox operation	Reserved
24	Stand alone/AC	Jukebox operation	Reserved

Table 5-31 Functional Switch Connector Pin Assignments (Continued)

SWITCH NUMBER	DESCRIPTION	DEFAULT
SW1-1	DEC MVAX Mode	Off
SW1-2	Disable Auto Spin Up	Off
SW1-3	Disable SCSI Bus Parity	Off
SW1-4	Enable Apple Mode	Off
SW1-5	Disable Removable Media	Off
SW1-6	Disable Optical Device	Off
SW1-7	Disable Write Cache	Off
SW1-8	Disable Read Cache	Off

Table 5-32 Configuration Switch Settings (SW1)

2.1.6 Magneto-Optical Drive (MOD) - Sony SMO-F551-SD

2.1.6.1 GE Specific Jumper Settings

GE specific settings for the Sony SMO-F551-SD **MOD** are shown in Figure 5-65. See Table 5-33 for descriptions of the Functional Switch connectors.

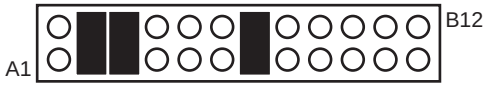


Figure 5-65 Sony MOD Functional Switch - GE specific settings

2.1.6.2 Jumper Descriptions

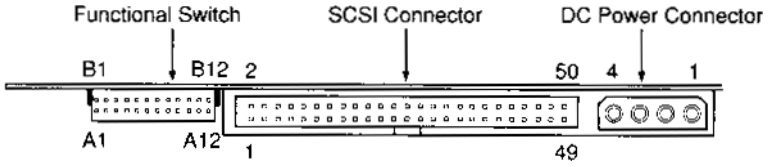


Figure 5-66 Sony SMO-F551-SD (MOD) connectors (Rear view)

A1	**SCSI** ID2	B1	GND
A2	**SCSI** ID1	B2	GND
A3	**SCSI** ID0	B3	GND
A4	Disable **SCSI** Parity	B4	GND
A5	Disable Write Cache	B5*	Reserved
A6	Disable AUto Spin-up	B6*	Reserved
A7	Force Verify for Write command	B7*	Reserved
A8	Disable Manual Eject	B8*	Reserved
A9	Enable Fast **SCSI**	B9*	Reserved
A10	Device Type	B10*	Reserved
A11	Enable Termination	B11	GND
A12	Terminator Power	B12	Terminator Power Source

* This pin is NOT directly connected to the GND. Do not use this pin as GND. SMO-F551-SD drives the signal to GND level depending on the functional switch setting. Otherwise, the signal is not driven to GND level.

Table 5-33 Functional Switch Connector Pin Assignments (Sony MOD)

2.1.7 Prescribed Tilt Board (2269601)

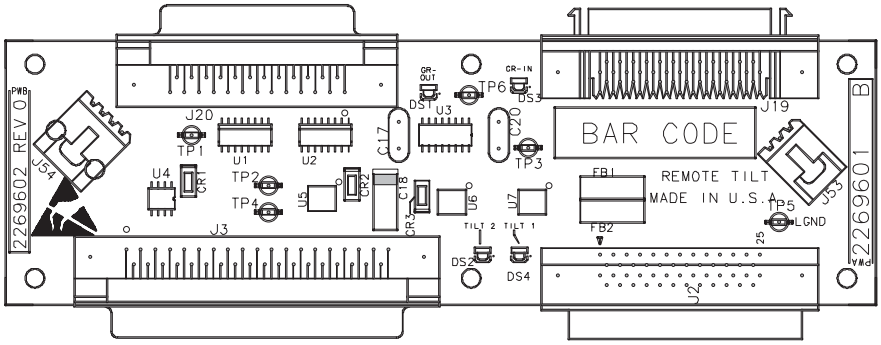


Figure 5-67 Prescribed Tilt Board (2269601) Physical Layout

2.1.8 Console Intercom Board (2167014)

2.1.8.1 GE Specific Settings

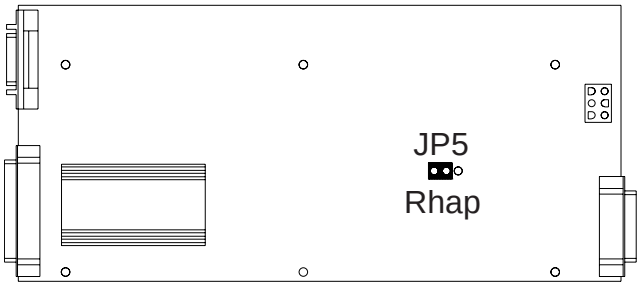


Figure 5-68 Console Intercom Board - GE Specific Settings

2.1.8.2 Software Settings (Autovoice Control)

See Figure 5-69 for the normal (default) settings of the software audio panel. This audio panel is displayed on the right-head monitor, in the upper left-hand corner when Applications is down.

To adjust the Gantry Speaker volume, adjust the right volume thumb wheel while autovoice is playing, and check the volume for the gantry speaker.

To adjust the Console Speaker Volume, bring up the Autovoice volume control audio panel.

- Select the OPTIONS pull-down menu.
- Select OUTPUT SLIDERS INDEPENDENT.
- Adjust the RIGHT Channel volume only (Analog Out)—this is the only volume control.
- The LEFT Channel must be kept locked at the maximum.
- The Analog In settings will affect the level of Autovoice record, and if you desire, you can click on the METER selection box to view the recording levels.
- DO NOT turn on the MONITOR selection, as it will cause immediate and uncontrollable feedback.
- Select FILE - SAVE when you have finished, to retain your settings.

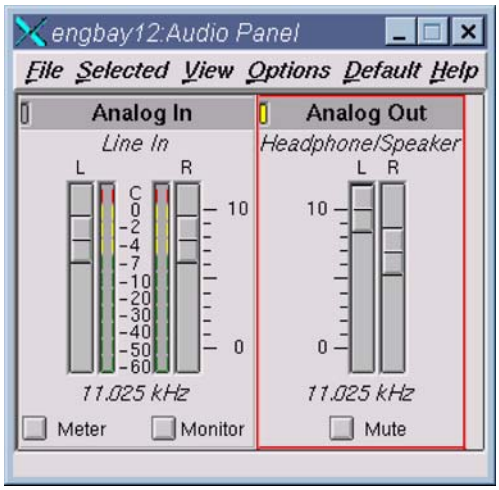


Figure 5-69 Autovoice Control Audio Panel

2.1.9 Media Adapter (AT-MC15, Allied Telesyn)

2.1.9.1 GE Specific Switch Settings

1.) Termination switch is set to **OFF** and BNC "Tee" adapter with 50 ohm termination plug attached to 10 Base 2 connector.

2.) MDI switch set to **MDI** position

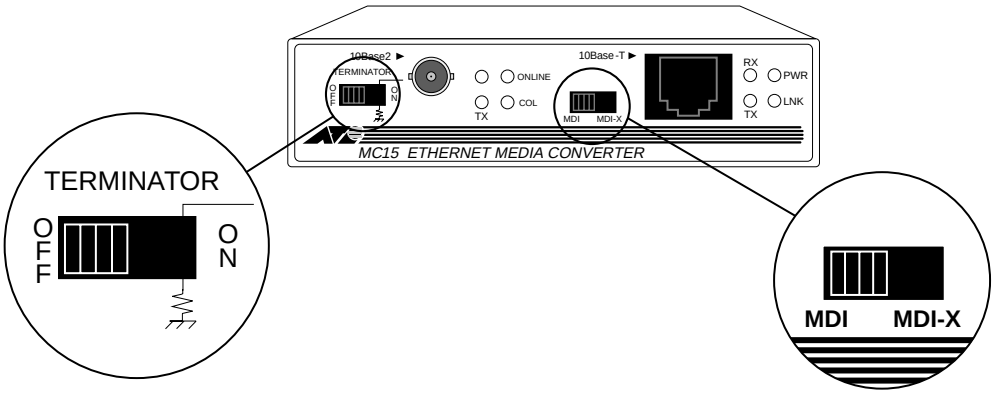


Figure 5-70 GE Specific AT-MC15 Switch Settings

2.1.9.2 LEDs

Status LEDs are located on the front panel next to each port. See Figure 5-71. Each LED is described in the table below (Table 5-34).

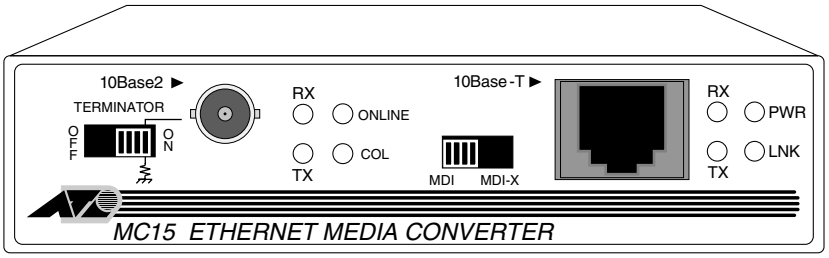


Figure 5-71 AT-MC15 (Allied Telesyn)

LED	DESCRIPTION
PWR	Indicates power is applied
LNK	Indicates link is established
TX (right)	Indicates data is being transmitted
RX (right)	Indicates valid data is being received
TX (left)	Indicates data is being transmitted on the BNC port
RX (left)	Indicates valid data is being received on the BNC port
ONLINE	Indicates the BNC port is connected to an active 10Base-2 segment
COL	Indicates the BNC port is sensing a collision signal

Table 5-34 AT-MC15 LEDs

2.1.10 Series Fast Ethernet Switch (AT-FS705, Allied Telesyn)

For additional product information, see Allied Telesyn web site at ***www.alliedtelesyn.com.***

2.1.10.1 Overview

All connectors and LEDs are located on the front panel.

Figure 5-72 AT-FS705 Front Panel

2.1.10.2 GE Specific Switch Settings

None.

2.1.10.3 Cables and Connections

Ports 1 through 5 are 10/100Base-TX connectors (RJ45). They are used to connect to a high performance workstation, server or hub.

Only use the cables supplied with the system. Category 5 cables must be used with 100Base-TX connections. Using any other category for a 100Base-TX connection can result in high error rates. If voice-quality cables are used in a 100Base-TX network system, data movement can be slow, collision-prone or non-existent. In addition, interface LEDs will usually indicate a valid link in such cases.

2.1.10.4 LEDs

Figure 5-73 illustrates the front panel LEDs; Table 5-35 lists and defines these LEDs.

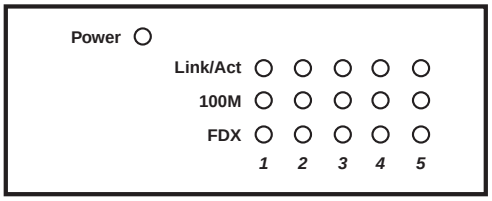


Figure 5-73 Front Panel LEDs

LEDS	COLOR	DESCRIPTION
Power (switch)	Green	**ON** indicates that the switch is receiving power. **OFF** indicates that there is no power to the switch.
LINK/ACT (port)	Green	**ON** indicates a valid physical link on the port. **Blinking** indicates data is being transmitted. **OFF** means no link.
100M (port)	Green	**ON** means the bandwidth is 100 Mbps. **OFF** means the bandwidth is 10 Mbps.
FDX (port)	Green	**ON** indicates full-duplex mode. **OFF** indicates half duplex mode.

Table 5-35 LED Status

2.1.10.5 Power Requirements

The AT-FS705 series switch uses an internal switching power supply with 100 to 120 VAC, 50/60 Hz input rating. Maximum power consumption is 50W.

2.1.11 Data Acquisition System Manager (DASM)

2.1.11.1 GE Specific Jumper Settings

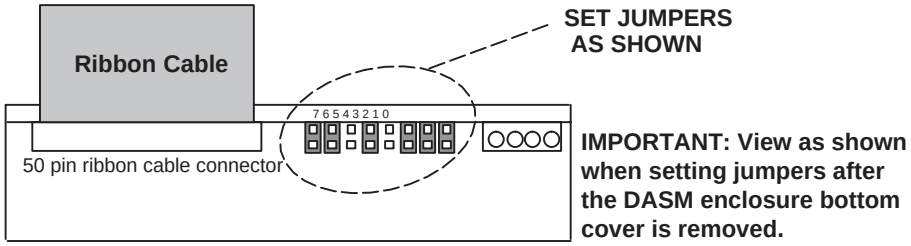


Figure 5-74 DASM Jumpers

2.1.11.2 GE Specific SCSI Settings

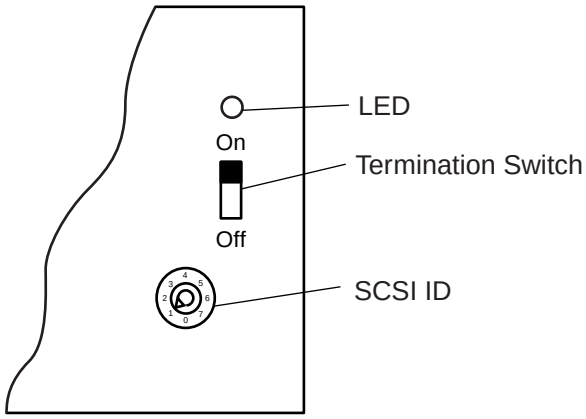


Figure 5-75 DASM Bottom, Showing SCSI Settings

2.1.11.3 DASM/LCAM Host Control Serial Link (Digital DASM Only)

RS232 serial host control interface, 25-pin D-type connector

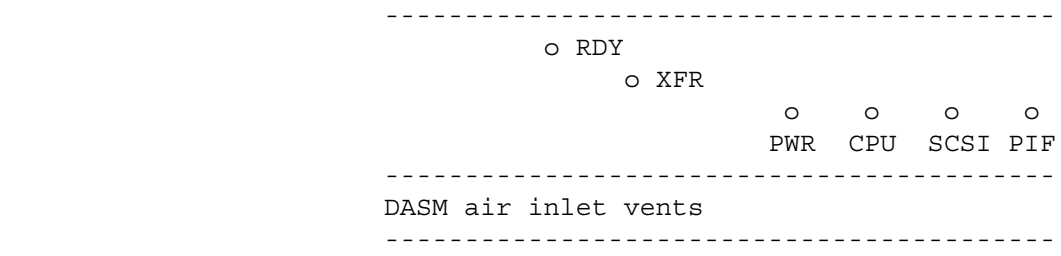
- pin 2 (TX)
- pin 3 (RX)
- pin 7 (GND)

A null modem cable may be required (reverses pins 2–3) between some cameras.

- baud rate = 1200
- start bits = 1
- stop bits =1
- parity = even
- end of message = CR
- protocol = ACK/NACK (3M M952)

2.1.11.4 DASM LEDs

DASM green LEDs viewed from front of DASM and air vents at bottom. The “RDY” and “XFR” LEDs only exist on the analog VDB DASM.



- PWR - on whenever DASM power applied (+5VDC)
- CPU - flashes idle heartbeat at 1 CPS or indicates CPU activity
- SCSI - flashes when OC and DASM communicate over the SCSIbus
- PIF - flashes when the DASM and camera communicate over the serial port
- RDY - analog VDB only, indicates an image is ready to be “grabbed” by the camera video/ analog input port
- XFR - analog VDB only, indicates an image is being “grabbed” by the camera video/analog input port

2.1.11.5 DASM/LCAM Image Data Interface

RS422/RS485 8-bit digital image data interface, 37-pin D-type connector (3M M952 defacto industry standard digital interface).

- pixels: 512
- lines: 512
- bits/pixel: 8
- protocol: 3M M952

The gray scale reference bar option at the left of the filmed images is *NOT* supported by the digital filming interface.

2.2 Scan Reconstruction Unit (ICEbox)

2.2.1 Scan Data Disk Assembly

If you have a need for further information, please visit Seagate's WEB site at www.seagate.com

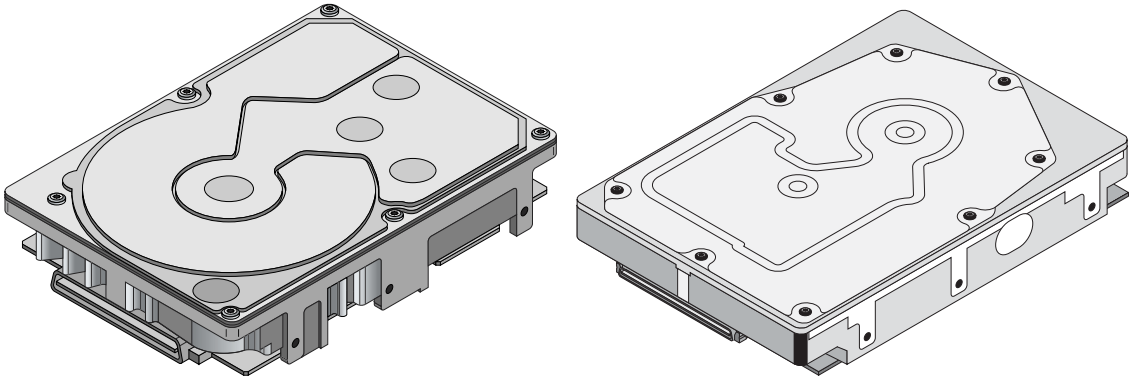


Figure 5-76 Scan Data Disk Drive (Seagate P/Ns ST318404, left, and ST318452, right)

2.2.1.1 Electrostatic Discharge and Protection for Disk Drives

NOTICE **Removal of circuit boards by personnel not performing depot repair will damage components.**

All drive electronic assemblies are sensitive to static electricity, due to the electrostatically sensitive devices used within the drive circuitry. Although some devices such as metal-oxide semiconductors are extremely sensitive, all semiconductors, as well as some resistors and capacitors, may be damaged or degraded by exposure to static electricity.

2.2.1.2 GE Specific Jumper Settings

Please set your SCSI Disk as shown in Figure 5-77.

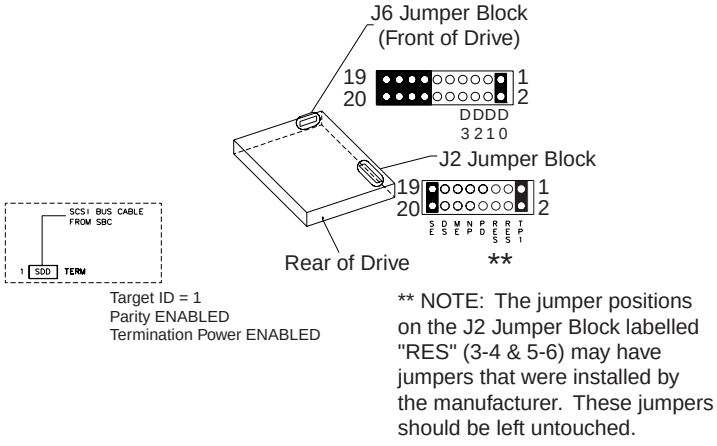


Figure 5-77 Scan Data Disk – GE Specific Settings

2.2.1.3 Jumpers

SCSI ID

The scan data drive must be configured as shown in Figure 5-77. The following information is provided for reference only.

Figure 5-78 shows a view of the drive's ID select jumper connectors (at left) and the drive's J5-auxiliary jumper connector (at right). Both J5-auxiliary and J6 have pins for selecting drive ID and for connecting a remote LED cable. Only one or the other should be used, although using both at the same time will not damage the drive.

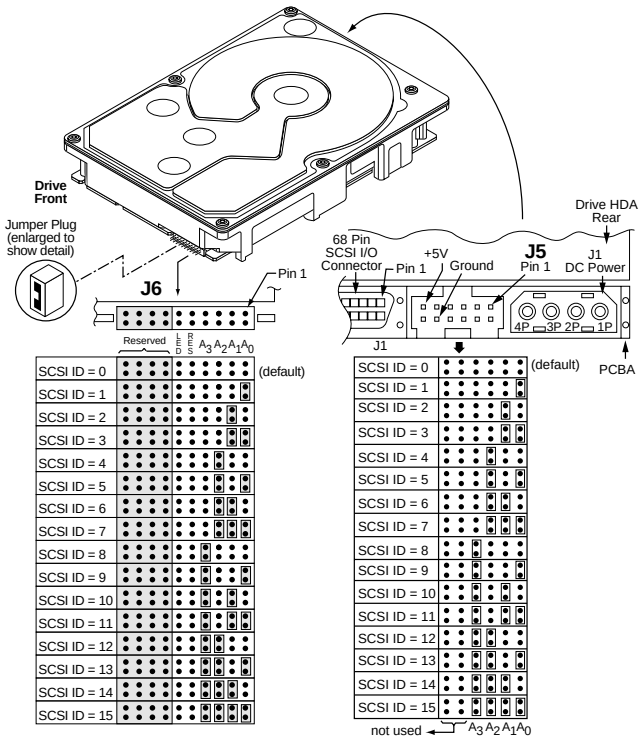


Figure 5-78 Scan Data Disk – SCSI Jumpers

Options (J2) Jumpers

Figure 5-79 shows the option select jumper header for all models.

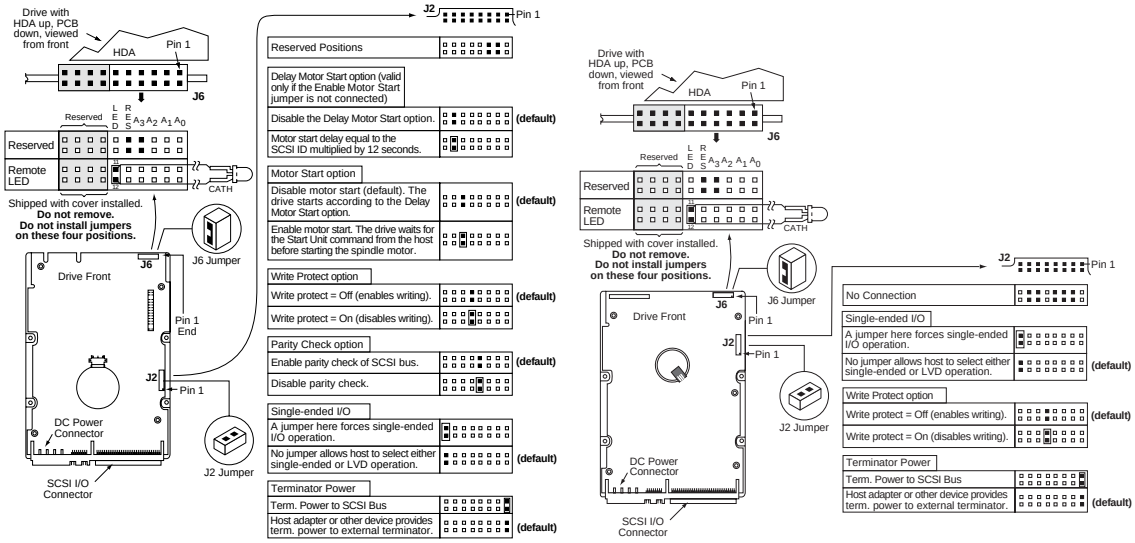


Figure 5-79 Scan Data Disk (J2 Header) Option Jumpers - ST318404 (lt) & ST318452 (rt)

Drive Termination (General Overview)

ST318451LW and ST318452LW drives do not have internal terminators or any other way of adding internal termination to the drive. External termination is required.

The example in Figure 5-80 shows an internal hard disc at one end of the SCSI bus with the SCSI controller at the other end (both are terminated). The bottom example shows two additional SCSI devices connected externally—this means the SCSI controller is no longer on the end of the SCSI chain and should not be terminated.

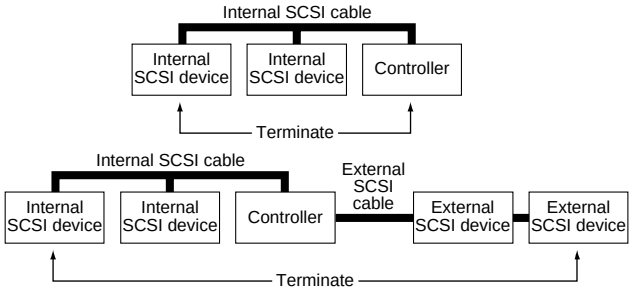
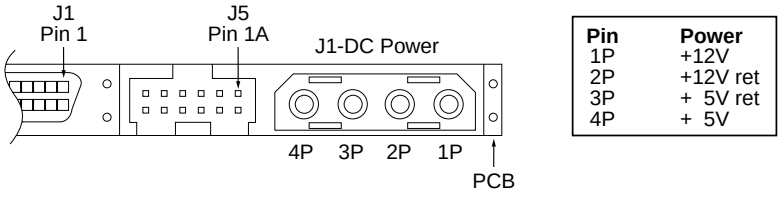


Figure 5-80 Typical SCSI bus Termination

Power Connections



Pin	Power
1P	+12V
2P	+12V ret
3P	+ 5V ret
4P	+ 5V

Figure 5-81 DC power connector

2.2.2 VME Power Supply

The following figure shows the terminal connections, adjustment potentiometers, and specifications for the power supply.

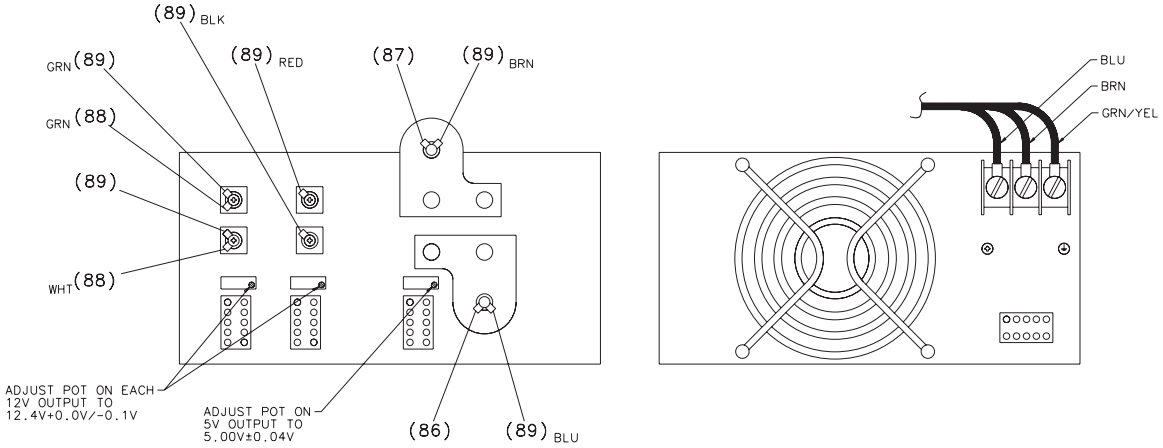


Figure 5-82 VME Power Supply Terminals & Adjustments (Astec)

2.2.3 VME Backplane

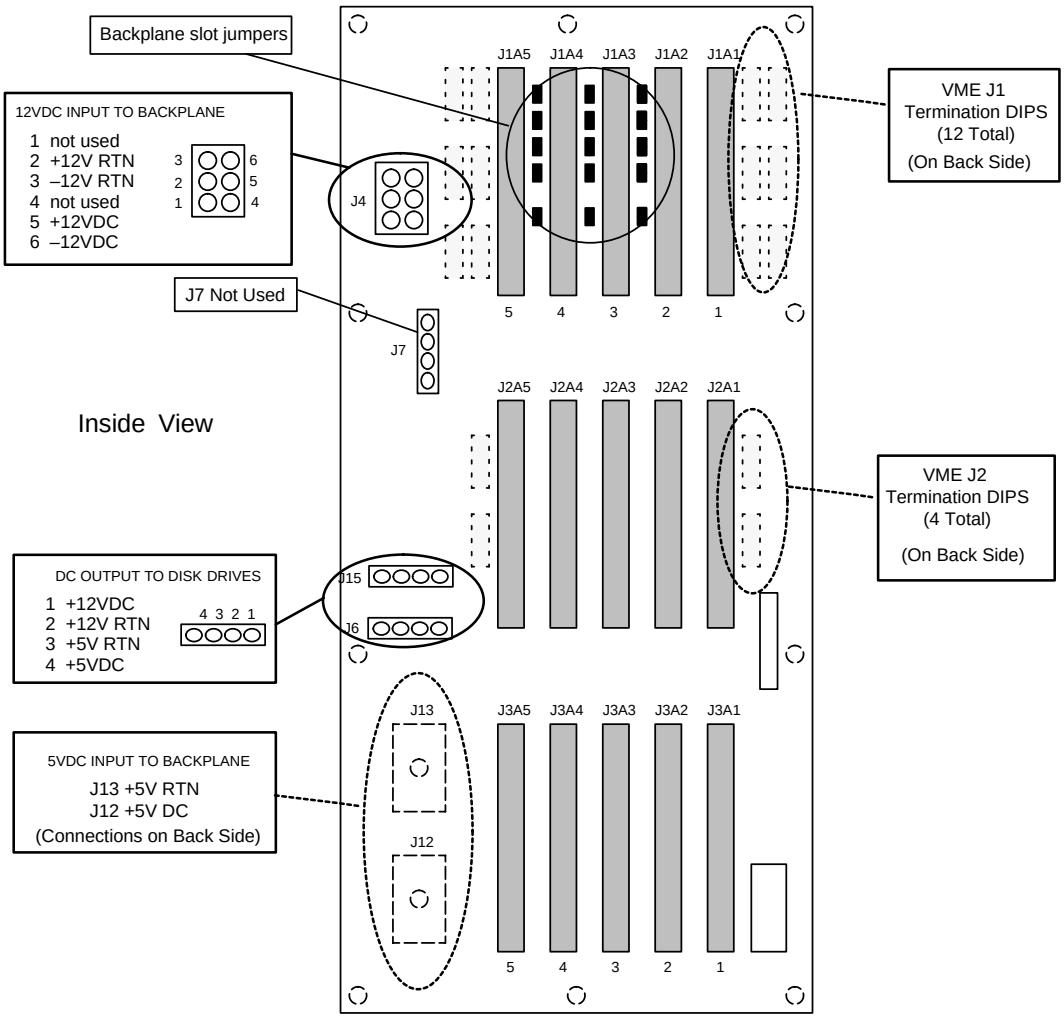


Figure 5-83 Scan Recon Chassis VME Backplane, Inside View

2.2.4 Recon Interface Processor (RIP) - Motorola Board

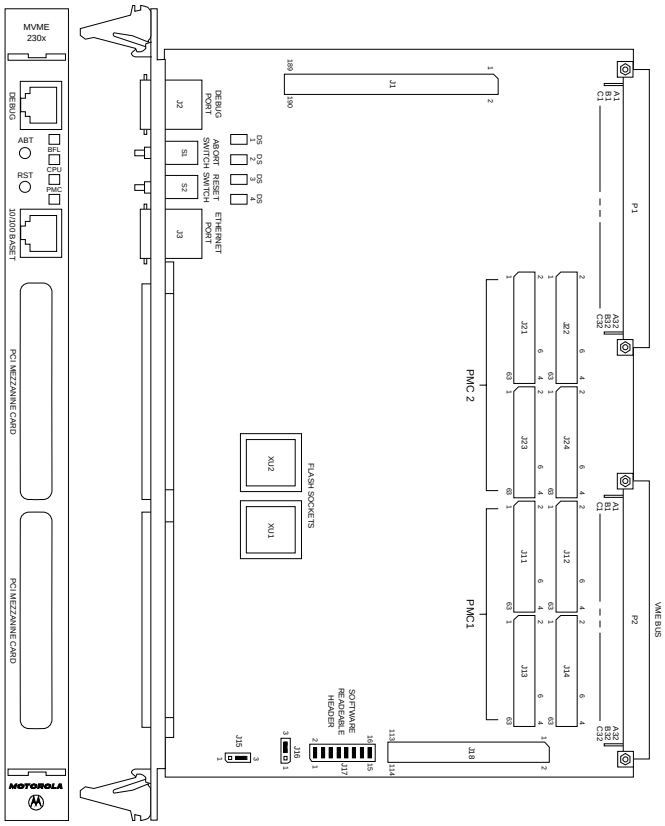


Figure 5-84 Recon Interface Processor Board Layout (VME230x)

2.2.4.1 Switches

There are two switches (ABT and RST) and four LED (light-emitting diode) status indicators (BFL, CPU, PMC (two)) located on the MVME230x front panel. See Figure 5-84.

ABT (S1)

When activated by software, the Abort switch, ABT, can generate an interrupt signal from the base board to the processor at a user-programmable level. The interrupt is normally used to abort program execution and return control to the debugger firmware located in the Flash memory. The interrupt signal reaches the processor module via ISA bus interrupt line IRQ8*. The signal is also available from the general purpose I/O port, which allows software to poll the Abort switch after an IRQ8* interrupt and verify that it has been pressed.

The interrupter connected to the ABT switch is an edge-sensitive circuit, filtered to remove switch bounce.

RST (S2)

The Reset switch, RST, resets all onboard devices and causes HRESET* to be asserted in the MPC604. It also drives a SYSRESET* signal, if the processor module is the system controller.

The Universe ASIC includes both a global and a local reset driver. When the Universe operates as the VMEbus system controller, the reset driver provides a global system reset by asserting the VMEbus signal SYSRESET*. A SYSRESET* signal may be generated by the RESET switch, a power-up reset, a watchdog time-out, or by a control bit in the Miscellaneous Control Register (MISC_CTL) in the Universe ASIC. SYSRESET* remains asserted for at least 200 ms, as required by the VMEbus specification.

Similarly, the Universe ASIC supplies an input signal and a control bit to initiate a local reset operation. By setting a control bit, software can maintain a board in a reset state, disabling a faulty

board from participating in normal system operation. The local reset driver is enabled even when the Universe ASIC is not system controller. Local resets may be generated by the RST switch, a power-up reset, a watchdog time-out, a VMEbus SYSRESET*, or a control bit in the MISC_CTL register.

2.2.4.2 Status Indicators

There are four LED (light-emitting diode) status indicators located on the front panel: BFL, CPU, PMC2, and PMC1. See Figure 5-84.

BFL (DS1) - The *yellow* BFL LED indicates board failure; lights when the BRDFAIL* signal line is active.

CPU (DS2) - The *green* CPU LED indicates CPU activity; lights when the DBB* (Data Bus Busy) signal line on the processor bus is active.

PMC (DS3) - The top *green* PMC LED indicates PCI activity; lights when the PCI bus grant to PMC2 signal line on the PCI bus is active. This indicates that a PMC installed on slot 2 is active.

PMC (DS4) - The bottom *green* PMC LED indicates PCI activity; lights when the PCI bus grant to PMC1 signal line on the PCI bus is active. This indicates that a PMC installed on slot 1 is active.

2.2.4.3 10/100 BASE-T Port

The RJ45 port on the front panel of the MVME230x labeled 10/100 BASE-T supplies the Ethernet LAN 10Base-T/100Base-TX interface, implemented with a DEC 21140/21143 device.

2.2.4.4 RIP - Motorola Board - GE Specific Settings

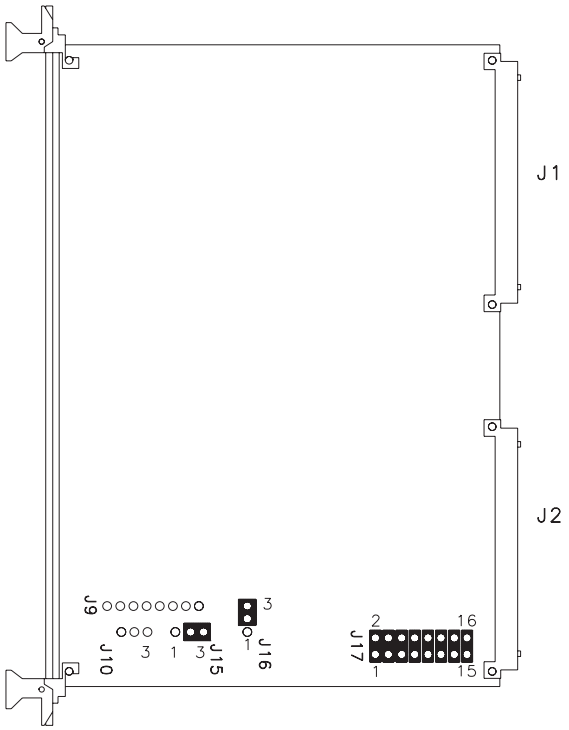


Figure 5-85 RIP - Motorola Board - GE Specific Settings (MVME230x)

2.2.5 SCSI "PMC" Card (2265396) - SBS Technologies

GE SPECIFIC SETTINGS

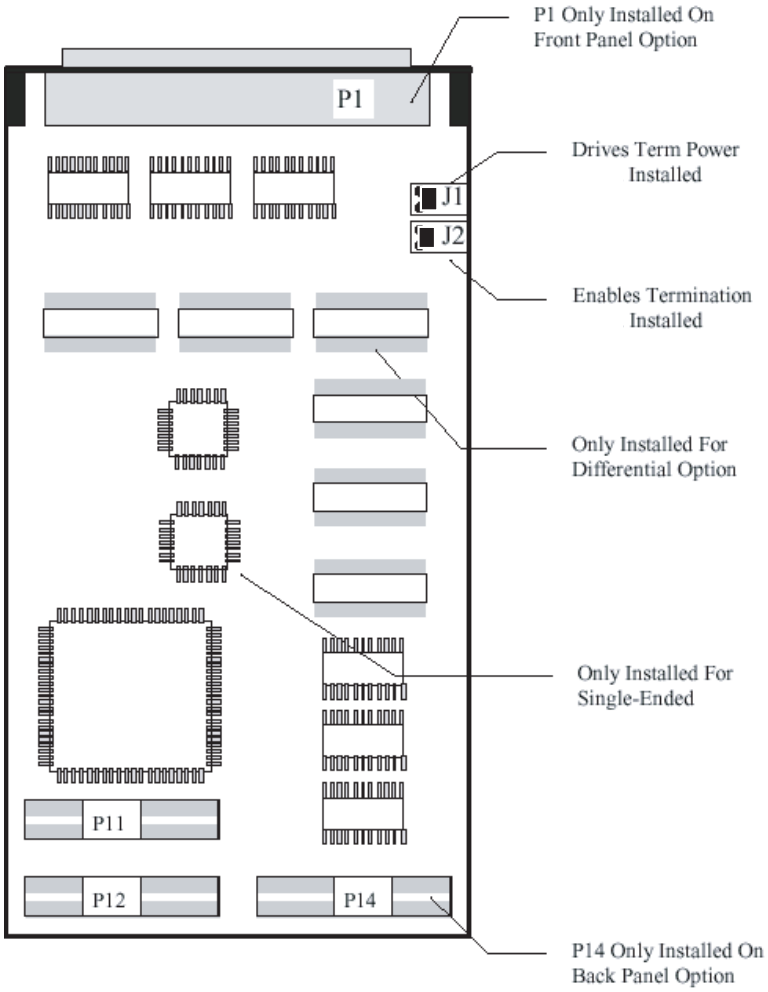


Figure 5-86 PMC SCSI Board - GE Specific Settings

2.2.6 DIP "PMC" Board

2.2.6.1 Jumpers and Switches

There are no jumpers, switches or pots that either the customer or service will operate.

2.2.6.2 LEDs

There is one LED on the DIP. It illuminates when the PCI Bus is activating the FRAME signal. This signal is active on all PCI cycles.

2.2.6.3 Connections

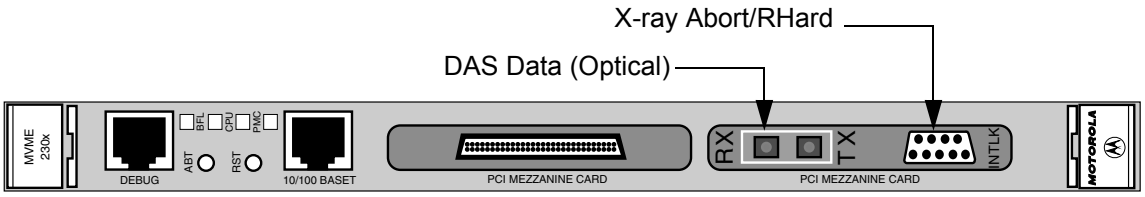


Figure 5-87 DIP Board External Cable Connections

GLASS FIBER OPTIC CABLE CONNECTION

For the slip ring interface (DAS Data) and data loopback.

Note: Orientation of RX and TX connectors

The optical cable connection is made to the RX port, which is located above the TX port as viewed from the front of the unit.

EDGE CONNECTORS

Two PMC-compliant 64-pin card edge connectors for the 32-bit PCI interface, as well as VCC and LGND.

X-RAY ABORT AND RHARD INTERFACE

The X-ray Abort and RHARD interface is a male, 9-pin Subminiature-D connector that is accessible from the front face of the DIP. Two of the pins are dedicated to the relay contacts for X-ray Abort, two for the RHARD, and two are dedicated to a read of cable status. See table below for pinout.

PIN NUMBER	SIGNAL NAME	PIN NUMBER	SIGNAL NAME
1	ABORT IN	2	Not connected
3	ABORT OUT	4	Not connected
5	Cable Read OUT	6	RHARD OUT
7	Not connected	8	RHARD IN
9	Cable Read IN		

Table 5-36 DIP Board's X-ray Abort and RHard Pinouts

2.2.7 Pegasus Image Generator (PEG-IG)

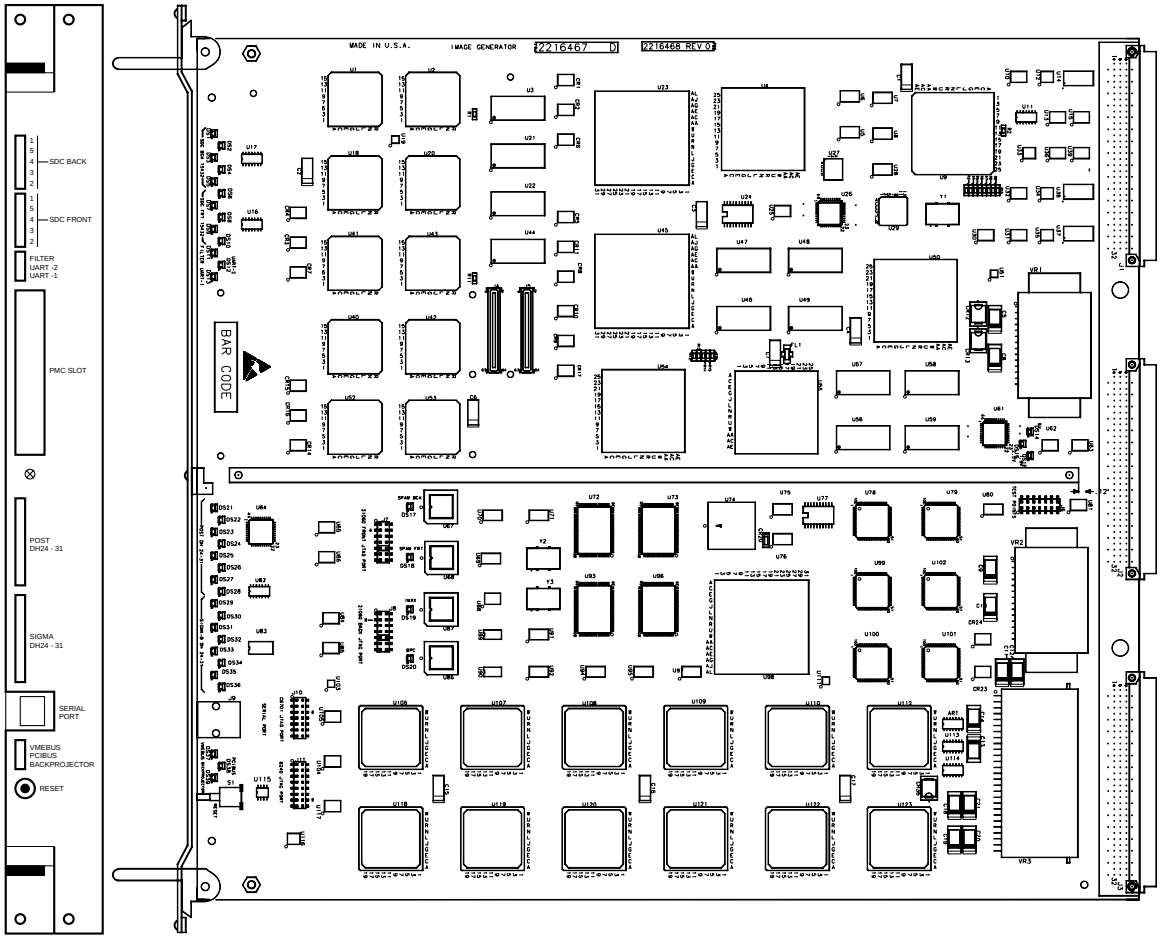


Figure 5-88 Pegasus Image Generator (PEG-IG) Board

2.2.7.1 LEDs

The Diagnostic LEDs can be visually inspected to assist in monitoring the various functions. Refer to Figure 5-88, on page 336, for LED locations.

DS17, DS18, DS19, and DS20 signify when the Xilinx FPGAs have completed their programming phase and are in application mode. (These should all go “on” about a half-second after power-up or board RESET).

DS12 and DS13 are user programmable via a register located in the UART serial port interface. (Currently not used during Diagnostics)

DS14, DS15, and DS16 indicate power supply status:

DS14 - 5.0 Volt Supply is “up”

DS15 - 2.6 Volt Supply is “up”

DS16 - 1.9 Volt Supply is “up”

DS7-11 are user programmable via the FLAG(3) pin of the ADSP-21060 processor located in SDC-VW Processing Front-end. (These will blink during the “collision test” diagnostic).

DS1, DS2, DS3, DS4, and DS5 are user programmable via the FLAG(3) pin of the ADSP-21060 processor located in SDC-VW Processing Back-end. (These will blink during the “collision test” diagnostic).

DS11 is user programmable via the Timer-1 Out pin of the TMS320C6701 located in Filter Processing. (Currently not used during Diagnostics)

DS21-28 are user programmable via data bits 24-31 of the Post Processor.

Here are the functions of these LEDs during ROM-based diagnostics:

(Top) DS31 - (Unused)
DS30 - (Unused)
DS29 - APU LED. Blinks when the APU diags are running.
DS28 - C67 LED. Blinks when the C67 diags are running.
DS27 - IMAX LED. Blinks when the IMAX diags are running.
DS26 - SPAM1 LED. Blinks when the SPAM1 diags are running.
DS25 - SPAM0 LED. Blinks when the SPAM0 diags are running.
(Bottom) DS24 - VxWorks Heartbeat LED. Blinks when VxWorks is running.

During System tests, DS24 is the heartbeat LED for VxWorks.

DS29-36 are user programmable via data bits 24-31 of the Sigma_B Processor.

Here are the functions of these LEDs during ROM-based diagnostics:

(Top) DS31 - (Unused)
DS30 - (Unused)
DS29 - (Unused)
DS28 - (Unused)
DS27 - (Unused)
DS26 -. (Unused)
DS25 - Dual Port LED. Blinks when the Dual Port Diag is running.
(Bottom) DS24 - VxWorks Heartbeat LED. Blinks when VxWorks is running.

During System tests, DS24 is the heartbeat LED for VxWorks.

DS39 is active whenever the Image Memory's DMA Controller is active. (Blinks during IMAX and APU diagnostics)

DS38 is active whenever PCI data transfers are taking place.

DS37 is active whenever VME data transfers are taking place.

2.2.7.2 PEG-IG Jumpers

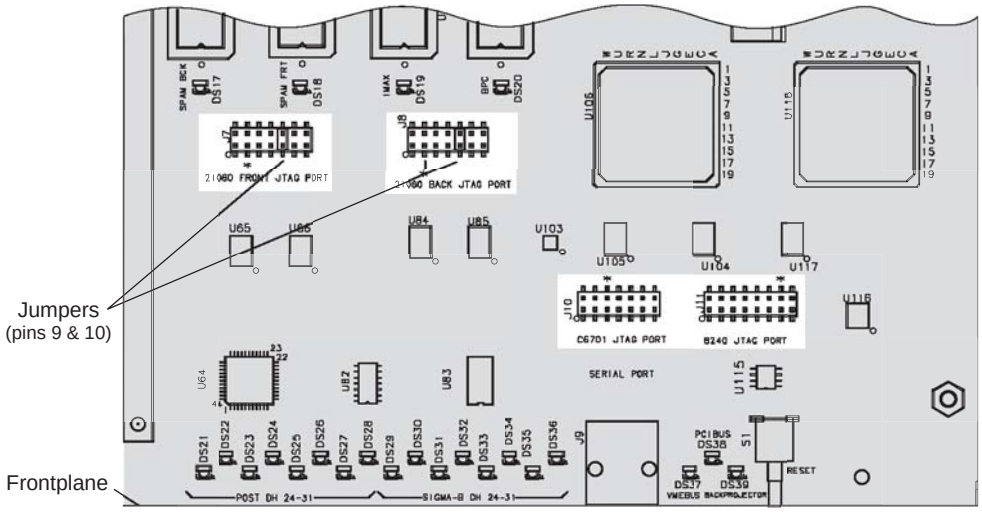


Figure 5-89 Pegasus Image Generator (PEG-IG) Board

Section 3.0
Replacement Procedures

3.1 Host Hardware

3.1.1 Console Front Cover

3.1.1.1 Removal Procedure

1.) From the service desktop, shut down the system
2.) Turn off console power.
3.) While holding the cover in place with your hand, use a 4mm “allen” wrench to rotate the pull-rings counter-clockwise. Slowly lean the cover forward and lift out of place with both hands. See Figure 5-90.

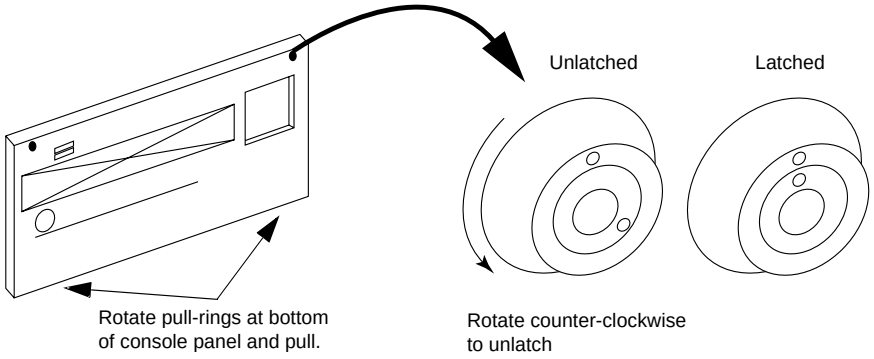


Figure 5-90 Removing Console Front Cover

3.1.1.2 Installation Procedure

1.) Lift the cover and engage the bottom edge of the cover with the bottom lip of the console.
2.) Slowly lean the cover inward until in place.
3.) While holding the cover in place, use a 4mm “allen” wrench to rotate each pull-ring clockwise.

3.1.2 SCIM/Keyboard

TOOLS NEEDED

- 4mm allen wrench
- Flash light or work light
- Small side cutters
- Small flat blade screw driver
- Tie-wraps

3.1.2.1 SCIM/Keyboard Removal

1.) From the service desktop, shut down the system, then turn off console power.
2.) Remove the console front cover. See Section 3.1.1, on page 338.

3.) Using caution, carefully remove the existing keyboard cable from the rear of the computer. Ty-rap existing keyboard cable to other cables located along the back wall of the console.

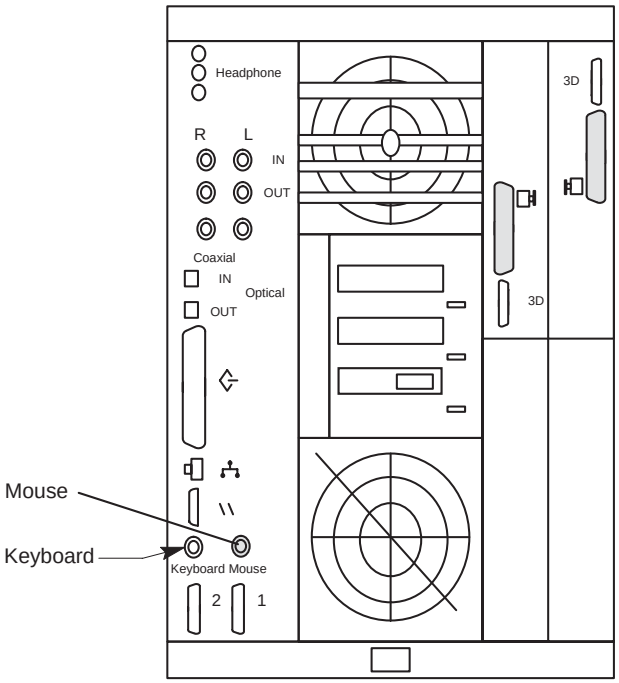


Figure 5-91 Rear view of Octane, showing keyboard and mouse connection

4.) Dress all cables to form a neat service loop to prevent the computer cables from pulling out, then insert the computer tray.

3.1.2.2 SCIM/Keyboard Installation

CONNECTING THE KEYBOARD, TRACKBALL, AND MOUSE

1.) Route the keyboard cables under the SCIM, as shown in Figure 5-92 and Figure 5-93.

Figure 5-92 SCIM with keyboard cable routed through cable opening

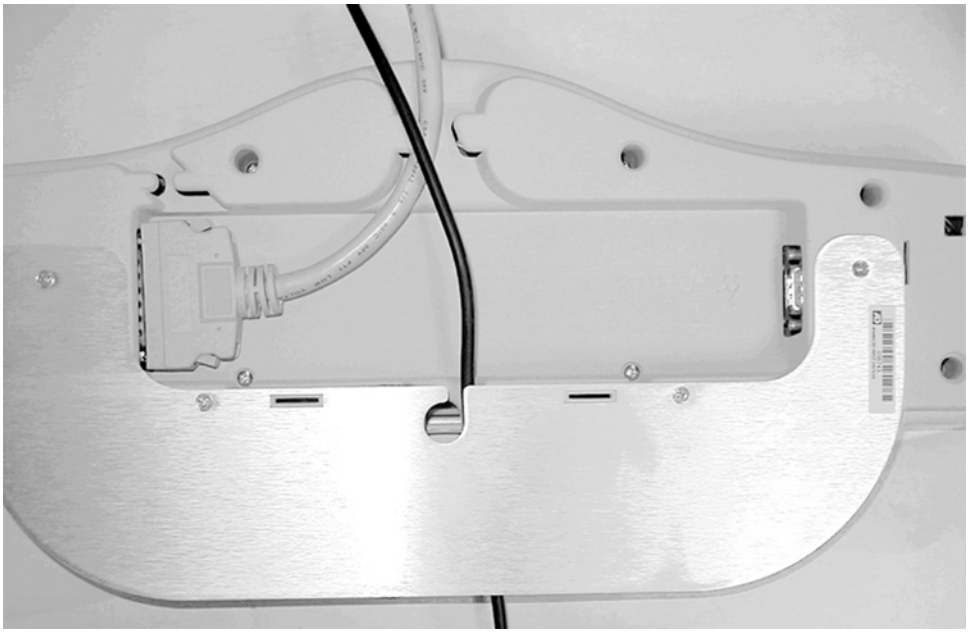


Figure 5-93 SCIM bottom, showing cables and keyboard mounting bracket.

2.) Route the mouse and keyboard cable (Run 5) through the console desktop raceway and through the 1" hole on the top of the console. Connect the mouse and keyboard cables directly to the back of the Octane computer (Figure 5-91). Use supplied tie-wraps to dress both cables and form a service loop.

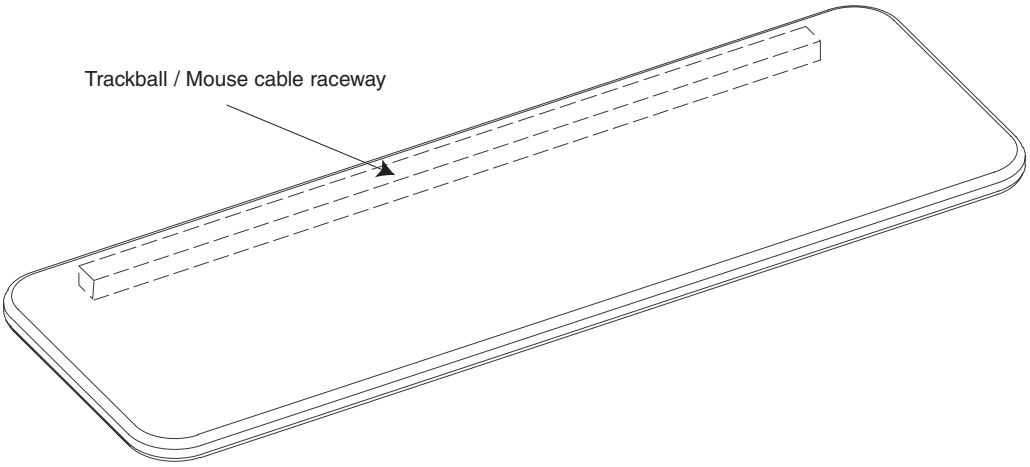


Figure 5-94 Console desktop raceway

3.) Route the trackball cable (Run 6) through the console desktop raceway, and connect it directly to the SCIM.

4.) The SCIM cable is run under the monitor table top and connected to the console back bulkhead J19.

5.) Select and install the proper overlay for your system: (1) with Tilt or (2) without tilt.

6.) The keyboard should attach to the SCIM using the supplied Velcro strip and fit snugly against the SCIM when finished, as shown in Figure 5-95.

Figure 5-95 SCIM connected to the keyboard with the US English tilt overlay installed.

7.) Check all cable connections and install front cover. Turn on console power and check that the console boots without errors. At the application level, complete functional checks of the keyboard and SCIM. Set voice controls and listening volumes to appropriate levels.

Note: The trackball and mouse cables should be routed through the cable raceway so that neither will be able to touch the floor when you are finished.

3.1.3 Octane Computer

After removing or installing any component, verify that the CPOP and Light Bar LEDS provide the expected values. See “Light Bar LEDs,” on page 372, and “CPOP Connector LEDs,” on page 373.

When replacing components in the Octane/OC, it may also be necessary to press the Reset Button on the front panel of the Octane to restart the OC. Refer to Figure 5-59, on page 315.

If you experience problems after replacing a FRU, please see “Host Computer (Octane),” on page 371, for troubleshooting information.

3.1.3.1 General Service Guidelines

To avoid damaging the system module, PCI module or XIO modules, follow these guidelines whenever these items are outside the computer.

- Do not touch the pads of the compression connector with anything.
- Whenever a module or board is not in the chassis, put the protective cap over the compression connector and put the module or board in an antistatic bag.
- Before laying a board on a surface, make sure that the surface is free of dust, lint, powder, metal filings, oil, water, and so on.
- Do not blow dust, dirt, or powder anywhere near a board when it is not inside its protective bag.
- Do not use a cleaning product that contains any of the following ingredients: halogenated hydrocarbons, aromatic hydrocarbons, ethers, sulphur, ketones, or solvents of any kind. These substances cause irreparable damage to the connector's surface.

- A compression connector should never need to be cleaned if you keep the protective cover on whenever the module or board is not in the chassis.

  If you must clean it, hold a can of dry compressed inert gas so that the tip of the applicator is one or two inches away from the first row of pads at the topmost edge of the connector. Maintain a slight angle so that the spray hits each pad and flows downward.

  Do not allow the applicator to touch the pads. Start spraying. As you spray, move the spray along the side of the connector until the entire first row has been sprayed. Move down to the next row. Repeat until all rows have been sprayed.

COMPRESSION CONNECTORS

In order to achieve high performance, the OCTANE workstation uses compression connectors to connect the system module, the *PCI module* and the *XIO modules* to the frontplane circuit board.

Each compression connector has 96 pads and two halves. One half is on the frontplane of the chassis; the other is on the system module, PCI module, or XIO board. Each pad on a frontplane connector is a flat gold-plated surface. *Each pad on the system module, PCI module or XIO board is composed of hundreds of tiny bristles. When a bristled pad is pressed into a gold-plated pad, a connection is created for one signal.*

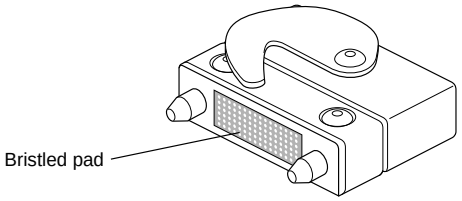


Figure 5-96 Control Connector

The bristled pads attract and hold dust, lint, grease, powder, and dirt. The presence of these substances clogs or damages the bristles and prevents them from making proper contact with the system's frontplane.

3.1.3.2 Internal Hard Drives

Hard drives come in a special carrier and require no assembly or disassembly. *Place the primary system drive in the bottom bay* on the front of the computer. The second system (image) disk is placed in the middle drive bay. The host's hardware automatically assigns SCSI IDs. The primary disk (lowest one) is assigned SCSI ID 1 (`dks0d1sN`). The one inserted above and in the middle of the drive bay then becomes SCSI ID 2 (`dks0d2sN`).

Note: Do not use the top slot.

Currently, the top slot in the drive bay is not used.

PROCEDURE

1.) Shutdown console power.

2.) Remove the console's front cover. Pull out platform upon on which the computer rests and release any tie-down strap if present.

3.) Remove the locking bar (if found).

NOTICE **You must wear a grounded ESD wrist strap. Place removed electronic parts on or in an antistatic surface.**

CAUTION **Wait five minutes after power is off before you continue. Let it cool.**

4.) Press both bezel release buttons on front upper sides.

5.) Tilt the cover forward and lift to remove it.

6.) Lift the drive's handle to the horizontal position and *gently* slide it into the bay. *Pushing a drive in with too much force can damage it. Seat the drive carefully but firmly.*

7.) When it is flush with the chassis, rotate the handle down to lock it in place.

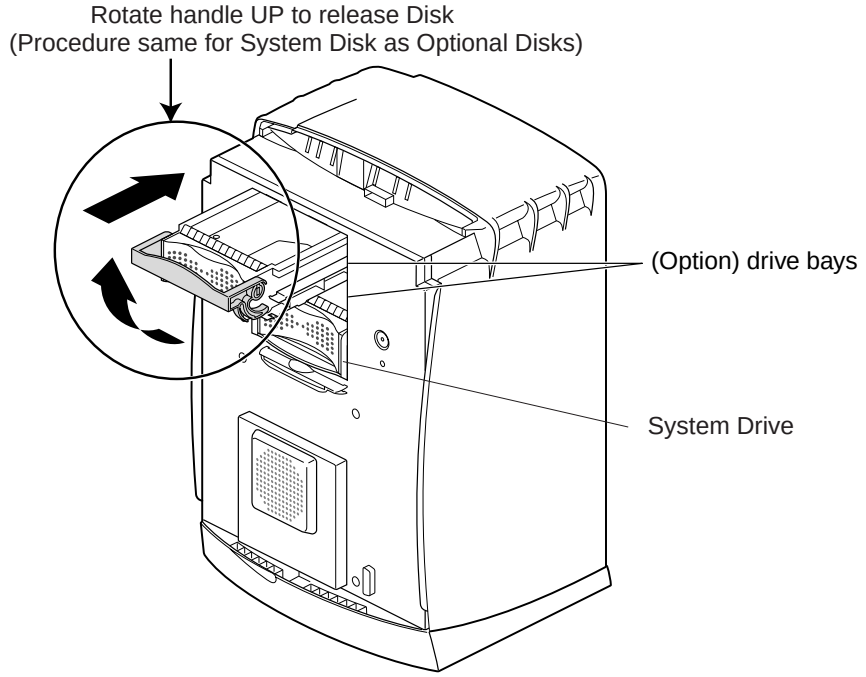


Figure 5-97 Host (Octane) System Drive

8.) If needed, remove the plastic panel for a new bay if adding a disk. Keep it in case it is needed later. Snap a saved panel to the cover if you permanently remove a hard drive from a bay. *This insures proper air flow. Do not remove a drive unless you have a replacement or a cover for the bay.*

9.) Re-power the system, press STOP FOR MAINTENANCE, and use **hinv** to verify that the host recognizes the hard drive(s).

3.1.3.3 Light Bar

To replace the Light Bar or LED Module, remove the front cover, then squeeze both top and bottom wings of the light together at both ends, gently and evenly pull straight out.

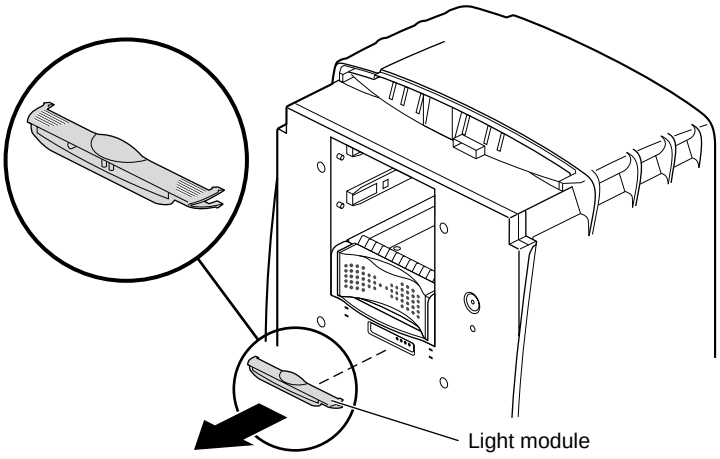


Figure 5-98 Host (Octane) Light Bar

3.1.3.4 System Module

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on or in an antistatic surface.**

CAUTION **Wait five minutes after the power is off before you continue. Let it cool.**

1.) Shutdown the system and remove power.
2.) Remove the console's front cover. Pull out the platform upon which the computer rests. Release its tie-down strap (if present).
3.) Remove the locking bar (if applicable).
4.) Loosen the captive screw in the sliding handles on the top and bottom.
5.) Pull both handles at the same time until they are fully extended.

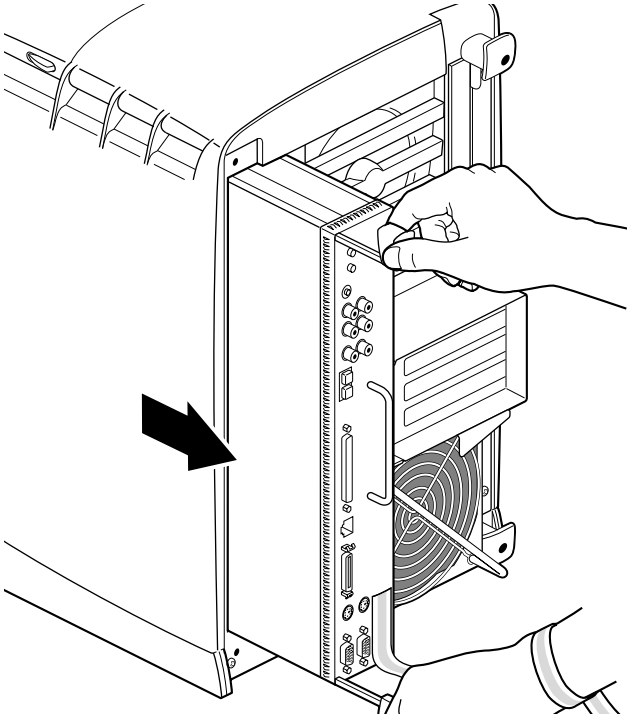


Figure 5-99 Removing the System Module

6.) Grasp the module handle with your left hand and place your right hand against the top of the computer's back. Pull the module out without allowing the delicate connectors on its back edge to touch anything.
7.) Place the system module on an antistatic surface with the component side up.
8.) Place a cap on each compression connector.
9.) To replace the system module, perform the above steps in reverse order.
10.) You may need to set/reset boot environment variables. See Section 3.3, on page 368, and Section 2.1.4, on page 176, for details.

3.1.3.5 System ID Module

The **System ID Module** can be seen inside computer after the System Module is pulled. It actually resides on the computer's frontplane assembly. It holds the preprogrammed Ethernet address for the Octane computer. It is a small circular disk held by a metal retaining clip. See page 353.

3.1.3.6 Host Processor

Orientation and Connection

A Single Processor (brick) is held by four screws; the Dual Processor by six. The Single Processor is placed closest to the panel of audio connectors. Take care to align connectors in the System Module with those on the Processor.

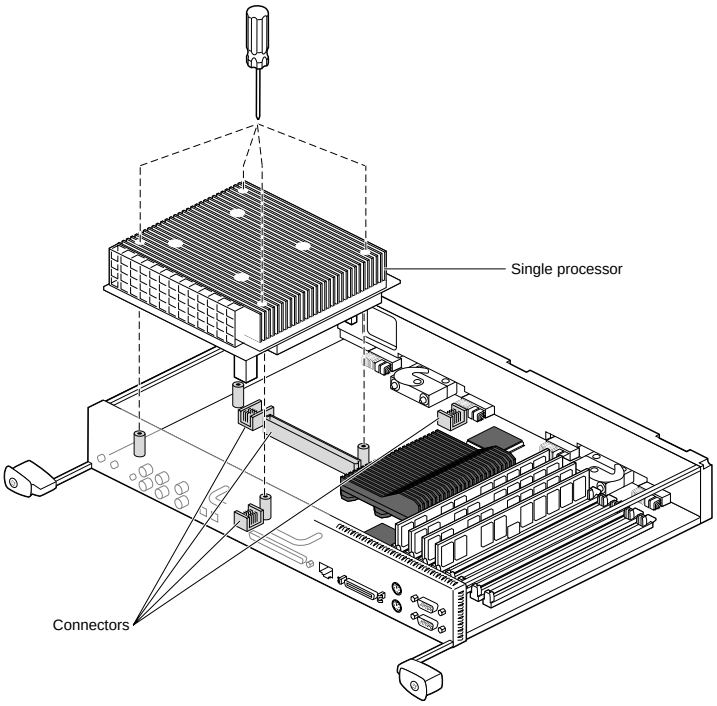


Figure 5-100 Replacing the processor (single processor shown)

Procedure

To install or remove a processor, you must power off the console, wait 5 minutes to allow the heat sinks to cool, and attach a wrist strap. Then remove the system module. Follow the instructions in Section 3.1.3.4, on page 344. Then return to these instructions.

1.) Loosen the four (4) captive Phillips screws that hold the CPU in place. (The dual processor has six screws.)

NOTICE
Potential for equipment damage

Do not remove the four inner screws (not Phillips) holding the heatsink to the CPU.

2.) Slide your fingers under the edge of the single processor closest to the back of the module, and push up to release it. (Use the side bar, for the dual processor.) You may need to use two hands to lift it out.

3.) Turn over the new CPU to determine where the connectors are located. Align the connectors on the base of the CPU with the connectors on the system board.

4.) If you are installing a single processor, place it on the side of the system module closest to the panel of connectors. See Figure 5-100.

5.) Lower the CPU onto the standoffs and connectors as shown in Figure 5-100. (Additional standoffs are used for a dual processor.)

6.) Tighten the four captive screws to the standoffs. (Six screws are used for a dual processor.)

3.1.3.7 DIMM Memory

Populating Memory

The Octane/Octane2 workstation has four DIMM banks with two DIMM sockets in each of the banks. Before you install the two 1 GB DIMMs, review the following information:

- Bank 1 (sockets 1 and 2) must always be filled.
- The highest density DIMMs must be installed in Bank 1, while lower density DIMMs must be installed in the remaining banks by order of their size (highest density first).
- Banks must be filled sequentially; when Bank 1 is full, fill Bank 2. Do not skip banks.
- Each bank must be empty, or contain two DIMMs, one in each of the two sockets.
- Capacity refers to the number of megabytes or gigabytes of memory in a DIMM: 32, 64, 128, or 256 MB, and so on, or 1 GB.
  - Minimum memory capacity is 64 MB (2 x 32 MB DIMM).
  - Maximum memory capacity is 1.5 GB (6 x 256 MB **DIMM**).
  - Minimum memory configuration is 64 MB in a bank (2 x 32 MB DIMM).
  - Maximum configuration is 2 GB in a bank (2 x 1 GB DIMM).

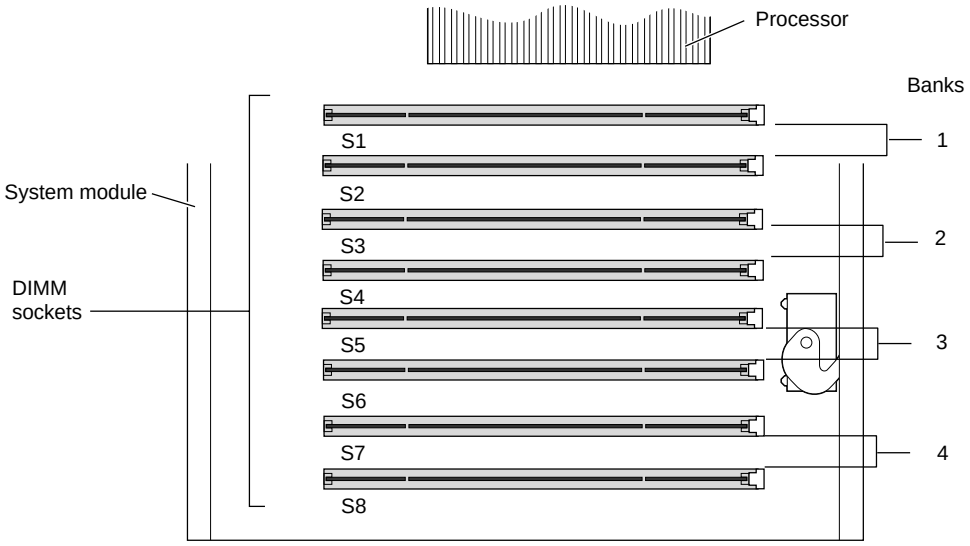


Figure 5-101 (Octane) Host - DIMM Socket and Bank Identifications

GE Specific Memory Configurations

OCTANE 1

Without D3D, 512MB Total

BANK 1		BANK2		BANK3		BANK4	
S1	S2	S3	S4	S5	S6	S7	S8
256	256	Empty	Empty	Empty	Empty	Empty	Empty
128	128	128	128	Empty	Empty	Empty	Empty
128	128	64	64	64	64	Empty	Empty

Table 5-37 Octane 1, Non D3D, 512MB Total

With D3D, 1.5GB Total

BANK 1		BANK2		BANK3		BANK4	
S1	S2	S3	S4	S5	S6	S7	S8
256	256	256	256	256	256	Empty	Empty
256	256	256	256	128	128	128	128

Table 5-38 Octane 1, D3D, 1.5GB Total

OCTANE 2

With and without D3D, 1.5GB Total

BANK 1		BANK2		BANK3		BANK4	
S1	S2	S3	S4	S5	S6	S7	S8
256	256	256	256	256	256	Empty	Empty

Table 5-39 Octane 2, with and without D3D, 1.5 GB Total

Procedure

NOTICE

Avoid Touching Bristles

- **Memory modules are extremely sensitive to static electricity. Use an ESD wrist strap and handle with care.**
- **Be aware that the heat sinks inside the computer become very HOT.**
- **DIMMs are located near a very delicate compression connector. Be extremely careful not to touch the compression connector's gold bristles. Always use the compression connector protective cap.**

To install or remove memory, you must power off the console, wait 5 minutes to allow the heat sinks to cool, and attach a wrist strap. Then remove the system module. Follow the instructions in Section 3.1.3.4, on page 344. Then return to these instructions.

1.) Locate the DIMMs you want to remove or replace.

As shown in Figure 5-102, press down on the latch at (A), near the end of the DIMM socket. The DIMM partially ejects from the socket. It can then be removed (B, in Figure 5-102).

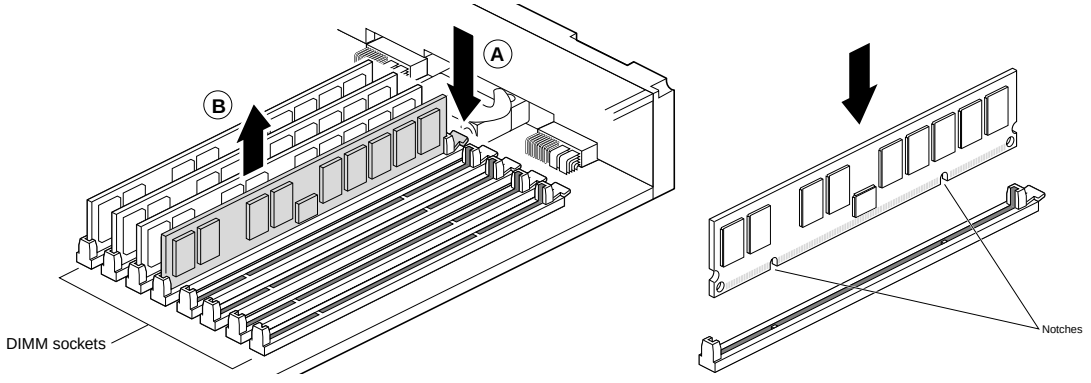


Figure 5-102 Host (Octane) DIMM Removal & Installation

2.) Insert the replacement DIMM into the socket, gently but firmly. You hear a click as it is seated, and the latch on the end of the socket moves up. DIMMs are notched on the bottom so that they cannot be inserted incorrectly. See Figure 5-102.

3.) Check to be sure both sockets in the bank are full. DIMMs must be installed in pairs.You have finished installing memory and are ready to replace the system module.

Common Mistakes

- **DIMM Sockets not populated correctly** - Both sockets in a DIMM bank must be either empty or populated. If you are removing one DIMM and not replacing it immediately, also remove the other DIMM in the bank and replace it when you install a new DIMM.
- **DIMM not seated properly** - Before replacing a memory module, check that all are seated correctly in their slots. Memory is installed correctly when it is vertical and perpendicular to the motherboard, and the latches on the both sides fit snugly around it. If the memory module appears to be leaning, wear an ESD wrist strap and push it into a vertical position.
- I**ncorrect memory combinations** - The first bank has two DIMMs that are exactly the same. The second bank, if used, has two DIMMs that are exactly the same, and so on for each succeeding bank. See the Table 5-40, below, for additional information about memory DIMM identification.

DIMM MFG - MEMORY CAPACITY	MFG P/N	GE P/N (PAIR)	OTHER CODING (E.G., LABEL COLOR)	COMMENTS
SGI - 32MB	9940069		Yellow	Never used on Plus
Dataram - 32MB	60056	21998061	n/a	Never used on Plus
SGI - 64MB	9940084 9470178		Blue Green	Used on standard 3-D Option only
Dataram - 64MB	62614	2199806-21	n/a	Used on standard 3-D Option only
SGI - 128MB	9470168		Brown*	Standard Memory
SGI - 128MB	9010020		Brown**	Standard Memory
Dataram - 128MB	62615	2199806-51	n/a	Standard Memory
SGI - 256MB	9010021		White**	Standard/Direct-3D
SGI - 256MB	9470223		Red**	
Dataram - 256MB	62621		High Profile	Direct-3D Option
Dataram - 256MB	62649		Low Profile	Direct-3D Option

* 2K Refresh DIMMs, must be used as a matched pair in a bank, typically used in the original IP-30 System Module (SGI P/N 030-0887-003, GE Healthcare P/N 2169940-13).

** 4K Refresh DIMMs, must be used as a matched pair in a bank, and will only function in an Enhanced IP-30 System Module (SGI P/N 030-1467-001, GE Healthcare P/N 2169940-45).

Table 5-40 DIMM Identification

3.1.3.8 Octane (Original): Graphics Subsystem - XIO Module

Before removing a graphics board or TMRAM, you must power off the OCTANE workstation, wait 5 minutes for the heat sinks to cool, attach a wrist strap, and not allow the compression connectors to touch anything. Test for heat before touching any of the parts.

XIO Module

1.) Bring down the system.

2.) Power off console

3.) Remove the console's front cover. Pull out platform upon which the computer rests. Release its tie-down strap, if present.

4.) Remove the locking bar (if applicable).

5.) Unplug the Octane power cord.

6.) Remove all the cables from the XIO module.

CAUTION **The heat sinks on the XIO boards become very hot. Wait 5 minutes after powering off the OCTANE workstation before you remove the XIO module. Test before touching any of the XIO boards.**

NOTICE **The components inside the OCTANE workstation are extremely sensitive to static electricity; you must wear the wrist strap while replacing parts inside the workstation.**

7.) When you remove the XIO module, the compression connectors on the back of the XIO module (XIO boards) are accessible and easily damaged. All XIO graphics boards have compression connectors, and most XIO option boards do.

NOTICE
Avoid Damage **The compression connectors on each XIO board are very delicate and easily damaged. Do not touch or bump the gold bristled pad.**

8.) Loosen the two captive screws in the XIO module handles with a Phillips screwdriver until the screws are disconnected from the chassis.

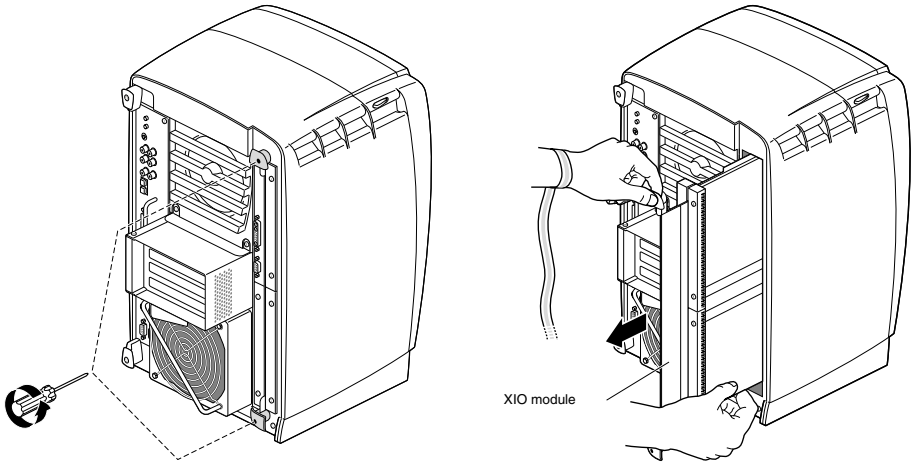


Figure 5-103 Removing the XIO Module

9.) Grasp the handles and pull until the XIO module protrudes about an inch from the chassis. The handles and XIO module move out about one inch before the I/O panels move.

10.) Continue to pull on the handles until the XIO module releases from the workstation. Grasp the XIO module along its length, and support the base of the module with your hand as you remove it from the chassis.

11.) The handle area protrudes when the XIO module is out of the chassis. When protruding, the identification slots for the XIO boards, D and A, B and C, are visible.

Note: Do not push on the handle area after you have removed the XIO module. The XIO module locks to the workstation only if the handle area is protruding.

12.) Place the XIO module on a flat, antistatic surface.

XIO Components

1.) Before you remove a graphics board or TMRAM, place a cap on the XIO compression connector to prevent accidental damage.

NOTICE
Avoid Damage

Never touch the gold (front) surface of the XIO compression connector. Touching it could damage the connector. Place a protective cap on XIO compression connector to prevent damage when components are removed from the OCTANE workstation.

2.) Using a Phillips screwdriver, remove the screws from the graphics board. The OCTANE SI and/or SE graphics board attaches with 4 screws. The TMRAM is attached at the back with one nylon screw.

Note: Only use nylon screws to attach the TMRAM to its base or it will not work properly.

3.) Grasp the graphics board on both the I/O panel and the side of the board with no connectors and lift.

4.) With the same side facing up, place the board on a clean, antistatic surface.

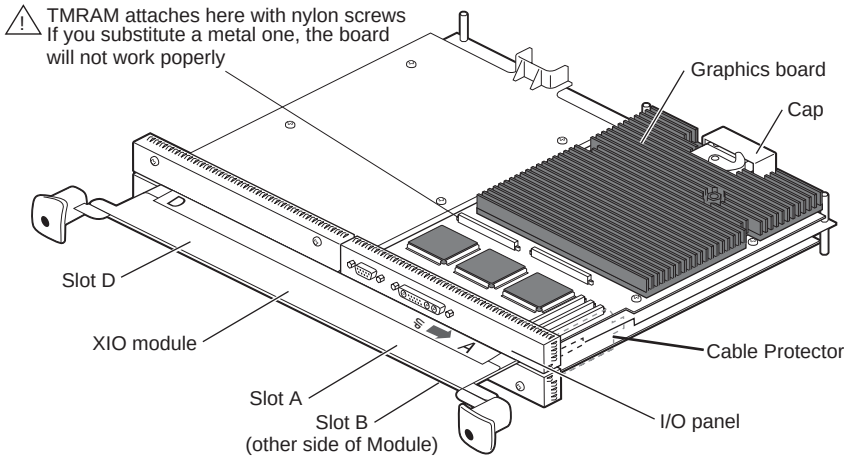


Figure 5-104 Inside the Octane XIO module

Installing a Graphics Board, Option Board, or Blank Panel

1.) Place the XIO module on its side, with the handles facing you.

2.) The OCTANE SI or SE graphics board with TMRAM always goes in slot A. The secondary SI or SE goes into slot B (NOT D), on the other side of the module, such that the two boards are “back-to-back” at the top of the module.

3.) Orient the board so that the component side is up.

4.) Place the graphics board on the standoffs.

5.) Replace the screws, tightening the board to the standoffs.

Note: Be sure all of the XIO slots are filled with a graphics board or blank panels. The system will not cool properly if any of the slots are empty.

Note: To have the host report what graphics board information it sees, type the following in a shell:

/usr/gfx/gfxinfo

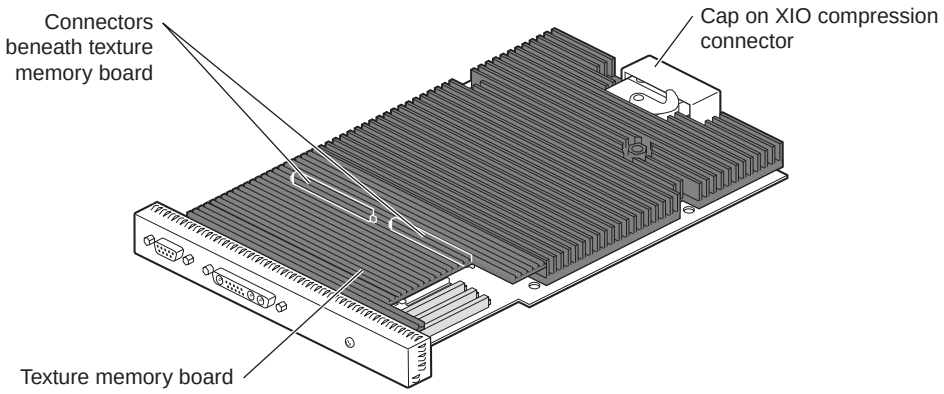


Figure 5-105 Octane Solid Impact board with Texture Memory

Installing the XIO Module

NOTICE **Please observe the following:**

- **Place the XIO module with the graphics boards facing toward the inside of the workstation. The boards may be damaged if placed the other way.**
- **Wear an antistatic wrist strap.**

1.) Slide the XIO module into the guides on the top and bottom of the workstation.

2.) Before you insert the XIO module, make sure the handle portion protrudes in a locked position from the I/O panels. If the handles are flush with the I/O panels, the XIO module will stop during insertion. Pull out the handles until the sliding portion of the XIO module is rigid, then continue inserting the XIO module into the chassis.

3.) Grasp the handle area while supporting the XIO module, and slide the module into the chassis.

4.) Use the handles to push the XIO module into a locked position. (The I/O panels are nearly flush with the workstation when properly inserted, however, there is a slight variation in the depth of the boards.)

5.) Tighten the captive screws in the handles.

6.) Remove the wrist strap.

7.) Reconnect all XIO cables to the XIO module.

3.1.3.9 PCI Expansion Card Module

Preparation

1.) Shutdown system and remove power.

2.) Remove the console's front cover. Pull out the platform upon which the computer rests. Release its tie-down strap, if present.

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on an anti-static surface.**

3.) Remove any cables from the PCI module.

4.) Loosen the two captive screws (see Figure 5-106).

5.) Pull out the release lever along the bottom of the module (see Figure 5-106).

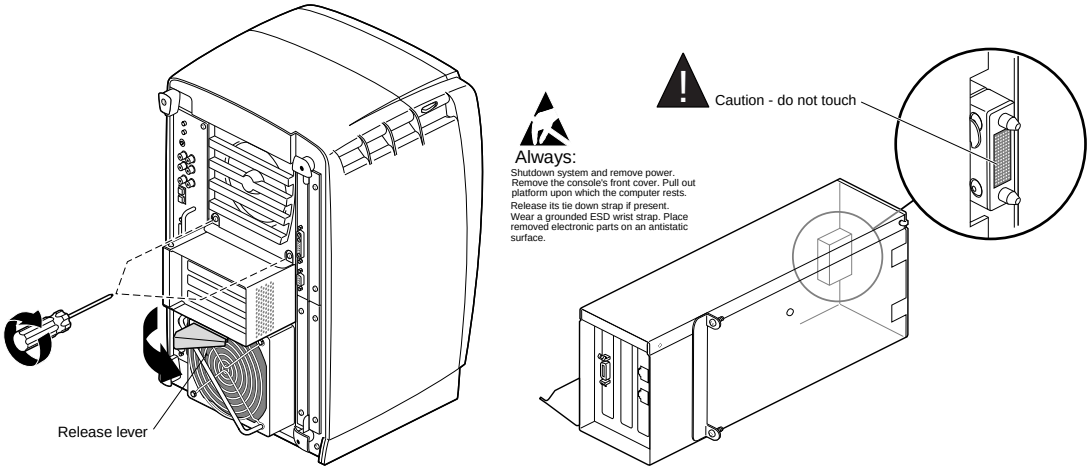


Figure 5-106 (Octane) Host - Removing the PCI Module

6.) Slide out the module, taking care not to allow the compression connector to touch anything. Cap the compression connector, once the module is resting on an antistatic surface.

PCI Card Removal

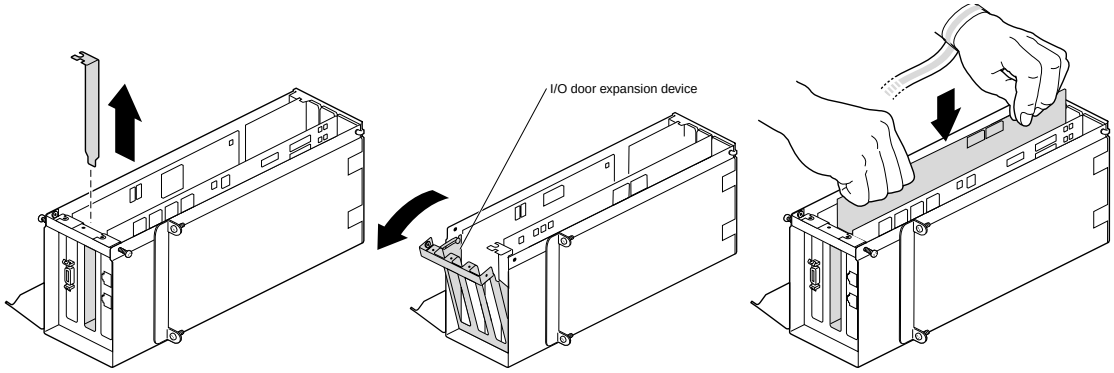


Figure 5-107 PCI Card Removal/Installation

7.) Lie the module on its right side and loosen the two screws that hold the left side access cover. Then lift and remove this cover.

NOTICE **PCI cards are extremely sensitive to static electricity.**

8.) The PCI card resides in a slot. Unscrew the board from the front panel. You can also expand the I/O door. See Figure 5-107. The I/O door expands open if necessary.

Note: Any slots without cards require a panel to ensure good air flow.

9.) To re-install, reverse the previous steps.

3.1.3.10 Octane Power Supply

1.) Shutdown system and remove power.
2.) Remove the console's front cover. Pull out platform upon which the computer rests. Release its tie-down strap, if present.
3.) **Remove the PCI module** (refer to page 352).

NOTICE **Wear a grounded ESD wrist strap. Place removed module on an antistatic surface.**

Note: The power supply is grounded while its power cord is plugged in. Just have power off to the console.

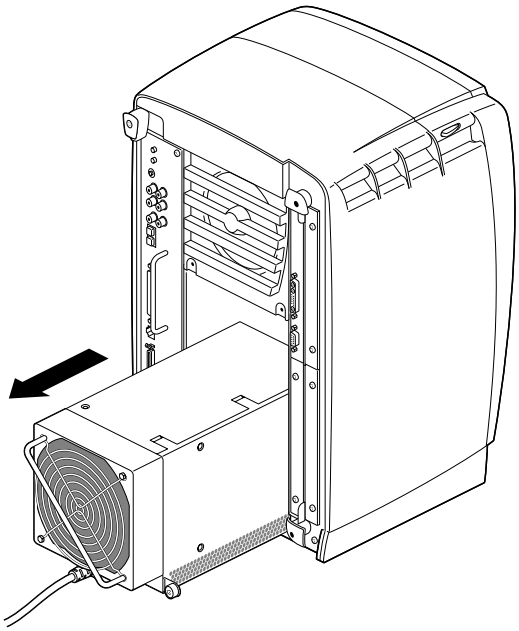


Figure 5-108 Octane Power Supply

4.) Use a phillips screwdriver to loosen the two captive screws at the base of the power supply module.
5.) Grasp the handle, pull it out then unplug the power cord.
6.) Reverse these steps to reinstall.

3.1.3.11 Octane Frontplane Module

Follow this procedure to replace the **System ID Module**, the **Fan Module** or the **Frontplane Module**.

Note: Save your ID Module
If the Frontplane Module is replaced, move the System ID Module from the old unit to the new. See Figure 5-109. The new front plane module does not come with a system ID module.

1.) Shutdown system and remove power.
2.) Remove the console's front cover. Pull out platform upon which the computer rests. Release its tie-down strap if present.

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on an antistatic surface.**

3.) Remove the System Module. Refer to page 344.
4.) Remove the XIO Module. Refer to page 348.
5.) Remove the PCI Module. Refer to page 352.
6.) Remove the Octane Power Supply. Refer to page 352.
7.) Squeeze both buttons on upper front sides of Octane computer, then tilt forward and lift to remove its front cover.
8.) Remove all Octane Disk Drives. Refer to page 342.
9.) Remove the Light Module. Squeeze both top and bottom wings of the light together at both

ends, gently and evenly pull straight out.

10.) Loosen the six (6) captive screws that hold the frontplane module to the chassis. Refer to Figure 5-109, below.

11.) Place your hand inside the drive bay and lift the module from the base.

12.) Place it face down on an antistatic surface. Avoid touching any components.

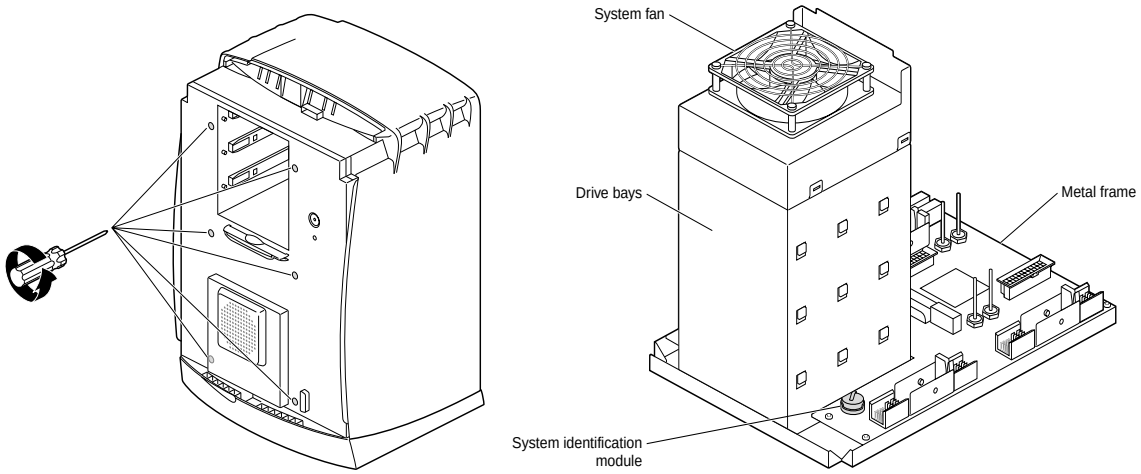


Figure 5-109 Removing the Frontplane Module from the Chassis

Now you can replace the System ID module or the Fan. The **System ID Module** holds the pre-programmed Ethernet address for the Octane computer. It is a small circular disk held by a metal retaining clip next to the drive bay. If the System ID module is changed, all software options (MODs) will have to be re-ordered, as the Options MOD(s) is fingerprinted to the Host Ethernet address at first installation.

Power Supply Fan

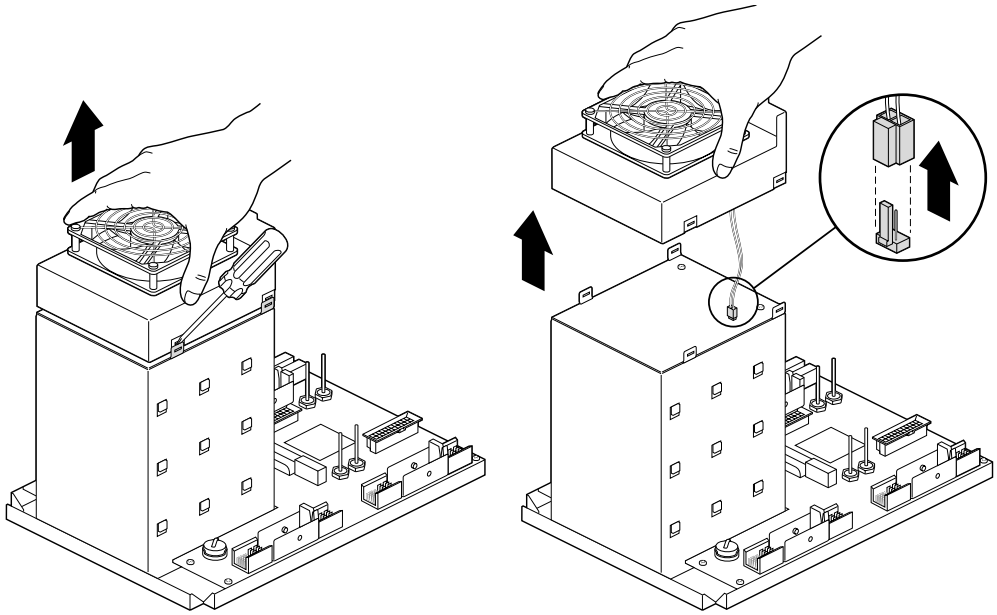


Figure 5-110 Releasing the PS Fan

13.) Use a flat headed screwdriver to separate the four tabs holding the fan module to the back of the drive bay.

14.) Disconnect the power connector under the fan

System Identification Module

Remove the system identification module only when replacing the frontplane module.

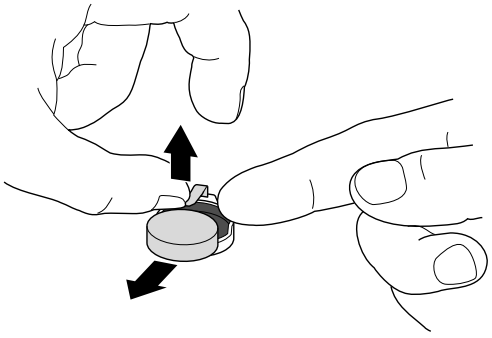


Figure 5-111 Removing the System ID Module

1.) Remove the system identification module.
   a.) Lift up on the metal retaining clip.
   b.) Slide the system identification module to the side and out.

2.) Place the system identification module on the new frontplane.
   a.) Lift up on the retaining clip.
   b.) Slide the system identification module under the clip.

Note: The System ID Module contains the host Ethernet Address number. If you replace this item, all of your Software Options (which are fingerprinted to this number) will be unavailable. You will have to order a new Options MOD(s) to restore option software, in this case.

3.1.4 Octane2 Computer

3.1.4.1 Before You Begin

The Octane computer field replaceable unit (FRU) is shipped configured to reuse components from the computer it replaces. The computer is shipped minus the following components:

- Disk Drives
- PCI Module and PCI boards
- Memory Modules
- System ID Module

You will remove these components from the computer being replaced and re-install them in your replacement computer. All of the above components are also available as individual FRUs.

Avoiding Equipment Damage and Personal Injury

Avoid damage to components and personal injury by taking the following precautions:

- Do not touch or clean the compression connector.
- Place the protective cap over the compression connector, if available.
- Lay all modules and board on antistatic surfaces only.
- Place all modules and board in antistatic bags.
- Wear a grounded ESD wrist strap in good working order.
- Maintain a clean work environment.
- Tag and lockout power.
- Wait five minutes after power is off before you continue. Let the system module cool.

Disk Drives

Disk drives are packaged in special carriers and require no assembly or disassembly. The primary system drive is placed in the bottom bay and the (image) disk in the middle drive bay. No jumpers are required because the computer's hardware automatically assigns SCSI IDs.

The ID Module

The system ID module is unique to your CT system. The System ID Module contains the computer's unique "Ethernet Address" number. If you loose the ID module, all of the Software Options you have installed will not be available for use. System software is locked to this unique ID during installation.

3.1.4.2 Octane2 Replacement Process

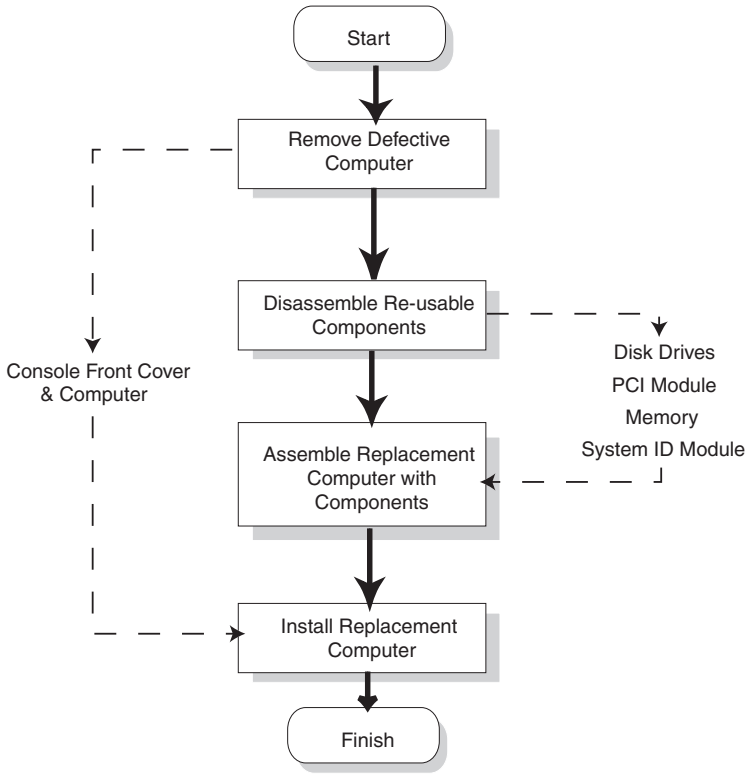


Figure 5-112 Replacement Process

NOTICE
Potential for Equipment Damage

Electronic devices are extremely sensitive to ESD damage. Always do the following:

- **Wear a grounded ESD wrist strap.**
- **Place parts on antistatic surfaces.**
- **Transport parts in antistatic bags.**

Remove Defective Computer

1.) From the service desktop, shut down the system.
2.) Tag and lockout system power.
3.) Turn off console power.
4.) Remove the console's front cover. Use a 4mm "allen" wrench to rotate each pull-ring counterclockwise.
5.) Pull out computer tray.
6.) Disconnect the cables attached to the back of the computer.
7.) Lift the computer out and place on a stable and clean work surface.

Disassemble Reusable Components

DISK DRIVES

1.) Remove the front bezel (cover) from the computer. Press both bezel release buttons simultaneously to release the cover.

2.) Tilt the bezel toward you and lift up to remove.

3.) Grasp a drive handle and lift it to a horizontal position.

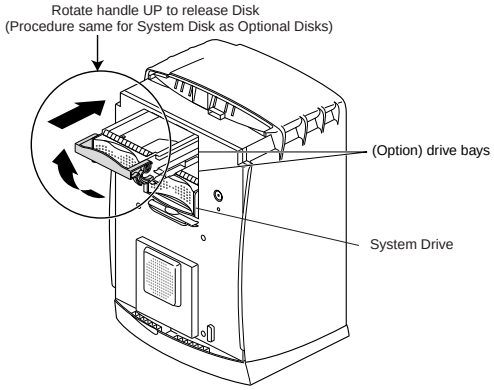


Figure 5-113 Removing & installing Disk Drives

4.) Applying gentle and steady pressure, pull out the drives.

5.) Place each drive on an antistatic surface or in an approved antistatic bag.

6.) Re-install the front cover.

PCI MODULE

1.) Loosen the two captive screws (see Figure 5-114).

2.) Pull out the release lever along the bottom of the module (see Figure 5-114).

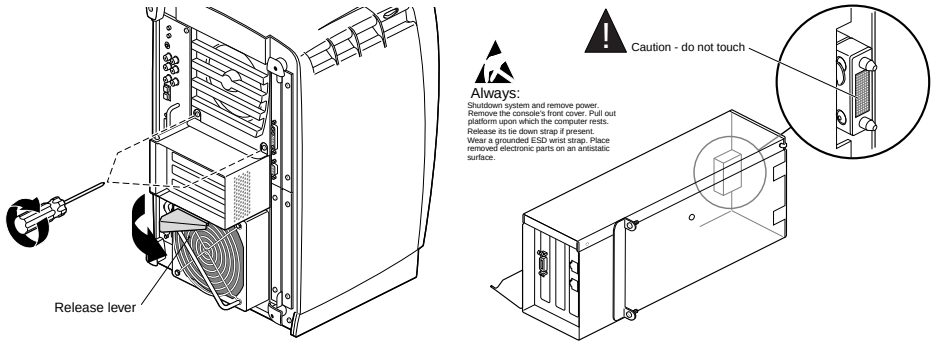


Figure 5-114 Removing the PCI Module

3.) Slide out the module, taking care not to allow the compression connector to touch anything. Cap the compression connector, once the module is resting on an antistatic surface.

MEMORY

CAUTION
Potential for Personal Injury

Allow computer components to cool. Wait 5 min. after power off before handling components.

1.) Remove the system module.

a.) Loosen the captive screw in each sliding handle.

b.) Pull both handles at the same time until they are fully extended (Figure 5-115).

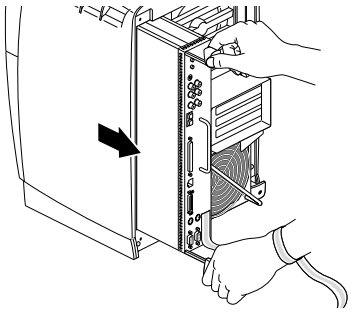


Figure 5-115 System Module

c.) Grasp the module handle with your left hand and place your right hand against the top of the computer's back. Pull out the module without allowing the delicate connectors on its back edge to touch anything.

d.) Place the system module on an antistatic surface, component side up.

2.) Remove the memory modules.

a.) Locate and unlatch the memory on the System Module. Press down on the latch, near the end of each DIMM socket (Figure 5-116). The DIMMs will partially eject from the socket.

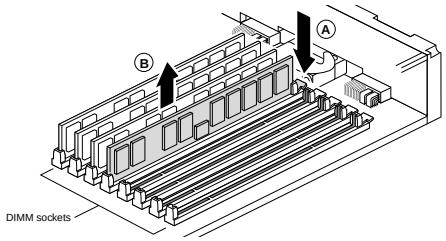


Figure 5-116 DIMM Removal & Installation

b.) Remove the memory modules and place in an antistatic environment.

ID MODULE

With patience, the ID module can be extracted from the frontplane without damage to either. If this process proves too difficult, follow the process outlined in Section 3.1.3.11, on page 353.

1.) Visually locate the ID module. It's on the frontplane near the top, as viewed looking into the slot vacated by the System Module. It is a small silver disk, held in by a metal retaining clip.

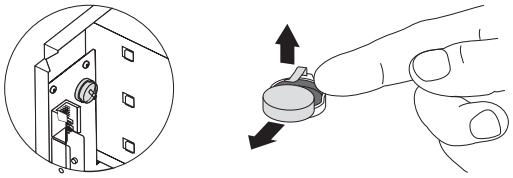


Figure 5-117 System ID Module

2.) With one hand, reach inside the computer and use your fingers to extract the ID module.

Assemble Replacement Computer with Components

NOTICE
Potential for equipment damage

Do not use excessive force to install any component. Excessive force can result in component failure. Be patient and use only gentle but firm pressure.

ID MODULE

1.) Remove the system module from the replacement computer.
   a.) Loosen the captive screw in each sliding handle.
   b.) Pull both handles at the same time until they are fully extended.
   c.) Pull out the system module.
   d.) Place the system module on an antistatic surface component side up.
2.) Install ID Module into replacement computer
   a.) With one hand, reach inside the replacement computer and use your fingers to insert the ID module.
   b.) Visually inspect the ID module and make sure it is securely in place.

MEMORY

1.) Install Memory Modules
   a.) Insert the DIMMs into their sockets on the new system module. You'll hear a click when they are latched. Notice how the latch on the end of the socket moves up when they're seated properly. *DIMMs are notched on the bottom so that they cannot be inserted incorrectly.* See Figure 5-118.

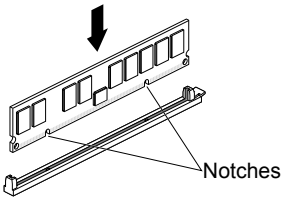


Figure 5-118 Inserting Memory Modules

   b.) Verify that both sockets in a bank are populated. DIMMs must be installed in pairs. See Figure 5-119

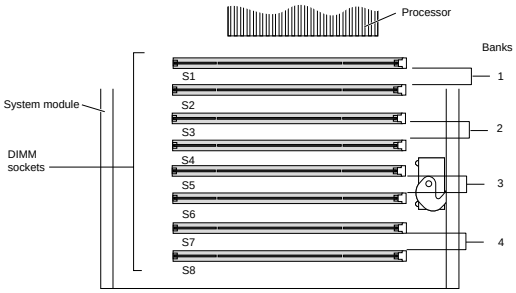


Figure 5-119 DIMM Socket and Bank Identifications

2.) Install System Module back into replacement computer
   a.) Grasp the module and push inwards, without allowing the delicate connectors on its back edge to touch anything.
   b.) With the module inserted, push both handles in at the same time until they are fully seated.

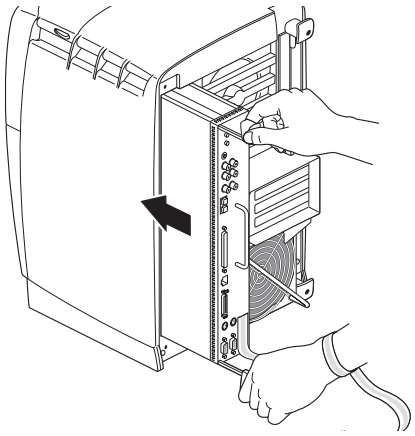


Figure 5-120 System Module

c.) Tighten the captive screw in each sliding handle.

PCI MODULE

1.) Slide the PCI module in the replacement computer. Do not to allow the compression connector to touch anything (be sure to remove compression cap before inserting).

2.) Push the release lever in to close (latch). (See Figure 5-121 for location of lever.)

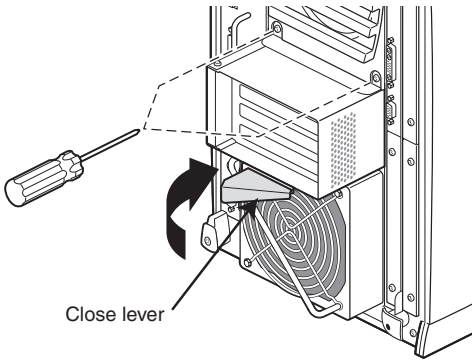


Figure 5-121 PCI Module Installation

3.) Tighten the two captive screws (Figure 5-121).

DISK DRIVES

1.) Remove the replacement computer front bezel (cover). Press both bezel release buttons simultaneously to release the cover.

2.) Tilt the bezel toward you and lift up to remove.

3.) Grasp a drive handle and lift it to a horizontal position.

4.) Applying gentle and steady pressure, push the drives into place.

5.) Rotate the drive handle to the vertical position to lock the drive in place.

6.) Re-install the front bezel.

Install Replacement Computer in Console

1.) Place computer on computer tray.

2.) Reconnect cables.

3.) Install console's front cover.

a.) Lift the cover and engage the bottom edge of the cover with the bottom lip of the console.

b.) Slowly lean the cover inward until in place.

4.) Turn on system power.

5.) Turn on console power switch to start-up computer.

3.1.4.3 Octane2 Memory

For memory replacement, please refer to "DIMM Memory," on page 346.

3.1.4.4 Octane2 9GB Disk Drive

For hard disk replacement, please refer to "Internal Hard Drives," on page 342.

3.1.4.5 Octane2 PCI Card Cage Assembly

For PCI card cage replacement, please refer to "PCI Expansion Card Module," on page 351.

3.1.5 Magneto Optical Disk (MOD)

System software options are deployed through a special MOD. If you happen to lose that MOD, please contact your OLC representative, who will contact the proper CT Manufacturing personnel to procure a new options MOD. If the Host (Octane) **System ID module** (small disk inside the Frontplane Module) is replaced, a new options MOD is required.

3.2 Image Reconstruction Unit (ICE Box & VME Chassis)

3.2.1 Reconstruction Interface Processor (RIP) Board

The RIP Board has two PCI Mezzanine Cards (PMCs), piggybacked on the board (see Figure 5-122, on page 364). These two PMCs are the SBS SCSI Controller Card and the GE DIP Card.

The connectors for the PMCs are very fragile, and must be treated gently. Be especially careful when removing or installing a PMC, so that you do not damage the connectors.

3.2.1.1 RIP Board Flash Procedure

Once the RIP Board has been replaced, the flash ROM on it must be programmed to work in the LightSpeed system. This procedure is normally executed as a part of the Config/Reconfig procedure (during or after a Load From Cold).

⚠ **NOTICE** **P/N 2197234-2 has been replaced by P/N 2339284. The new replacement part requires a COMPLETE LFC to properly flash it. If your console uses this new board, then refer to the *Software Installation Procedures* manual to perform a complete software "Load from Cold" before continuing.**

Use the following procedure to execute the flash procedure manually:

1.) Shutdown Applications:

a.) Click on the SERVICE DESKTOP.

b.) Click on the UTILITIES icon.

c.) Click on APPLICATION SHUTDOWN.

2.) Open a UNIX Shell.

3.) Launch the RIP Board `pflash` routine.

At the ctuser prompt, type:

cd /usr/g/ice/bin ENTER

ice stop ENTER

pflash ENTER

When the pflash routine is complete, the shell displays:

`info - the board was successfully flashed`

and returns to the ctuser prompt

Example:

{ctuser@hel2}[10] `pflash`
`info - locating the controller board`
`error - failed to restart the card`
`error - failed to flash the board` (caused by failing to issue the)
`error - please press [RESET] on the ICE card` `("stop" command before "flash")`
{ctuser@hel2}[11] `pflash`
`info - locating the controller board`
`info - confirming correct firmware jumper position`
`info - starting flash procedure`
`info - identifying the board revision`
`info - configuring the download parameters`
`info - setting the clock`
`info - downloading the bootrom.............`
`info - flashing the bootrom...............`
`info - flash programming complete`
`info - setting romboot parameters`
`info - rebooting the controller board...`
`info - reboot was successful`
`info - the board was successfully flashed`
{ctuser@hel2}[12]

Refer to the Replacement Verification tables in Section 3.3, on page 368.

3.2.1.2 LightSpeed Motorola Board Configuration

Check the RIP to assure valid configuration information and update if necessary.

1.) Shutdown Applications if they are running
2.) **cu ice**
3.) If the prompt is [VxWorks Boot]: type b to go to PPC1-Bug
4.) If step 3 fails, press the reset button on the RIP board in the Ice Box.
Type **cnfg** and the following should appear:

PPC1-Bug>**cnfg**
Board (PWA) Serial Number = "5436750 "
Board Identifier = "MVME2304-0141 "
Artwork (PWA) Identifier = "01-W3345F40D "
MPU Clock Speed = "333"
BUS Clock Speed = "067"
Ethernet Address = 0001AF07FC05
Primary SCSI Identifier = "07"
System Serial Number = "0000000000000000"
System Identifier = "00000000000000000000000000000000"
License Identifier = "5436750 "

5.) If you see the fields filled in similar to above, then you are done. If all fields are full of ????????, then go to step 6.

6.) Type **cnfg;m** and each field will come up one at a time. You can enter the same identical data as above. After the last entry, be sure to enter **y** to update.

3.2.1.3 DIP "PMC" Board Replacement

NOTICE **The DIP board is a static sensitive device. Good ESD practices should be followed.**

The DIP is mounted on top of RIP board, which is located in the VME (ICE Box) chassis of the console. It necessary to remove the RIP board to replace the DIP Board

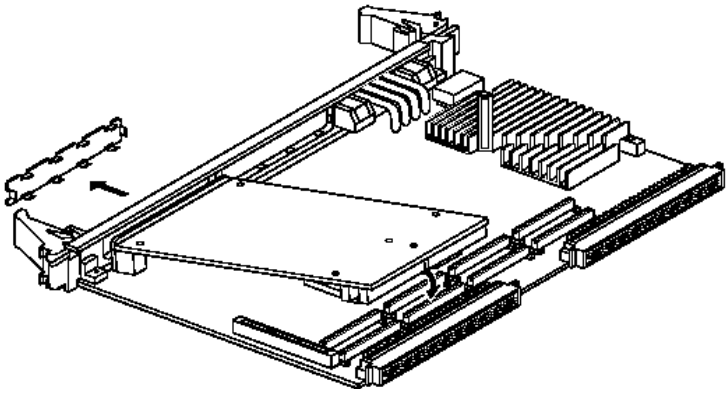


Figure 5-122 DIP Board Installation

1.) Shutdown application and operating system software.
2.) Power down the console using the power switch located on the front cover.
3.) Tag and lockout the main system power, at the main disconnect).
4.) Using a 4mm hex wrench, release the cover latches and remove the console front cover.
5.) Remove the front EMC cover from the "ICEbox".
6.) Remove the cables connected to RIP board.
7.) Disconnect the optical cable from the port optical connector labeled RX. This is the cable that brings DAS data into the DIP.
8.) Loosen the thumb screws (knurl nuts) so that the RIP card can be removed.

9.) Gently but firmly, grasp the RIP board by it handles and pull it loose and towards you.

10.) Immediately place the RIP board in a anti-static bag or onto a static free work surface.

11.) To remove the DIP from the RIP Board, do the following:
(It's not necessary to remove any standoffs from the RIP to remove the DIP Board.)

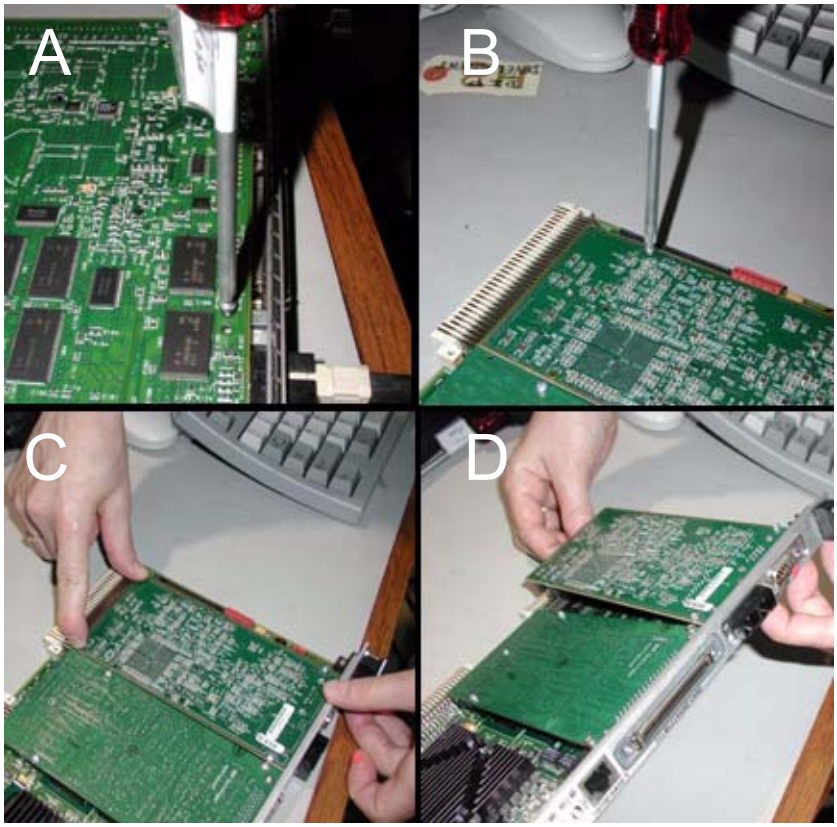


Figure 5-123 DIP Board Removal and Installation

a.) On the bottom of the RIP board assembly, remove the two (2) screws nearest the face plate that attach the DIP to the RIP. These screws thread into the DIP board's edge connectors. See Figure 5-123, A.

b.) On the top side of the RIP board, remove the two (2) screws nearest the edge connector retaining the DIP. It's not necessary to remove the stand-offs. See Figure 5-123, B.

c.) Gently pull the DIP and RIP board apart, where they are attached by the PCI/PMC edge connector. See Figure 5-123, C.

d.) Lift the DIP board out. Figure 5-123, D. Place into a anti-static bag immediately.

12.) To install a DIP board, do the following:

a.) Rotate the DIP into position and gently but firmly press down on the PCI/PMC edge connector to seat. See Figure 5-123, D then C.

b.) Re-install all of the removed screws. See Figure 5-123, B then A.

13.) Gently but firmly, re-install the RIP board assembly into its VME card cage slot and secure with thumb screws.

14.) Attach cables to RIP, SCSI and DIP boards and replace covers.

15.) Remove lockouts and power up console.

3.2.2 Pegasus Image Generator (PEG-IG) Board

1.) Bring software down, and shutdown system, via normal shutdown procedures.

2.) Tag and lockout the main system power, supplied to the PDU (i.e., main disconnect).

WARNING **POTENTIAL FOR PERSONAL INJURY OR DEATH BY ELECTRIC SHOCK. TO AVOID RISK OF ELECTRIC SHOCK, FOLLOW PROPER LOCKOUT/TAGOUT PROCEDURES.**

3.) Using a 4mm hex wrench, remove the console's front cover.

4.) Remove the front EMC cover from the "ICEbox".

5.) Disconnect the serial cable from the faceplate of the Pegasus IG board.

6.) Remove the side bulkhead assembly by loosening the knurl nut. Position the bulkhead so that it is out of the way of the card cage asm. (use care handling the ribbon cable).

7.) Remove the four (4) 2mm allen head screws that hold the PEG-IG circuit board in place.

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on an anti-static surface.**

8.) Remove the old PEG-IG board from the card cage and place it into a static bag.

9.) Remove the new PEG-IG board from its static bag, and inspect the board.

a.) Verify that it has only two (2) jumpers installed as follows (see Figure 5-89, on page 337):

* J7: positions 9 and 10
* J8: positions 9 and 10

b.) Verify that the board's connectors are free from foreign objects and that no pins are bent.

10.) Install the four (4) allen head screws and two (2) nylon flat washers on the PEG-IG board faceplate. The washers should be used for the mounting holes on the "tabs" at the left of the faceplate.

11.) Place the new circuit board into the card cage and tighten the four (4) allen head screws to properly secure the board.

12.) Reinstall the side bulkhead assembly. Route the ribbon cable above as usual.

13.) Reattach the serial cable to the serial port on the PEG-IG board's faceplate.

14.) Replace the ICEbox and Console front covers.

15.) Reapply power, bring the system back up, and run the appropriate diagnostic tests.

3.2.3 VME Power Supply

Figure 5-124 ASTEC Power Supply

TERMINAL	# OF WIRES	WIRE COLOR
+ 5 VDC	2	1 lg black & 1 brown
5 VDC return	2	1 lg black & 1 blue
1 (+)	2	red
3 (–)	2	black
5 (+)	3	green
6 (–)	3	white

Table 5-41 Power Supply Terminal Identification

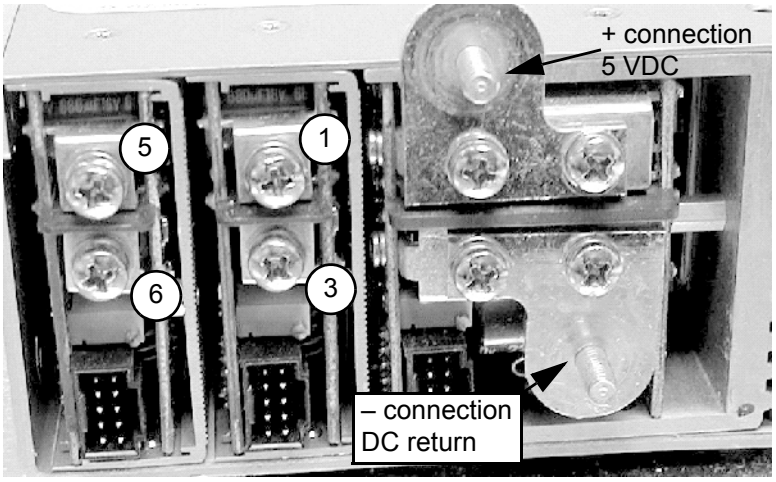


Figure 5-125 Power Supply Terminals

Note: Verify leads and colors on your console power supply before removing them from the existing Power One supply.

TERMINAL	COLOR	# WIRES
N	BLUE	1
~	BROWN	1
GND	GREEN	1

Table 5-42 AC Connections for VME power supply

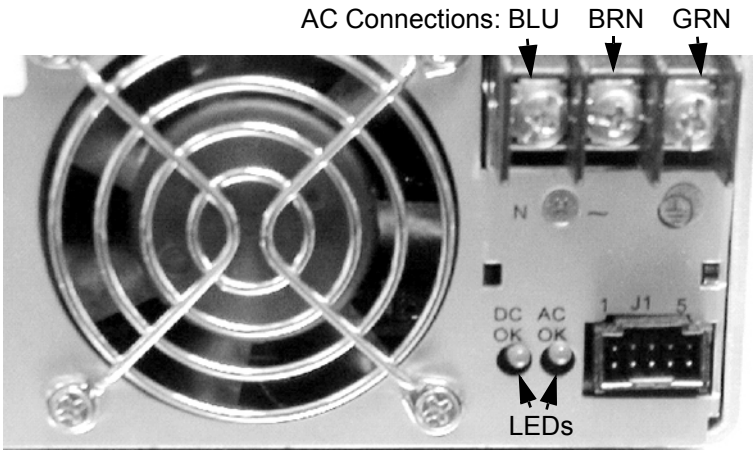


Figure 5-126 Front view of VME power supply

3.3 Replacement & Verification of Console Hardware

NOTICE **General Precautions when servicing Console Hardware components:**

- **Shutdown applications and turn off console power before servicing hardware components.**
- **Use ESD precautions when handling circuit boards and computer components.**
- **The console's front cover must always be removed prior to component replacement.**
- **Refer to the Illustrated Parts Manual for an Assembly view of the components. This will aid in the removal of parts.**

ITEM/FRU	ACTION	VERIFICATION PROCESS
Cabletron Interface	Pull out console tray. Disconnect the cables to the converter and remove.	Perform a system hardware reset, then scan, reconstruct an image and ping the gantry & table subsystems.
CD-ROM	Remove User Drive Assembly. Remember to disconnect cables. Pull cover off User Drive Box. Remove and replace CDROM. Set switch and jumper settings (SCSI ID 6, no termination—see Section 2.1.4.1, on page 319).	Perform several queries to the CDROM to make sure it is recognized. Run **scsistat** to verify SCSI address.
Faulty Host Component	Replace per procedures in Section 3.1, on page 338. If system does not come up, perform a computer reset. Verify Octane "**hinv**" parameters. See Section 4.1.1.3, on page 375.	Perform a normal system scan and recon, print, network, etc.
Image Data Drive (Octane Host Drive)	Archive any data that the customer does not want to lose if possible. Pull front cover off Octane. Remove and replace per procedures in Section 3.1.3.2, on page 342. You can use "install2Disk" script in a Unix shell to configure the second disk (instead of having to perform a LFC when replacing the second disk).	Retro recon some raw data from a known image. Scan with both a retrospective and prospective recon.
Intercom Interconnect Board	Pull off the cover from the recon/VME Chassis. The Intercom/Interconnect Board is located in the lower right corner above the VME power supply and below the MOD/CDROM User drive assembly. Set the jumpers and switches. Refer to Section 2.1.8.1, on page 323 Switches and Jumper Settings.	Perform normal scanning. Use the intercom and the autovoice feature. Push the Emergency Stop to make sure it operates properly. Run the Hardkey/ Keyboard Diagnostic test.
Keyboard	Disconnect cables and route new cable so they are not pinched by covers.	Use the keyboard entry and perform normal scanning activity. Also, run the Hardkey/ Keyboard Diagnostic test.
LAN Switch	Pull out Console tray. Disconnect cables to Host Computer. Set the computer to the side. Be careful as the Host is heavy. Disconnect LAN cables, remove box, and replace with new component. It may be necessary to pull out the Raw Data Drive Box.	Perform a Scan, recon, and system pings to the major subsystems.

Table 5-43 Console Hardware Re-Test Matrix

ITEM/FRU	ACTION	VERIFICATION PROCESS
MOD	Remove User Drive Assembly. Remember to disconnect cables. Pull cover off User Drive Box. Remove and replace MOD drive. Set switch and jumper settings (SCSI ID 3, No termination) See Section 2.1.5, on page 320, for the correct settings.	Return system to operating configuration and save and restore to the MOD. Run **scsistat** to verify SCSI Address.
Mouse/ Trackball	Disconnect cables and route new cable so they are not pinched by covers.	Use the trackball and mouse to select normal functions.
PEG-IG Board	Before removing the PEG-IG, remove the Bulk-head connector and cables. Carefully remove the board. Avoid hitting it on surrounding sheet metal. Remove and replace board. Verify switch and jumper settings (see Section 2.2.7.2, on page 337). Reinstall any cables, etc. that were moved/removed to make room for PEG-IG Board removal.	Run the Recon Data Path test with several iterations and do a system scan and recon.
PMC DIP (DAS Interface Processor) Board	Remove the RIP board, and place it on a static-safe surface (see ACTION for RIP bd., below). Remove and replace the DIP Board from its piggy-back position on the RIP Board (see Figure 5-122, on page 364). There are no switch or jumper settings on the DIP Board. Reinstall the RIP Board. When seating the board, it may be necessary to tap the board a little to get it to seat, as the pins are very tight. Make sure that it is flush with the frame. Replace the screws. Reconnect the Network & Serial connections to the RIP Board, the fiber-optic cable to J2 (lower jack), and the scan abort cable to the DIP. Reconnect the SCSI cable to the SCSI Board.	Run the Recon Data Path test with several iterations and do a system scan and recon.
PMC SCSI Board	Remove the RIP board, and place it on a static-safe surface (see ACTION for RIP bd., below). Remove and replace the SCSI Board from its piggy-back position on the RIP Board (see Figure 5-122, on page 364). Verify the jumper settings on the SCSI Board (see Section 2.2.5, on page 334). Reinstall the RIP Board. When seating the board, it may be necessary to tap the board a little to get it to seat, as the pins are very tight. Make sure that it is flush with the frame. Replace the screws. Reconnect the Network & Serial connections to the RIP Board, the fiber-optic cable to J2 (lower jack), and the scan abort cable to the DIP. Reconnect the SCSI cable to the SCSI Board.	Run the Recon Data Path test with several iterations and do a system scan and recon.

Table 5-43 Console Hardware Re-Test Matrix (Continued)

ITEM/FRU	ACTION	VERIFICATION PROCESS
Raw Data Drive (Scan Data Disk)	Raw Data will be lost when replacing drive. Loosen screws holding sheet metal box. Disconnect Cables to drive, power and data. Remove and replace drive. Set switch and jumper settings (refer to Figure 5-77, on page 328). Run Reconfig to regenerate the scan database.	Perform a scan. Save data to and from the drive.
Recon Interface Processor (RIP) - Motorola Board	Remove the screws holding the RIP board in its slot. The small black tabs on the board help remove the board. Push the tabs in to unseat the board. Disconnect the Network & Serial connections from the board, the fiber-optic and scan abort cables from the DIP board, and the SCSI cable from the SCSI board. Remove and replace the board. Verify switch and jumper settings on the board (refer to Section 2.2.4.4, on page 333). Reinstall the DIP and SCSI PMC piggyback boards (refer to Figure 5-122, on page 364). Reconnect all cables. When seating the board, it may be necessary to tap the board a little to get it to seat, as the pins are very tight. Make sure that it is flush with the frame. Replace the screws. Run pflash to download the correct flash prom image and set up boot parameters on the board	Run the Recon Data Path test with several iterations and do a system scan and recon.
System Drive (Octane Host)	Remove and replace per procedures in Section 3.1.3.2, on page 342. Replacement will require a load from cold.	Boot the system, load software and do a system scan and recon.
VME Power Supply	Remove the Power Supply tray. If replacing a Power-One power supply with a like unit, you will have to disassemble the supply from the tray, and reassemble. If replacing with an Astec power supply, you will replace the entire tray with the power supply attached. See Figure 5-82, on page 331 for details of connecting and adjusting the supply.	Power ON system and perform a normal system scan and recon, print, network, etc.

Table 5-43 Console Hardware Re-Test Matrix (Continued)

Section 4.0 Troubleshooting

4.1 Host Subsystem

4.1.1 Host Computer (Octane)

4.1.1.1 Overview: Diagnosing Host Computer Hardware Problems

There are number of ways that Octane hardware problems can be identified and diagnosed. These range from a hardware inventory, to diagnostic testing, to a simple command line executable.

POWER-ON TESTS

Power-On tests run automatically whenever the host computer is powered-on or reset. They test the motherboard, memory modules and graphics boards. Fault notification is done through light bar LED codes and Error Messages in the OC `/var/adm/SYSLOG`, or on the console monitor (CRT).

HARDWARE INVENTORY

Using the **hinv** software command, a listing of the hardware devices that the host computer can communicate with or not communicate with is displayed.

INTERACTIVE DIAGNOSTIC ENVIRONMENT (IDE)

IDE offers more in-depth tests of the SGI hardware. Fault reporting is done through error messages. Quickly interrupt the scanner's boot-up, select **Stop for Maintenance.**

CONFIDENCE TESTS

Use the SGI Confidence Tests to test:

- **keyboard** (alpha-numeric keys only),
- **CDROM** (place a CD inside first),
- **monitor** (use to adjust convergence) or
- **mouse**

4.1.1.2 Power-On Tests

Power-Up Sequence - Overview

The computer follows a sequential power-up process. After power to the computer is applied, the lightbar on the front of the computer turns Red. While the motherboard is running its power-up self-test, the bar remains RED.

When the bar first lights, during power-on, the monitor displays `Running power-on diagnostics` on screen.

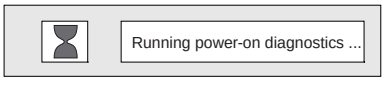


Figure 5-127 “Power-on Diagnostics” Notifier

After all of the power-on tests have passed, the light bar turns white, and the `Starting Up the System` pop-up window appears. This is when you can access SGI diagnostics and its host command line. Press the **ESC** key or click on the STOP FOR MAINTENANCE box if you want to

access the firmware based tools.

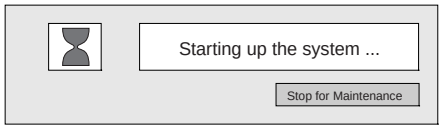


Figure 5-128 “Starting up the system” notifier

If you don't interrupt, after a few seconds the “System Is Coming Up” pop-up will appear.

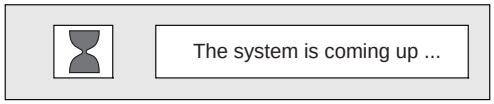


Figure 5-129 “The System is coming up” notifier

Light Bar LEDs

The light bar LEDs on the front of the Octane computer provide useful diagnostic information. If a problem occurs during computer initialization, the Octane computer will report it using these LEDs. In this section, failure symptoms are described, as well as their possible causes and remedies.

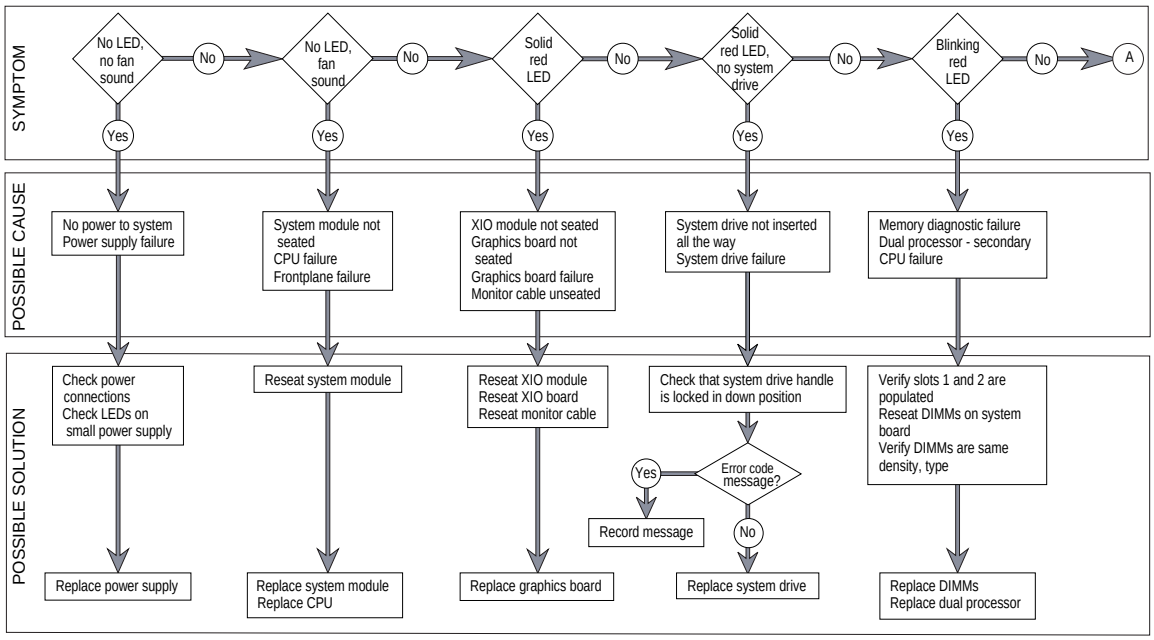


Figure 5-130 Interpreting the Light Bar LEDs

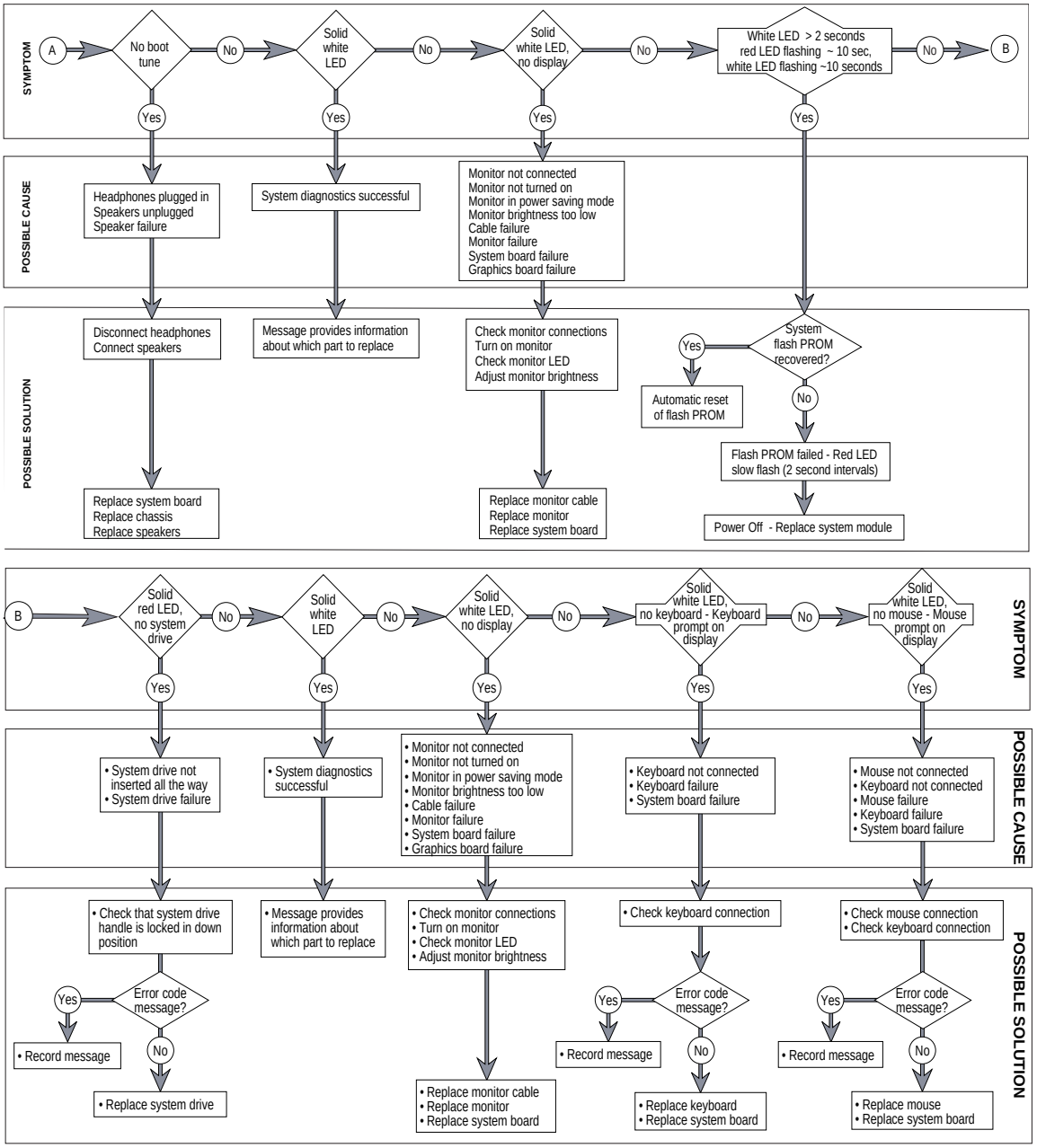


Figure 5-130 Interpreting the Light Bar LEDs (Continued)

CPOP Connector LEDs

Located immediately behind the lower right front cover are seven (7) green LEDs. These LEDs are visible with the front cover removed by looking through the holes located in the lower front right of the chassis (see Figure 5-131). The LEDs you will see are attached to the back of the front plane circuit board, as viewed through the holes in the lower right area of the chassis next to the DB15

connector. There are 2 columns: 1 column consisting of 4 LEDs and another with 3 LEDs. They are depicted in Table 5-44 and Table 5-45 that way.

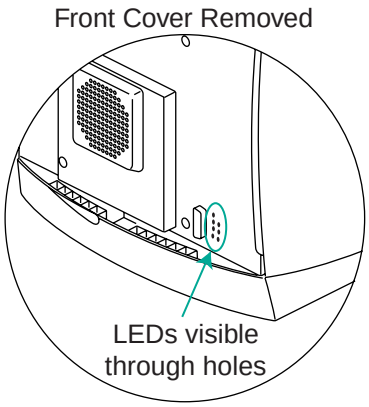


Figure 5-131 CPOP Connector LEDs

DESCRIPTION	COLUMN 1	COLUMN 2	DESCRIPTION
Base IO	OFF		
Quad A	OFF	OFF	PCI
Quad C	OFF	OFF	Quad B
Quad D	OFF	OFF	Heart

Table 5-44 CPOP Connector LEDs - Generic Application

DESCRIPTION	COLUMN 1	COLUMN 2	DESCRIPTION
System Module	ON		
Quad A (SI w/ TM)	ON	ON	PCI Chassis
Quad C (None in Plus)	OFF	OFF	Quad B (None in Plus)
Quad D (SI)	ON	ON	Heart ASIC

Table 5-45 CPOP Connector LEDs - Plus Specific Application

The purpose of these LEDs is NOT “diagnostic” in nature—these LEDs simply indicate whether the XIO modules are properly seated and have been detected by hardware. In the case of the Heart ASIC, the LED is a “status OK” indicator.

Brief descriptions of these 7 green LEDs follow:

Base IO	Main System Module is seated/detected OK
Quad A	Top left XIO quad module is seated/detected OK
Quad C	Lower right XIO quad module is seated/detected OK
Quad D	Lower left XIO quad module is seated/detected OK
PCI	PCI chassis/ASIC seated/detected OK
Quad B	Top right XIO quad module seated/detected OK
Heart	Heart memory control ASIC on System Module status OK

Computer Panics

Panics are un-recoverable errors caused by a computer hardware failures. The symptom includes a Panic error message, computer hangs, and the need to re-boot.

The key to troubleshooting `PANIC` errors is understanding the error message. In most cases, the message will state the symptom. Such as `WIDGET_ERR`, as shown in Figure 5-132 for example. `WIDGET_ERR` is not the cause but the symptom. To localize, look for a hardware device that is reporting the error.

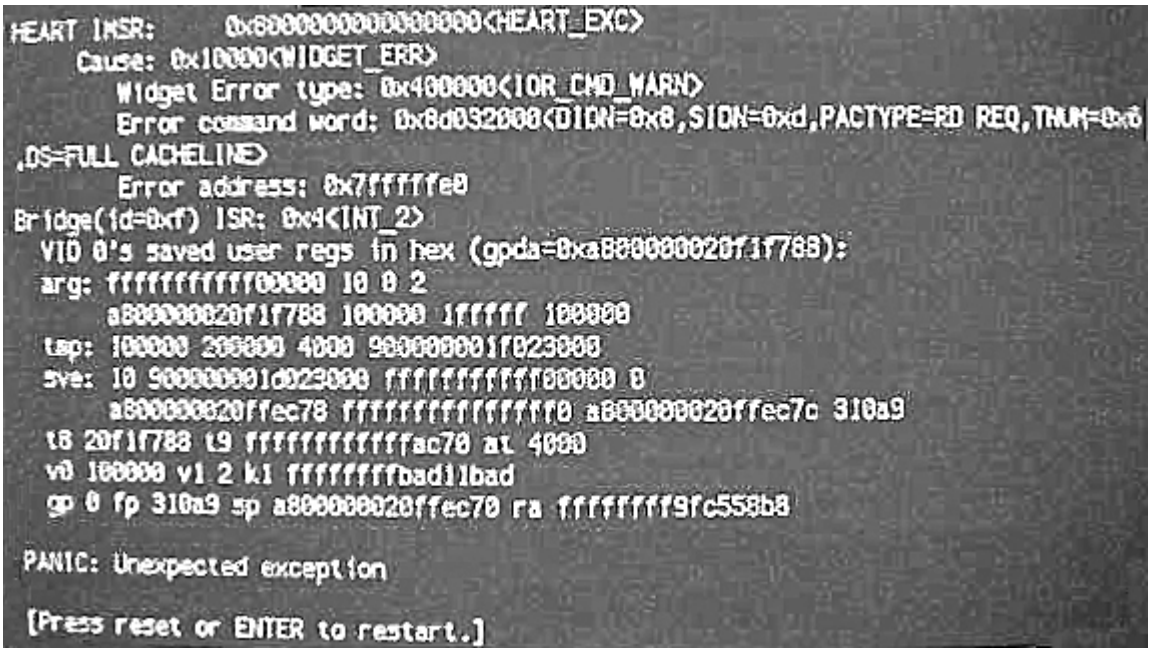


Figure 5-132 Example Panic Error Message

In Figure 5-132, the error screen indicates an unexpected interrupt being reported by the `Heart`. The "Heart" is an ASIC on the Octane IP30 motherboard. Therefore the IP30 is experiencing problems. Another SGI hardware acronym that can show up is `Xbow`. Xbow stands for crossbow. It's the XIO ASIC on the Octane frontplane. It interconnects the IP30, XIO graphics, and the PCI module. These are the two most commonly encountered hardware acronyms.

4.1.1.3 Host (Octane) Hardware Inventory "hinv"

Every time the system boots, it will log what hardware was found. You can read this log with the **hinv** command, and verify the software is able to talk with the hardware you expected. If, because of a bad memory module, the system finds less memory than is installed, then IRIX will use more of the virtual memory in the swap space (this will require more swapping to the disc drive and slow down the software). The error log will show no entry about missing memory. IRIX will identify each disc drive connected to the SCSI controller, but the DASM is not a known device for IRIX, so it is labeled as a disc drive.

The following example shows the use of and output from the **hinv** command. Comments have been added for clarification.

Example: 'hinv' command

```
{ctuser@ct10_oc}[10] hinv

1 300 MHZ IP30 Processor
```

The line above identifies the system as having a standard single 300MhzProcessor Module "CPU brick," which is plugged into the Octane IP30 System Module.

```
CPU: MIPS R12000 Processor Chip Revision: 2.3
FPU: MIPS R12010 Floating Point Chip Revision: 0.0
```

MIPS R12000 Microprocessor IC (inside the PM) is identified in the first line above. The MIPS R12010 Floating Point coprocessor IC (inside the PM) is identified in the next line. Revision levels may change over time. You should not become alarmed if yours is different.

```
Main memory size: 1536 Mbytes
```

Standard Main Memory configuration is identified in the line above. The Octane computer utilizes Dual Inline Memory Modules (DIMM) using Error Correction Code (ECC). The Octane IP30 has eight DIMM connectors, arranged in four banks of two. They are labeled S1 through S8. DIMMs must be installed in like-pairs into connectors S1-S2, S3-S4, S5-S6, and S7-S8. (2 x 64MB) DIMMs are normally in connectors S1 and S2. (2 x 64MB) DIMMs are normally in connectors S3 and S4.

```
Instruction cache size: 32 Kbytes
Data cache size: 32 Kbytes
```

In the above two lines, the MIPS R12K primary instruction cache & data cache memory inside the R12K microprocessor in the PM (CPU brick) is identified.

```
Secondary unified instruction/data cache size: 2 Mbyte
```

Secondary cache memory inside the PM (CPU brick) and its size are reported in the above line.

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
```

SCSI Bus 0 (internal SCSI controller 0, internal devices)

```
Disk drive: unit 1 on SCSI controller 0
```

System Disk 1

```
Disk drive: unit 2 on SCSI controller 0
```

System Disk 2

```
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
```

SCSI Bus 1 (internal SCSI controller 1, external devices)

```
Optical disk: unit 3 on SCSI controller 1
```

MOD Drive

```
CDROM: unit 6 on SCSI controller 1
```

CDROM Drive

```
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
```

SCSI Bus 2 (internal PCI SCSI controller 1, external devices - DASM)

```
Disk device: unit 1 on SCSI controller 2
```

DASM - Controller 2 is visible only if the Device connected is powered-on and connected

```
IOC3 serial port: tty1
```

The next line is the 9-pin D-type native serial port #1 on the IP30. RS232 device /dev/ttym1 for remote boot or PPP connections. This is also the Octane primary console port via device /dev/ttyd1 (can be used for laptop control via firmware command).

```
IOC3 serial port: tty2
```

This is the Octane's 9-pin D-type native serial port #2 on the IP30. Used for Service Key and is linked to /dev/servkey.

```
IOC3 parallel port: plp1
```

The next line shows the Octane's native Centronics parallel port on the IP30 which is not used.

```
Graphics board: ESI with texture option
```

Driving Right Display Head

```
Graphics board: ESI
```

Driving Left Display Head

```
Integral Fast Ethernet: ef0, version 1, pci 2
```

The internal network interface is shown on the line above. This is the FAST ethernet (100 megabit/sec) device mode of the Octane IP30 native 10/100 megabit (auto-sensing) ethernet chip.

```
Fast Ethernet: ef1, version 1, pci 3
```

PCI network card for external network interface.

```
Iris Audio Processor: version RAD revision 12.0, number 1
```

The line above shows the Octane IP30 native audio processor chip. It is used this for recording and playing Autovoice digital audio files.

```
PCI card, bus 0, slot 2, Vendor 0x114f, Device 0x4
```

PCI network card for external network interface

4.1.1.4 Integrated Diagnostics Environment (IDE) Tests

The IDE tests, available on the Octane, are more comprehensive than the confidence tests. They are stand alone tests that must be run at the boot PROM level. To invoke these tests, shut down the system. Start up the system, and when the System Start-up notification pops up, select STOP FOR MAINTENANCE. From the System Maintenance menu, choose RUN DIAGNOSTIC. A single user shell will open, and the results of an hinv probe will be displayed. The IDE tests will auto configure and start execution.

IDE Diagnostics are initiated during the Octane Computer boot-up process, and execution begins immediately upon entering the diagnostic environment. A default set of tests that exercise the CPU, memory, and graphics boards automatically start running. One complete pass of the default will take about 25 minutes. The test will stop when a failure is encountered. The test can be stopped at any time by pressing the **ESC** Key. This will return the user to the system maintenance/start-up menu where the user can choose to start the system.

If you wish to interrupt that testing, use the **CTRL-C** key stroke sequence to halt and return you to the ide diagnostic prompt. Test scripts, individual tests, and commands can be run by stopping the default tests using the **CTRL-C** command. This will bring the user to an ide>> prompt where commands can be executed. Entering exit at the prompt will return to the boot sequence.

Running General IDE Test Scripts

PROCEDURE - ENTERING IDE DIAGNOSTICS

The procedure for entering IDE diagnostics follows:

1.) Start or shutdown the system as needed. If the host computer is off, turn it on and proceed to Step 2. If the host computer is up and running, bring it down appropriately. After a few seconds, the screen will clear and you'll see a notification like the one shown in Figure 5-133, Select the RESTART button.

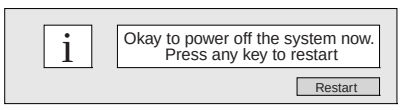


Figure 5-133 Okay to Power Off System - Notification Screen

Note: If the system is malfunctioning and you cannot communicate with it using the mouse or keyboard, then press the reset switch on the front chassis.

2.) Click on STOP FOR MAINTENANCE, using the mouse immediately. You only have three to five seconds to preform this action (refer to Figure 5-134).

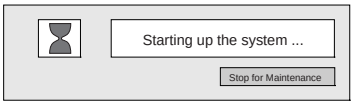


Figure 5-134 Maintenance Option Menu

3.) The following Host Maintenance menu appears.

```
Start System
Install System Software
Run Diagnostics
Recover System
Enter Command Monitor
Select Keyboard Layout
```

Click on the menu selection RUN DIAGNOSTICS. Notice that the screen blanks and the following text is displayed.

```
Starting diagnostic program ...
Press ESC to return to the menu
```

4.) If you have not pressed **ESC** to exit out of program, a default set of tests will begin automatically.

Running the IDE Tests from CD-ROM

The IRIX operating system CD-ROM contains IDE tests that will be run by default if present in the CD-ROM drive. This is useful if the system disk is defective. Make sure that the CD-ROM is in the drive, and invoke the IDE tests the same as the system disk IDE tests. Shut down the system, restart, and stop for maintenance. Choose RUN DIAGNOSTICS from the System Maintenance Menu. The CD-ROM version of the IDE tests will automatically be invoked, if present. If the IDE tests are found on the CD-ROM, a message will be printed to the screen saying "`booting IDE from distribution CD-ROM`". Otherwise, a message will be printed to the screen indicating that it was not possible to boot IDE from the CD-ROM. If no IDE tests are present on the CD-ROM, the IDE tests on the system disk will be invoked.

To run the CD-ROM versions of the default test script, verbose default test script, and general and specific FRU test scripts, use the same procedure as the system disk IDE tests.

4.1.1.5 Confidence Tests

Confidence Tests is a group of tests that can be run with applications up. They are useful in determining whether peripheral devices such as the keyboard, monitor, mouse, and CD-ROM drive are operating correctly.

The confidence tests are IRIX supplied diagnostics for testing items such as the mouse, keyboard, monitors, audio subsystem, and external SCSI devices. To invoke on the OC, enter "**confidence**" at a UNIX prompt. A window will pop up containing an icon for each testable device present. Clicking on that icon will invoke the diagnostic that will test that device. Below the icon window is a status window that displays information such as which devices are present and which are not. Tests can be run individually, or multiple tests can be selected. To select more than one test, choose the pull down menu "DEVICES" from the menu bar, and click on the box of each desired test.

Audio Test

Choosing the audio confidence test pops up a window, giving the user the choice of running an output or input audio test. When the output button is pressed, a voice replies with the message: "*This is the audio confidence test.*" If you hear this message, the test is successful.

CD-ROM Test

To run the CD-ROM confidence test, insert a CD into the CD-ROM drive, and click on the CD-ROM confidence test icon. Test pass and fail information is printed to the confidence test status window.

Keyboard Test

Choosing the keyboard confidence test brings up a picture of a keyboard. As the user presses the keys on the real keyboard, the keys on the picture are highlighted. This test can be used to verify that individual keys on the keyboard are working properly. To dismiss this test, press the **LEFT MOUSE BUTTON**.

Monitor Test

When the monitor confidence test is chosen, the screen becomes black, and a blue menu appears in the center. Clicking with the mouse on different menu items results in different patterns being displayed on the monitor. This test can be used to help verify that the monitor is working properly. The monitor on which the confidence tests are invoked is the monitor that will be tested by this confidence test. To dismiss this test, choose the exit option from the menu.

Mouse Test

When the mouse confidence test is chosen, the image on the screen is replaced by a gray background and an image of a mouse. The movement of this image duplicates the movement of the real mouse. Clicking on the **LEFT**, **RIGHT**, or **MIDDLE** mouse buttons causes the corresponding button on the image to be highlighted. This diagnostic can be used to verify that the mouse is working properly. Pressing the **ESC** key on the keyboard dismisses the mouse test.

4.1.1.6 Peripheral Component Interconnect (PCI) Support

Fast Ethernet (100Base-TX) Adapter - SGI

DEVICE RECOGNITION

The objective of this test is to verify that the hardware is detected by the operating system.

1.) Open a UNIX shell.
2.) At the prompt, type: **hinv | grep Ethernet**
3.) The following line must appear: `Integral Fast Ethernet: ef0, version 1, pci 2`
If no Ethernet board appears, your operating system doesn't recognize the hardware.

SCSI PCI Card - SGI

In the unlikely event you encounter a problem, the following checks can be preformed to help isolate the source of the failure. The checks are simple. First, verify the hardware is recognized. Next verify that its software driver is loaded into memory correctly. Finally, make sure the device is mapped properly by the operating system to the device.

DEVICE RECOGNITION

The objective of this test is to verify that the hardware is detected by the operating system.

1.) Open a UNIX shell.

2.) Check that the SCSI card is recognized, by using the **hinv** command.

a.) At the prompt, type: **hinv | grep Integral**

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
Integral Fast Ethernet: ef0, version 1, pci 2
```

b.) Inspect the output and verify that `Controller 2` is listed.

```
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
```

SOFTWARE DRIVER

Software driver support for SCSI cards is embedded automatically in the IRIX OS kernel and cannot be viewed. If defective, none of the SCSI devices will operate.

OPERATING SYSTEM MAPPING

The objective of this test is to verify that the SCSI card is mapped to a device. If no device (i.e. DASM) is attached to the PCI SCSI card's external connector, that PCI SCSI card is not listed in the **scsistat** output listing.

1.) Open a UNIX shell.

Note: DASM must be attached and "ON" to check PCI SCSI Card

2.) At the prompt, type: **`scsistat`**

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

3.) Inspect the screen output and verify that the DASM is recognized.

```
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

4.) If `"Device 2 1"` is not listed:

a.) Verify that a device is connected to the SCSI card and is turned "ON".

b.) Verify that all other devices in the PCI chassis operate correctly.

* If all other cards in the PCI work, the SCSI card or attached device may be defective.
* If other devices do not work, the frontplane or PCI card cage may be defective.

Serial Expansion PCI Card - Digi ClassicBoard

The following checks can be preformed to help isolate the source of a PCI serial card failure. The checks are simple. First, verify the hardware is recognized. Next verify that its software driver is

loaded into memory correctly. Finally, make sure the device is mapped properly by the operating system to the device.

DEVICE RECOGNITION

The objective of this test is to verify that the hardware is detected by the operating system.

1.) Open an Unix shell.

2.) Check that the Serial hardware is recognized, by using the **hinv** command.

   a.) At the prompt, type: **hinv | grep PCI**

   b.) If the Serial card is detected, you will see the following PCI card listed:

   ```
   PCI card, bus 0, slot 2, Vendor 0x114f, Device 0x4
   ```

   Verify the vendor ID for the serial card listed is `0x114f`

3.) If the Serial expansion PCI card is not listed, verify that other devices in the PCI chassis operate correctly.

   - If other devices work, the serial card is possibly defective.
   - If other devices do not work, the frontplane or PCI card cage may be defective.

SOFTWARE DRIVER

The objective of this test is to verify that the software driver for the Serial card is loaded in memory.

1.) Open a UNIX shell.

2.) At the prompt, type: **showprods | grep cdp**

3.) Verify you see the following:

   if you have installed version 1.0 serial software drivers.

   ```
   I cdp              03/09/2001 Digi ClassicBoard PCI Adapters
   I cdp.man          03/09/2001 Digi ClassicBoard PCI Documentation
   I cdp.man.relnotes 03/09/2001 Digi ClassicBoard PCI ReleaseNotes
   I cdp.sw           03/09/2001 Digi ClassicBoard PCI Software
   I cdp.sw.base      03/09/2001 Digi ClassicBoard PCI Base Software
   ```

   You should see the following, if you have installed version 1.1 serial software drivers.

   ```
   I cdpci              03/09/2001 Digi ClassicBoard PCI Adapters
   I cdpci.man          03/09/2001 Digi ClassicBoard PCI Documentation
   I cdpci.man.relnotes 03/09/2001 Digi ClassicBoard PCI ReleaseNotes
   I cdpci.sw           03/09/2001 Digi ClassicBoard PCI Software
   I cdpci.sw.base      03/09/2001 Digi ClassicBoard PCI Base Software
   ```

4.) If the Serial driver is not listed, see the software installation procedure on how to load the serial drivers.

OPERATING SYSTEM MAPPING

The objective of this test is to verify that the Serial devices are properly mapped to a device, by inspecting the `/etc/uucp/Devices` file.

1.) Open a UNIX shell.

2.) At the prompt, type: **cd /etc/uucp**

3.) Now type: **tail -5 Devices**

   The **tail** command lists the last 5 lines in the ASCII file called `Devices`.

   ```
   # Serial line connection for the sbc
   ```

```
ICE ttydp02 - 9600 direct
rhard ttydp00 - 9600 direct
pig ttydp01 - 57600 direct
ACU /dev/ttyf1 null 38400 212 x MultiTech
```

4.) Inspect the output. If the serial card is mapped correctly, you will see the serial devices connected. Such as `ICE`, `rhard`, `pig` and `ACU` hardware.

5.) If one or more of the devices is not listed, do the following:

a.) If no Serial device is listed, see the software installation procedure on how to load the serial drivers.

b.) If one is missing:

1.) Recheck the operational status of the missing subsystem containing the device.

2.) Check for a defective connection between the serial card and the subsystem.

4.1.1.7 DIMM Memory

Checking for Faults

DIMM errors appear in the OC error log file, SYSLOG, located in the directory `/var/adm/`. Hard (unrecoverable) memory errors will cause an SGI operating system (Irix) PANIC. Usually, a PANIC message will be posted to a screen window and logged in /var/adm/SYSLOG. The offending module will be identified by its socket number.

A boot-up failure message indicating "`PANIC: CPU parity error interrupt`" may mean there is a bad module in the first bank. If the system will not re-boot after a hard memory error `PANIC`, it is probably because the **Octane host needs the first memory bank to be in good working in order for boot up**. To eliminate this possibility, swap all modules in the first bank with those in the second. For the Octane host, this means swap the modules in S3 and S4 with those in S1 and S2 (see Figure 5-101, on page 346, or Figure 5-135, on page 383). Before doing this, check that all DIMMs are correctly seated in their slots.

To view only the critical host errors, open a shell and type:

sysmon /var/adm/SYSLOG for today's entries *or* **/var/adm/SYSLOG.0** for yesterday's

Or, from the Service Desktop, select ERROR LOGS and SYSTEM BROWSER, then select SYSLOG OC from the View pull-down menu, select the SYSLOG you wish to view in the Option box, and press VIEW FILE to view the entire syslog.

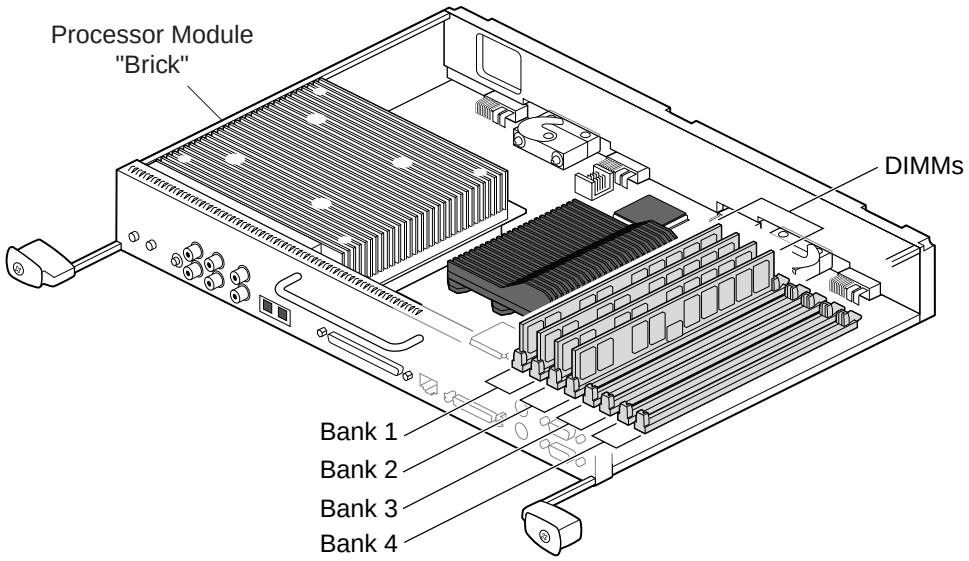


Figure 5-135 Octane System Module

To do a more complete test, interrupt **ESC** boot-up, Enter Command Monitor and type:

ide memtest

Memory Identification

SGI Part # 9940069 (YELLOW LABEL)

32MB DIMM—a pair makes 64MB

GE Healthcare part # =2169940-51 pair

SGI Part # 9940084 (BLUE LABEL) or 9470178 (GREEN LABEL)

64MB DIMM—a pair makes 128MB

GE Healthcare part # = 2169940-61 pair

SGI Part # 9470168 (BROWN)

28MB DIMM 2K REFRESH—a pair makes 256MB

GE Healthcare part # = 2169940-411 pair

SGI Part #9010020 (BROWN)

128MB DIMM 4K REFRESH—a pair makes 256MB

GE Healthcare part # = 2169940-411 pair

Note: The “4k refresh” DIMMs can only be used in the newer “Enhanced IP30”, which is GE Healthcare part # 2169940-45 (SGI #030-1467-001). These 4k refresh DIMMs cannot be used in the older Octane IP30, which is GE Healthcare part #2169940-13 (SGI #030-0887-003). Use the IRIX 'hinv -mvv' command, or read the IP30 label to determine the IP30 version you have.

SGI Part # 9470223 (RED)

256MB DIMM 4K REFRESH—a pair makes 512MB

GE Healthcare part # = 2169940-TBD1 pair

DATARAM Part # 60056 (no color code)

32MB DIMM—a pair makes 64MB

GE Healthcare part # - 21998061 pair

DATARAM Part # 62614 (no color code)

64MB DIMM—a pair makes 128MB

GE Healthcare part # - 2199806-21 pair

DATARAM Part # 62615 (no color code)

128MB DIMM—a pair makes 256MB

GE Healthcare part # - 2199806-51 pair

DATARAM Part #_____ (no color code)

256MB DIMM—a pair makes 512MB

GE Healthcare part # - 2199806-61 pair

4.1.1.8 Octane (Original) Graphics Subsystem

SI (Solid Impact) or SE (Solid Impact Enhanced)

The Octane graphics board that controls the primary “head,” (the monitor normally on the right) is in slot A. It is called SI (or SE) with Texture Memory or IMPACTSR with 4 TRAMs.

You can troubleshoot these boards by trying the secondary board in the primary slot, but at least one of the two must be installed in the primary slot and working to boot the system. The SI (or SE) with Texture Memory must be in Slot A to run the scanner applications.

Refer to page 348 for replacement procedure.

Octane Graphics System Hardware

To view those components of the graphics system that the SGI host currently sees, enter this command in a shell: **/usr/gfx/gfxinfo** You should see something that looks similar to the following example (example shown is with SE Graphics boards):

Example: "gfxinfo" command

```
Graphics board 0 is "IMPACTSR" graphics.
    Managed (":0.1") 1280x1024
    Product ID 0x2, 1 GE, 1 RE, 4 TRAMs
    MGRAS revision 4, RA revision 0
    HQ rev B, GE12 rev A, RE4 rev C, PP1 rev H,
    VC3 rev A, CMAP rev F, Heart rev F
    unknown, assuming 19" monitor (id 0xf)
    Channel 0:
    Origin = (0,0)
    Video Output: 1280 pixels, 1024 lines, 72.24Hz (1280x1024_72)
Graphics board 1 is "IMPACTSR" graphics.
    Managed (":0.0") 1280x1024
    Product ID 0x2, 1 GE, 1 RE, 0 TRAMs
    MGRAS revision 4, RA revision 0
    HQ rev B, GE12 rev A, RE4 rev C, PP1 rev H,
    VC3 rev A, CMAP rev F, Heart rev F
    unknown, assuming 19" monitor (id 0xf)
    Channel 0:
    Origin = (0,0)
    Video Output: 1280 pixels, 1024 lines, 72.24Hz (1280x1024_72)
```

4.1.1.9 Octane2 Graphics Subsystem

Common Problems

SYMPTOM	POSSIBLE CAUSE
V12 or Display Option Board does not appear in **hinv**.	Either the board is installed incorrectly, or it is defective. Make sure the board is correctly seated. If re-seating the board does not solve the problem, the board may be defective.
Same image appears on both monitors.	Timing mode is set to single channel.
Monitors are blank.	Remove the 13W3 cover from the VPro Graphics Board monitor port and connect a monitor to this port. Enter **hinv** in a UNIX shell to see if the system recognizes the board. If the system does not recognize the board, it may not be seated properly or it may be defective. If re-seating the board does not solve the problem, the board may be defective.
In single channel modes, one monitor displays the image correctly, but the other monitor's image is bad.	The board is probably defective.
The images on both monitors alternate between the correct image and noise, a constant color, or a badly flickering image.	The board is probably defective.
In dual channel mode, two superimposed flickering images appear on a monitor connected to the VPro Graphics Board monitor port.	Currently, the VPro Graphics Board monitor port is not disabled in dual channel mode. If you connect a monitor to the VPro Graphics Board monitor port in dual channel mode, the monitor displays alternating images from the left and right channels.

Table 5-46 V12 and DCD Common Problems

Operating System Hardware Recognition

1.) Open a UNIX shell.

2.) At the prompt, type: **hinv | grep Graphics**

3.) The following line must appear: `Graphics board: V12`

If no graphics board appears, your operating system doesn't recognize the hardware. You will not be able to communicate correctly with the graphics subsystem.

Operating System Compatibility

To function correctly, the V12 graphics card requires IRIX Version 6.5.10 or later. If for some reason after you installed software your graphics doesn't work, perform the following check.

1.) In a command line window, enter **uname -R**

2.) Verify the installation of IRIX 6.5.10 or later.

Hardware Compatibility

PROM

To function correctly, the V12 graphics card requires a PROM revision of 4.5 or later. There are two methods for checking version:

METHOD 1:

1.) While the system is booting, press the **ESC** key. The PROM menu appears.
2.) Choose ENTER COMMAND MONITOR in the PROM menu. The Command line interface screen appears.
3.) Enter version and verify the following:

`SGI version 6.5 Rev 4.5 IP30`, where `4.5` or later is the correct PROM revision for the V12 board.

METHOD 2:

You can also verify your PROM revision by typing **flash -V** in a UNIX shell, if your system is running IRIX 6.5.10 or later.

FRONTPLANE "XBOW"

The V12 graphics board must have a frontplane "xbow" revision of 1.4 or later. The xbow is an ASIC device located on the frontplane. There are two methods for checking revision.

METHOD 1:

1.) Shut down your system.
2.) Restart your system.
3.) While the system is booting, press the **ESC** key. The PROM menu appears.
4.) Choose ENTER COMMAND MONITOR in the PROM menu. The Command line interface screen appears.
5.) Enter System.

Xbow (rev 1.4 or later) should appear under Chips/NICs.

If Xbow (rev 1.3 or earlier) appears, the frontplane is incompatible with V12 graphics board.

METHOD 2:

If your system is running IRIX 6.5.10 or later, you can also verify this information as follows:

1.) Open a Unix shell.
2.) Enter **hinv** to display the hardware inventory list.

`Xbow ASIC: Revision 1.4` should appear in the list.

If `Xbow ASIC: Revision 1.3` or earlier appears, the frontplane is incompatible with V12 graphics board.

POWER SUPPLY

1.) Check your power supply by entering **hinv -m** in a command line window. The hardware inventory list appears, as shown in the example in Figure 5-136.
2.) The part number for `PWR.SPPLY.ER` must be: `060-0035-00`*x*, where *x* = `1` or higher, as shown in the example in Figure 5-136.

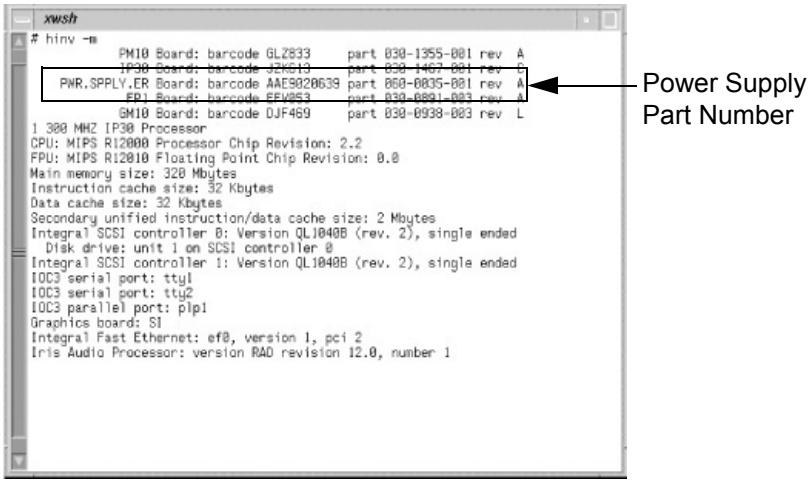


Figure 5-136 Power Supply Version

3.) If the above part number, in Figure 5-136, is not displayed for `PWR.SPPLY.ER`, your power supply is incompatible with the V12 graphics card.

4.1.1.10 SCSI (Integral) Interface

DEVICE RECOGNITION

The objective of this test is to verify that the integral SCSI controllers are detected by the operating system.

1.) Open a UNIX shell.

2.) Check that the integral SCSI controllers are recognized, by using the **hinv** command.

a.) At the prompt, type: **hinv | grep Integral**

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
Integral Fast Ethernet: ef0, version 1, pci 2
```

b.) Inspect the output and verify that `Controller 0` and `1` are listed.

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
```

SOFTWARE DRIVER

Software driver support for SCSI cards is embedded automatically in the IRIX OS kernel and cannot be viewed. If defective, none of the SCSI devices on any controller will operate.

OPERATING SYSTEM MAPPING

The objective of this test is to verify that the SCSI card is mapped to a device. If no device (i.e. DASM) is attached to the PCI SCSI card's external connector, that PCI SCSI card is not listed in the **scsistat** output listing.

1.) Open a UNIX shell.

Note: DASM must be attached and "ON" to check PCI SCSI Card

2.) At the prompt, type: **scsistat**

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
```

```
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

3.) Inspect the screen output and verify that the Disk, Optical and CD-ROM drives are recognized.

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
```

4.) If a `Device` is not listed: *(FW rev./ver. can vary)*

a.) Verify that a SCSI device is connected to the SCSI connector and is turned “ON”.

b.) Verify that all other devices attached to that SCSI connector operate correctly.

* If all other devices on the SCSI bus work, the SCSI card or attached device may be defective.
* If other devices do not work, the frontplane or system module may be defective.

4.1.2 Magneto Optical Disk (MOD)

In the unlikely event you encounter a problem, the following quick checks can be preformed to help isolate the source of the failure or remedy the situation.

4.1.2.1 Common Problems

MOD Will Not Archive

When the MOD will not archive, use the following flowchart to help isolate the problem.

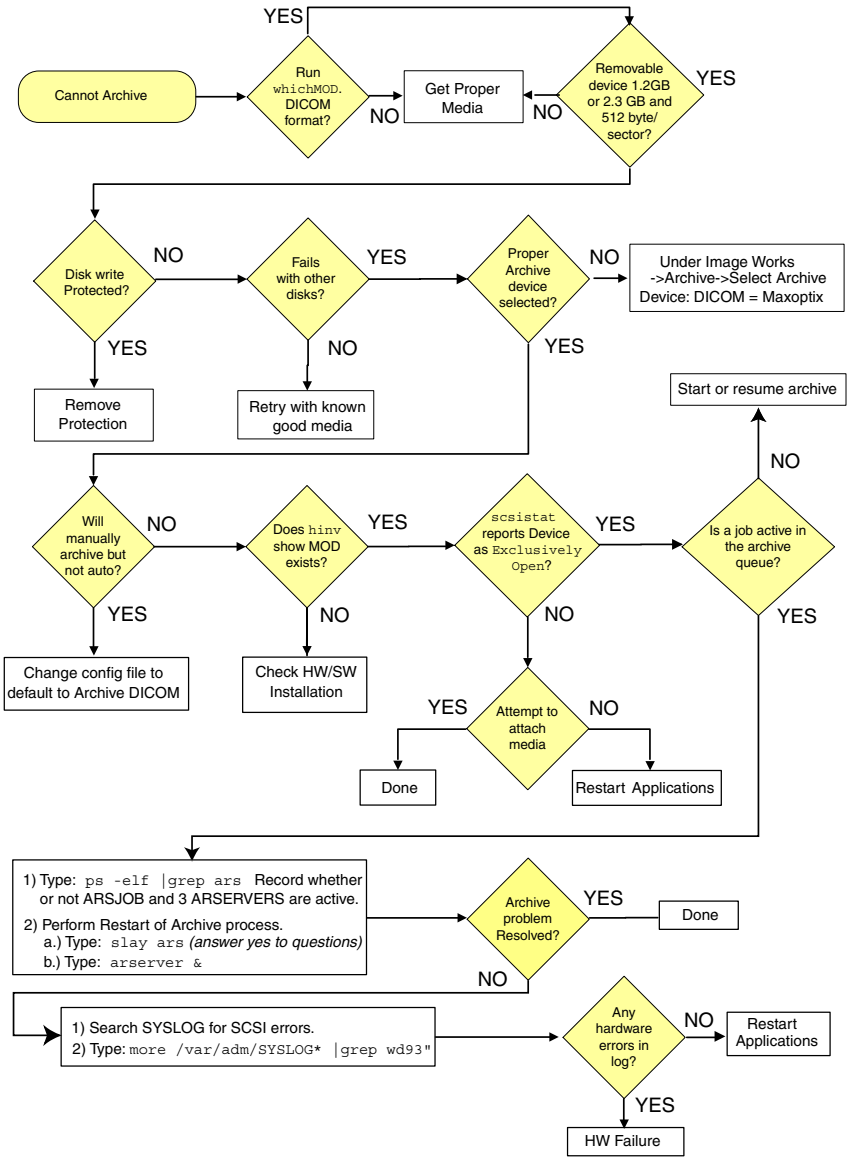


Figure 5-137 Troubleshooting Archive Problems

Verifying the HW/SW Installation

First, verify the SCSI hardware is recognized. Next, make sure the SCSI device is mapped properly by the operating system. When SCSI hardware is detected and mapped, software support is automatically loaded during boot.

To check that the above has been done, do the following by using pipe (|), **grep** and **tail** UNIX commands:

1.) Open an Unix shell.

2.) Check that the MOD's SCSI card is recognized, by using the **hinv** command.

a.) At the prompt, type: **hinv | grep Integral**

You'll output similar to the following.

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
Integral Fast Ethernet: ef0, version 1, pci 2
```

Note: Controller 2 depends on HW configuration

Depending on your system's hardware configuration, you may only see 2 controllers listed. For example, systems without a Pegasus IG board see only controllers 0 and 1.

b.) Inspect the screen output and verify that all integral controllers are recognized.

3.) Use the **scsistat** command to list attached SCSI devices recognized by the OS. If the MOD is listed, operating system support for the MOD has been installed during console boot-up.

Note: MOD must be attached and turned "ON"

a.) At the prompt, type: **scsistat**

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

b.) Inspect the screen output and verify that MOD (`Optical`) is recognized

4.) If either of the previous fails:

a.) Recheck your results by cycling power off and then on, and then re-booting the console. Run the above checks again.

b.) If `SCSI controller 1`is not listed in the output of the **hinv** command:

* Check all SCSI and power connections.
* Replace the IP30 board

c.) If `SCSI controller 1` is listed but no `optical` device is listed by **scsistat**, replace the MOD.

Disk Fails to Eject

Any number of situations can cause MOD disk to become locked and not eject from the MOD drive. They can include the drive being locked by a software process and not being released. For example, the operator fails to terminate an archive function properly.

The most common problem is a dirty MOD drive mechanism. If the MOD disk fails to eject repeatedly and its not caused by operator error or locked processes, it's suggested that the MOD be replaced. The MOD has no user serviceable parts and cannot be cleaned without disassembly.

To release a disk that is locked, the following steps should be followed:

1.) Open an Unix shell and become superuser.

Type: **su** -

Type #**bigguy** as the password.

2.) Determine the type of MOD disk in the drive. Type the following command: **whichMOD**

3.) If you receive the message `this is a GE DICOM Image Archive Disk`, do the following:

a.) Within an UNIX shell, type the following command: **scsistat**

```
Device 0 1  Disk      SGI      IBM DPSS-309170M FW Rev: S96A
Device 0 2  Disk      SGI      IBM DPSS-309170M FW Rev: S96A
Device 1 3  Unknown   EXCLUSIVELY_OPEN
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
```

b.) Inspect the **scsistat** listing.

1.) `device 1 3` is listed as `EXCLUSIVELY_OPEN`. You must do the following to detach it before you can eject the media:

i.) Pause the Archive Queue

ii.) Detach the Media

iii.) Press the **EJECT** button on the MOD and remove the disk.

iv.) When the MOD ejects, you are finished.

2.) If `Device 1 3 Optical Maxoptix T5-2600 FW Rev: H4.2` is displayed, do the following:

i.) Release the MOD by typing **eject /dev/scsi/sc1d3l0**

ii.) Press the **EJECT** button on the MOD and remove the disk.

iii.) Shutdown and restart CT applications

4.) If you receive the message `this is a GE SYSTEM STATE Disk`, do the following:

a.) Within an UNIX shell, type the following command: **unmountMOD**

b.) Press the **EJECT** button on the MOD and remove the disk.

5.) If any of the above procedures fail to eject the MOD disk, do one of the following:

a.) Force a SCSI bus reset.

1.) As super user, type **scsiha -r 1**

This resets SCSI controller 1, as shown in the scsistat output.

2.) Press the **EJECT** button on the MOD and remove the disk.

3.) Shutdown and restart CT applications

b.) Force an extraordinary 'unlock', of the MOD media to kill processes using the MOD.

1.) As super user, type **lockmod -f**

2.) Press the **EJECT** button on the MOD and remove the disk.

3.) Shutdown and restart CT applications

c.) If a forced unlock fails: shutdown the system, re-boot and remove the MOD disk.

Read Failures

Using the **readmod** command, a read of each sector on the media is done. The **readmod** command verifies reads can be done at the simplest level. When defects are detected, cross checking between two different MOD disks is suggested, to determine whether the MOD drive or the disk is defective.

It may be possible to recover a defective MOD disk. Defective disks may be cleaned using cleaners designed for CDROM disk surfaces. Be careful not to scratch the surface, or the MOD disk will need to be replaced.

Defective MOD drives must be replaced. Because the drive requires disassembly, cleaning of the optical drive mechanism in the field is not possible.

To test the basic read capability of the drive and media, use the following procedure:

1.) Open an Unix shell and become superuser.

Type: **su -**

Type **#bigguy** as the password.

2.) Load a blank/spare MOD disk into the drive.

3.) At the prompt type **readmod**

The reading will start at sector 0 and include 30000 sectors by default (no options selected).

4.) Inspect the output. If there are defective sectors on the medium, these will be reported during the read operation. Defective sectors will be reported with syndrome `####03` while "blank sectors" will be reported as `####08`. *Defects are BAD*.

Write Failures

⚠ **NOTICE**
Potential for Data Loss

The zapdmod command can write data to the sectors on an MOD and therefore destroy the contents of that medium. Make sure the MOD being used has only expendable data. As a precaution, the program requires "-do" command line switch to activate the write operations.

Use the **zapdmod** command to write data to every sector on the medium. The program is used to perform 'write' operations to every or "select" sectors on a medium to see that it can receive data at the simplest level. The original intent was to provide the ability to erase the first 30000 sectors of a medium so that it looked like a fresh medium. This is much like a media format preparation.

When defects are detected, cross checking between two different MOD disks is suggested. To determine whether the MOD drive or disk is defective.

It may be possible to recover a defective MOD disk. Defective disks may be cleaned using cleaners designed for cleaning CDROM disk surfaces. Be careful not to scratch the surface. Else, the MOD disk must be replaced.

Defective MOD drives must be replaced. Because the drive requires disassembly, cleaning of the optical drive mechanism in the field is not possible.

To test the basic read capability of the drive and media, use the following procedure:

1.) Open an Unix shell and become superuser.

Type: **su -**

Type **#bigguy** as the password.

2.) Load a expendable MOD disk into the drive.

3.) At the prompt type **zapdmod -do**

To activate the write mode, you must include a **-do** command line switch. The write starts at sector 0 and includes 30000 sectors by default (no switches selected). The writes will be performed in blocks of 64 sectors by default.

4.) Inspect the output.

4.1.2.2 Diagnostic Tools

The following commands can be used to interrogate and test the SCSI bus, MO drive and its disk. They must be executed as superuser (root).

---

scsistat

Usage: **scsistat [-h|-c|-i|-v|-V|-dl|-d #]** ***[scsi id(s) to check]***

scsistat with no argument prints out the firmware information for each device on the SCSI bus. Alternatively, one may specify any number of devices to be checked on the command line.

-c # Perform a configuration check of each specified device.

-dl Dump the defective sector list if media in drive.

-d # Takes the lower 2 bits of the number and sets the internal debug entry, to increase diagnosis.

-h Causes this message to be printed.

-i Dump the contents of the 'inquiry' packet.

-V Have `scsistat` print it's current version number.

---

scsiha

Usage: **scsiha [-r]<*scsi bus number* | *full name of the scsi bus vertex*>**

scsiha is used primarily to reset the SCSI bus through a SCSI controller. Controller 0 is attached to the local (OS and application disks) SCSI disks used for host computer operation. It's suggested that you do not attempt to reset controller 0 with CT application running. Controller 1 is attached to the external SCSI devices such as the MOD and CDROM. If you have a Controller 2, it's normally attached to the DASM.

-r Used to reset adapter and/or SCSI bus

---

lockmod

Usage: **`lockmod [-h] [-l] [-f] [-V]`** ***[<devicename>]***

With no arguments, the program unlocks the <***devicename***> media.

-I Locks the media into <***devicename***> and maintains persistent ownership until a '**lockmod**' command causes release. The process is persistent on a '**lockmod -l**' command making the media inaccessible to other process requests. Upon '**lockmod**' command, the persistent process will release media ownership and the media will become accessible. A FORCE unlock ability is available. Use advisedly. This is an abnormal release method.

-f Forces an extraordinary 'unlock', if the media must be released for some exceptional reason. This will not release a '**lockmod -l**' command locked media.

The default <***devicename***> is '**DMOD**'.

---

readmod

⚠ **NOTICE**
Potential for Data Loss if -do switch used

Usage: **readmod [-f devicename] [-k] [-L] \ [-v] [-R [-do]] [-b <blocks>] [-c <count>] [-s <start>]** ***[-o <filename>]***

This programs reads a range of media and optionally stores the data into an output file that can be used by **zapmod** or **zapdmod. devicename** can be PIONEER, DMOD, 0.6GB, 1.2GB, 2.3GB. The '**readmod**' default is 'DMOD'.

-b <*blocks*> The number of blocks to read as a group. The default is 64.

-c <*count*> The total number of blocks to read. The default is 30000.

-s <*start*> The starting block number of the media range to read. The default is 0. The starting sector is defined by **-s** #### and the count by **-c** #### options. The count will limit itself to maximum sectors on media if the limit is exceeded.

-i <*dirpath*> This is used to search a media for JPEG images. The <***dirpath***> is the location to receive the images found.

-k Switch tells the programs to "keep going" if there is a fault.

-L Look for `END_BLOCK_ID` to find rollfwd file.

-m Measure the percentage of the disk written.

-n	Do NOT report BLANK SECTOR occurrences.
-o <*filename*>	This is the destination filename for the data. Used to store the read data into the UNIX file system file
-C	Report all sector addresses in cluster relative notation.
-R	The **-R** switch add a little DOS knowledge about the "boot sector" and about the Archive media LABELs. Performs a ROOT dir recovery process on DICOM media. The '-do' switch is needed to effect a change. *Don't use the -do switch to write to the media.*

---

zapdmod

Usage: **zapdmod [-f devicename] [-do] \ [-b <blocks>] [-c <count>] [-s <start>] [-t] [-r] [-v] \ [-l] | *[-i <filename>]* | *[-fill <val>]***

This program writes zero data or fill options to the media range. devicename can be PIONEER, DMOD, 0.6GB, 1.2GB, 2.3GB. The 'zapdmod' default is 'DMOD'. The 'zapmod' default is 'PIONEER'.

-do	To activate the write mode, you must include a **-do** command line switch. Required to actually overwrite the first <count> blocks of the medium with selected fill data.
-b <*blocks*>	The number of blocks to write as a group. The writes will be performed in blocks of 64 sectors by default. **-b** ### changes
-c <*count*>	The total number of blocks to overwrite. The default is 30000.
-s <*start*>	The starting block number of the media range to overwrite. The default is 0. The starting sector is defined by **-s** #### and the count by **-c** ####. The count will limit itself to maximum media sectors if the medium size limit is exceeded.
-fill <*val*>	The data value used to fill the block. The default is 0. MAX val is 255.
-i <*filename*>	The <***filename***> contains the data to be written. The **-i** <***filename***> will use a UNIX file system file as the data to be written. The length must agree with the requested blocking factor size. The blocking factor is 64 sectors or the <***count***> whichever is less. Use **readmod -o** … to make the file.
-l	This will fill each sector with a flat dataset starting with 0 through 255, then ramp datasets.
-t	Test the range of sectors requested with write and read and compare byte for byte. Switch tells the program to write, then read, and compare the data
-r	Use a random sector selection in the range of sectors. The coverage using random selection is about 43. The random pattern is different every time.

4.1.2.3 Filesystem Tools

The following commands can be used to interrogate and modify the filesystem, DOS files and DICOM files located on a MOD disk.

DOS/FAT Filesystem Commands

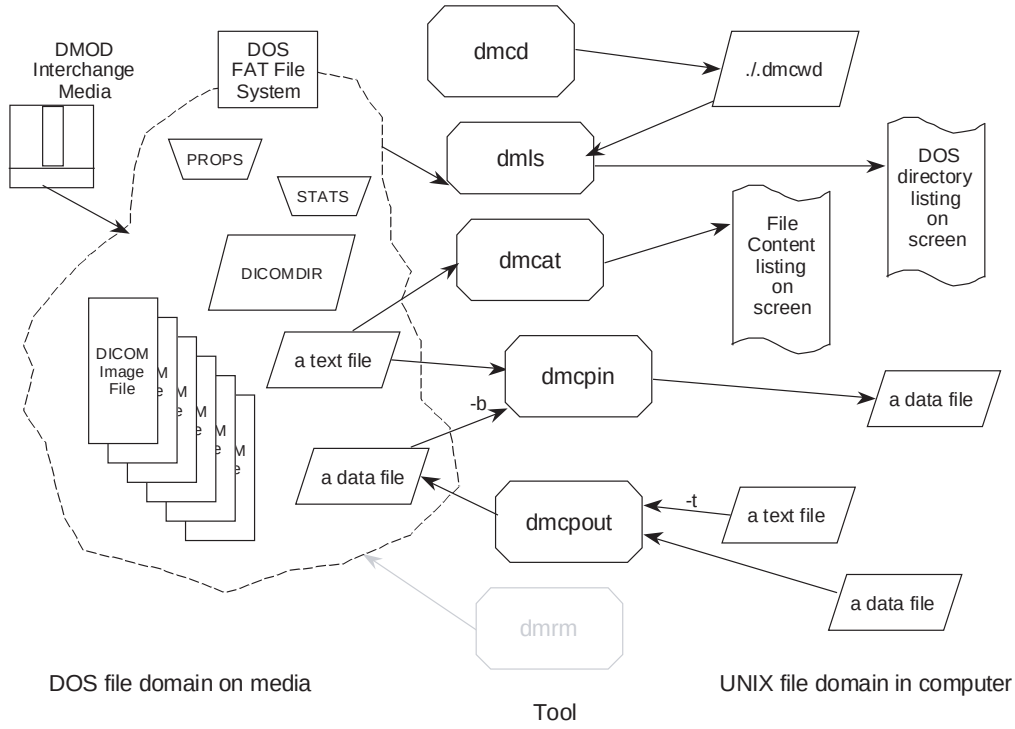


Figure 5-138 DOS/FAT Filesystem Commands - Graphical Overview

DMCD

Usage: **dmcd [-v] <*filename*>**

Performs a “change directory” in the DOS filesystem of the MOD media.

DMLS

Usage: **dmls [-v] [-f devicename] path**

Performs a “list of file” in the current DOS directory on the MOD media.

DMCAT

Usage: **dmcat [-f devicename] <*filename*>**

Performs a “cat of file contents” of a file on the MOD media.

DMCPIN

Usage: **dmcpin [-b] [-d] [-D #] [-f devicename] file destpath**

Performs a “copy of a file” from DOS filesystem to UNIX filesystem.

DMCPOUT

Usage: **dmcpout [-t] [-f devicename] file file ... destpath**

Performs a “copy of files” from the UNIX filesystem to DOS filesystem.

DMRM

Usage: **dmrm [-f devicename] path**

Performs a “remove file” from the DOS filesystem on the MOD media.

DICOM Filesystem Commands

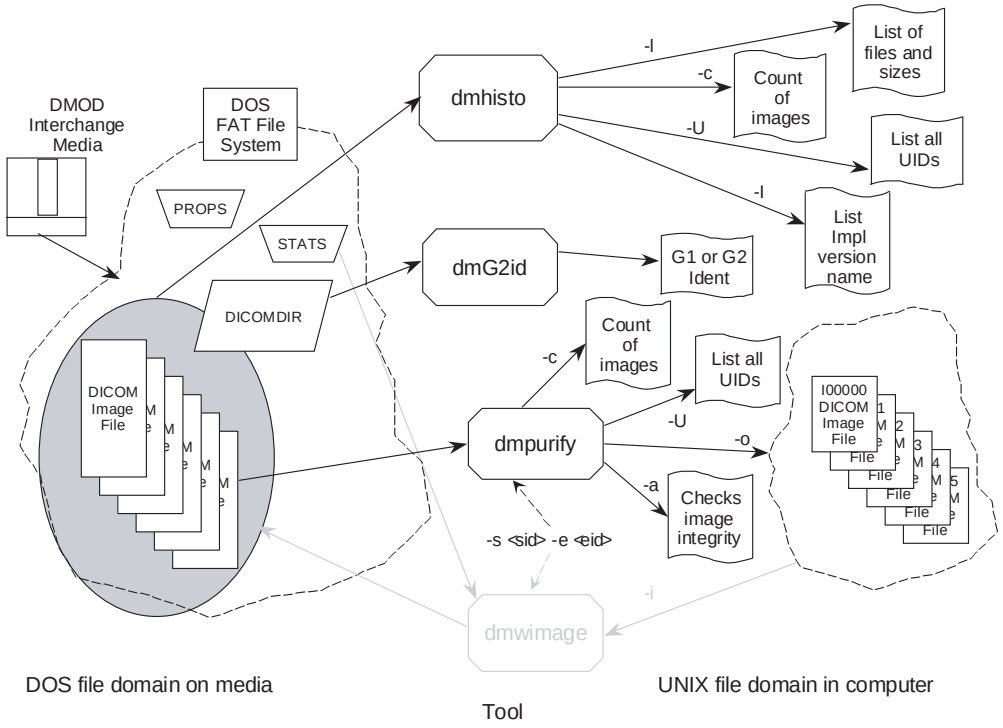


Figure 5-139 DICOM Filesystem Commands - Graphical Overview

dmhisto

Usage: **dmhito [-c] [-s <binsize>] [-d <debugDMOD>] [-t] [-v] [[-f] <*device_id*>**

This program looks at a GE Healthcare DICOM MOD and outputs a histogram of file sizes on the media in 1KB per bin. Each bin is a quantity of files.]

-c output the total file count along with the histogram info

-6 output the 6 sigma detailed sizes

-l output the detailed long list of files and sizes

-s sets bin size - default is 1024 resulting in a KB histo chart

-d sets the debugDMOD value - default is 0

device_id default is 'DMOD'

-t turns on some timing information

-v turns on increases the verbosity of the output

dmG2id

Usage: **dmG2id [-d <debugDMOD>] [-c] {-v} *[-f* <*device_id*>**

This program looks at a GE Healthcare DICOM MOD and locates the DICOMDIR and searches for the Frame of Reference entry in the file. This FoR only occurs in the Generation 2 DICOM MOD and it is the KEY that keeps a G2 media from mounting to a G1 system.]

-D Selects a virtual device name. DMOD is default

-f Selects disk filename.

-d Sets the debugDMOD value - default is 0. `device_id` default is 'DMOD'

-v Increases the verbosity of the output (multiple allowed).

- The verbose of 1 will report record category counts
- The verbose of 2 will report the images that are G2.

-c Reports the number of times FoR was found in DICOMDIR

---

dmpurify

Usage: **dmpurify [-d <debugDMOD>] [-f <device_id>] [-c] {-v|-U} \ [-s <sfid> [-e <efid>]] [[-g] [-r] -o <output_dir>] \ [[-m] [-a] [-do]**

This program looks at a GE Healthcare DICOM MOD and scans that disk for images that have Multiple Fragments. Each of the MFI images can be converted to a Single Fragment image by this routine.]

-d Sets the debugDMOD value - default is 0

Device_id default is 'DMOD'

-f Selects a virtual device name. DMOD is default

-c Reports the number of files and size stats

-v Increases the verbosity of the output (multiple allowed). The -v is used to simply scan the media for MFI's.

-U Don't look for MFIs but simply report UIDs. (g2e2, g2e3, g2e10, g2e12, g8e16, g10e10, g20eD, g20eE, g8e18, g20E52)

-s Sets the starting file identifier number (0=default)

-e Sets the ending file identifier number (lastUsed=default)

-g Grab each file from the media and place it in the output receiver directory defined with -o. This disables end of image testing and allows for the recovery of short images.

-r Use the 'real' file index for the grabbed file (0=default)

-o Output the images that were found on media to this directory pathname as sequentially numbered files.

-a Search for DICOM encoding problems in g18e20 and g18e22 tags

-m Search for multi-fragment images (original program purpose)

-do Is required to actually fix the problems and write the results to MOD. IF you don't understand, DON'T '-do' IT.

4.1.3 Autovoice/Intercom

4.1.3.1 Autovoice/Intercom Volume

Some of the processing for AutoVoice comes from the host's motherboard. If there is an autovoice problem, you may want to interrupt system boot up **ESC**, Enter Command Monitor, then type:

ide audiofield

to run diagnostics on the host's audio hardware.

4.1.3.2 Intercom Volume Verification

To adjust the Gantry Speaker volume, adjust the left-most volume thumb-wheel on the keyboard assembly while speaking into the console microphone.

To adjust the Console Speaker volume, adjust the center volume thumb-wheel on the keyboard assembly while speaking into the Gantry microphone.

4.1.3.3 Autovoice Volume Verification

To adjust the Gantry Speaker volume, adjust the right volume thumb-wheel on the keyboard assembly while autovoice is playing, and check the volume for the gantry speaker.

See Figure 5-140, for the normal (default) settings of the software audio panel. This audio panel is displayed on the right-head monitor, in the upper left-hand corner, when Applications is down.

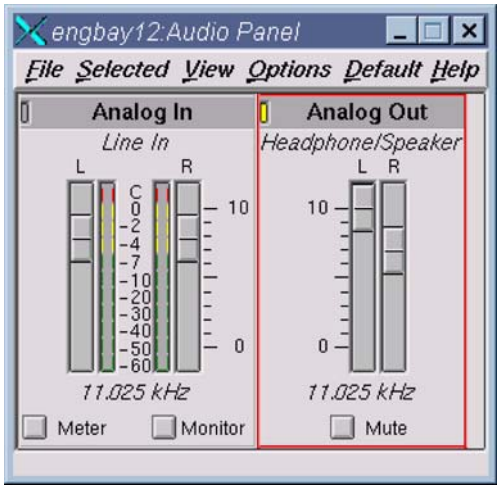


Figure 5-140 Autovoice Control Audio Panel

To adjust the Console Speaker Volume, bring up the Autovoice volume control audio panel.

- Select the OPTIONS pull-down menu.
- Select OUTPUT SLIDERS INDEPENDENT.
- Adjust the RIGHT Channel volume only (Analog Out) — this is the only volume control.
- The LEFT Channel must be kept locked at the maximum.
- The Analog In settings will affect the level of Autovoice record, and if you desire, you can click on the METER selection box to view the recording levels.
- DO NOT turn on the MONITOR selection, as it will cause immediate uncontrollable feedback.
- Select FILE - SAVE when you have finished, to retain your settings.

4.1.4 Console Intercom Board (2167014)

4.1.4.1 Functional Test

Preset Potentiometers

- R3 Max (25 turns) CW,< 10 ohms between pot pins 1 and 3
- R5 Max (25 turns) CW,< 10 ohms between pot pins 1 and 3
- R10 Max (25 turns) CW,< 10 ohms between pot pins 1 and 3
- R100 Set to 150K ohms between pot pins 1 and 3

Power Supply Currents

- +5 vdc supply Less than 1 ma
- +12 vdc supply 120 ma ± 20 ma
- –12 vdc supply 100 ma ± 20 ma

Supply Voltages

- +5 vdc supply ± 0.2 vdc (Across CR3)
- +12 vdc supply ± 0.6 vdc (Across CR2)
- –12 vdc supply ± 0.6 vdc (Across CR1)
- +6 vdc regulator ± 0.4 vdc (Across CR1)
- +5 vdc regulator ± 0.4 vdc (Across CR34)

Logic Tests

Table 5-47 shows the operation of the “Talk Button” logic with all ac signal sources removed.

PUSH-BUTTON	J2-3	U9-4 (AV_CNTL)	U4-6 (CON_CNTL)	U9-1 (OC_CNTL)
Open	High	High	Low	High
Close	Low	Low	High	Low

Table 5-47 Talk Logic (2167014) on the intercom Board

Autovoice Sensing

This test confirms the action of a signal level sensing circuit. The test starts with no signal on J4-2. The DC voltage on TP 3 should be more negative than –5 vdc. The voltage on U9-pin 1 should exceed +3.5 vdc.

Supply a 600 mv ± 10% peak to peak, 1000 Hz sine wave to J4-2 (Auto Voice Left). The DC voltage on TP 3 should exceed +5vdc. The voltage on U9-pin 1 should be less than +0.25 vdc. Reduce signal level to 240mv± 10% peak to peak. J4-2 will change to negative in 2 ± 0.5 seconds.

Gain Tests

The following gain tests are achieved by supplying a 1000 Hz, 100 mv peak-to-peak sine wave at the specified input, with respect to analog ground. Output voltages are measured at the specified connector pin.

- J3-11 (Gantry Microphone Pre-Amplifier) to J2-11 gain = 2.1 ± 10%
- J3-30 (Gantry Microphone Pre-Amplifier) to J2-11 gain = 2.1 ± 10%
- J4-2 (Auto Voice Left to Volume Control) J2-5 Gain = 1 ± 10%
- J4-3 (Auto Voice Right) Gain to TP 2 = 1 ± 10%
- J4-3 (AutoVoice Right) to TP 4 gain =.9 ± 10%, when AV_CNTL is High
- J4-3 (AutoVoice Right) to J2-17 gain = 25 ± 10%, when AV_CNTL is High
- J2-6 (AVVOL.WIPER) to TP 5 gain = 6 ± 10%, when AV_CNTL is High
- J2-9 (PATVOL.WIPER) to TP 5 gain = 10 ± 10%, when CON_CNTL is High
- J2-12 (Patient volume control) to TP 4 gain =.33 ± 10%, when OC_CNTL is High
- J2-12 (Patient volume control) to J2-17 gain = 10 ± 10%, when OC_CNTL is High
- Adjust Potentiometer R3 to Max CCW position.
- J2-12 (Patient volume control) to J2-17 gain = 3.3 ± 10%, when OC_CNTL is High

High Gain Tests

The following gain tests are achieved by supplying a 1000 Hz, 10 mv peak to peak sine wave at the specified input.

- J2-9 (PATVOL.WIPER) to J3-12 gain = 300 ± 10%, when CON_CNTL is High
- J2-6 (AVVOL.WIPER) to J3-12 gain = 190 ± 10%, when AV_CNTL is High
- Adjust Potentiometer R5 to Max CCW position.
- J2-6 (AVVOL.WIPER) to J3-12 gain = 60 ± 10%, when AV_CNTL is High

ALC Test

- Supply a 10 mv peak to peak, 1000 Hz sine wave to J2-15. J2-15 to J2-8 gain = 7.5 ± 20%.
- Supply a 100 mv peak to peak, 1000 Hz sine wave to J2-15. J2-15 to J2-8 gain = 1.5 ± 20%.

4.1.4.2 Potentiometer Settings

•	R3	2.k ohms	Console Max Volume
•	R5	1.5k ohms	Gantry Max Volume
•	R10	500 ohms	Gantry Min. Volume
•	R100	150k ohms	AutoVoice Detect delay

4.1.5 Host Media Adapter - CTP100T Coax to 10BASE-T

4.1.5.1 Troubleshooting - Using LANVIEW

The CTP100T adapter uses Cabletron System's built-in visual diagnostic and status monitoring system, LANVIEW. LANVIEW LEDs are more effective than a network monitor because networking personnel can quickly scan the LEDs to diagnose network problems and determine which node or segment is faulty.

The following discusses the function and purpose of each CTP100T LANVIEW LED shown below.

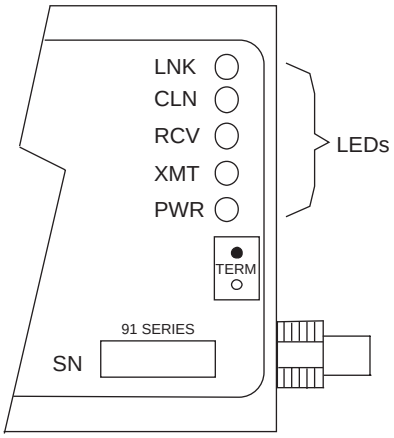


Figure 5-141 LANVIEW LEDs

4.1.5.2 Link OK (LNK) LED

When this green LED is ON, a link has been established between the CTP100T adapter and the device at the other end of the twisted pair segment. It remains on as long as the link is maintained.

If no data has been sent for 16 ms, a positive link test pulse of 100 ns is sent onto the transmit link of the twisted pair cable. The link pulses are received by the CTP100T adapter and checked to determine if they are occurring at the correct rate, polarity and pulse shape. If no pulses are received or the pulses are not correct, the transceiver enters the Link Fail State and the LED goes off. The CTP100T adapter will not receive or transmit data until the link is restored by receiving a correct link test pulse or a valid packet. If the polarity is reversed on the twisted pair segment receive link, the Link LED flashes, indicating that this condition exists. The segment should be removed from the module and the wiring corrected.

4.1.5.3 Collision Present (CLN) LED

This red LED flashes when the CTP100T adapter detects a collision condition. The frequency of the flashes may increase as network activity increases, since more collisions are likely to occur. The flash of the LED is pulse-stretched for viewing effect. A solid light indicates a jabber condition.

4.1.5.4 Receive (RCV) LED

This yellow LED flashes when the CTP100T adapter receives a data packet from the coaxial segment and transmits it on the twisted pair segment. The flash of the LED is pulse-stretched for viewing effect. The LED flashes when there is traffic on the segment, even if the data is not intended for the devices attached to the twisted pair segment on the other side of the CTP100T adapter.

4.1.5.5 Transmit (XMT) LED

This green LED flashes when a data packet is transmitted on the thin-net coaxial segment by the device connected to the CTP100T RJ45 port. The LED's flash is pulse-stretched for viewing effect.

4.1.5.6 Power (PWR) LED

This green LED is ON when the CTP100T adapter is receiving power from the external (wall) transformer.

4.1.6 Fast Ethernet Switch - AT-FS705 Series Switch

4.1.6.1 Connectivity Testing

Perform the following steps to test for a valid connection and to confirm correct network operation.

1.) Connect Port 1 and Port 2 of a single switch to two nodes or workstations, and turn on the switch power supply by connecting the AC power cord.

2.) Wait approximately 1-3 seconds for the auto-negotiation process to complete after power-on or after the cables are reconnected.

3.) Check to make sure the Link and other activity LEDs of both Port 1 and Port 2 are lit.

4.) After confirming that Port 1 and Port 2 are operational, reconnect one of the nodes/ workstations to another port, then repeat this communications test with the switch's remaining ports. Verify the connection in each port by checking the Link and other activity LEDs.

Note: When testing the cascade port (Port 5), make sure you connect to the proper jack (MDI or MDI-X) according to the type of device you are connecting to the port.

4.1.6.2 Is the Unit Receiving Power?

Check the power (PWR) LED on the front of the switch. This green LED should be lit.

If the power LED is not on, check both ends of the AC power cord. Make sure the power cord is plugged into a functioning outlet and that it is properly inserted into the switch's power connector on the back of the unit.

Note: There is no "power" switch on the AT-FS705 series switches. If the power cord is properly connected, the switch should be receiving power.

4.1.6.3 Is the Link/Activity LED Lit?

The Link LED on the front of the switch lights when a proper connection is established. If this LED is not lit, check for the problems listed below, and make corrections as necessary.

1.) Problem: The cable has been cut, damaged, or is the wrong type of cable.

Solution: Try making the connection with a different cable. Be sure you are using an undamaged cable of the correct type.

2.) Problem: Connected equipment is not turned on or not operating properly.

Solution: Check connected equipment (computer, another switch, etc.) and turn on power.

3.) Problem: For Port 5, the device is connected to the wrong jack (MDI/MDI-X).

Solution:

a.) When cascading two switches, the unit using the cascade port (Port 5) should use the MDI jack, while the other unit should use its MDI-X jack.

b.) When Port 5 of the switch is not connected to another switch but is used to connect to a workstation or other equipment, you should use the MDI-X jack.

4.) Problem: There is data loss between the switch and one of the attached network nodes.

Solution:

a.) Make sure that the distance between the switch and the connected network device is no greater than 100 meters.

b.) Make sure you are using Category 5 cable.

4.1.7 DASM

4.1.7.1 DASM Diagnostics

```
diagnostic(s): (OC) hinv, scsistat, showdasm, clrsp, rqs, rsp
error log(s): (OC)
```

The DASM runs a power up **self-test** as well as an idle test loop (heartbeat) when on. See the manual that comes with all DASMs for more info on LED error status and heartbeat indications. When the DASM is failing, its middle two LED's flash an error code, after all LED's are momentarily flashed ON.

There is an application utility called **showdasm** that can be run from any shell to check basic communications with the DASM by retrieving its configuration. Note however that while there are active filming jobs, **showdasm** *will fail* with an "open failure" because the DASM device is opened exclusively by the filming print filter/manager.

A **SCSIbus0 reset popup ALERT** message is a clear indication of a physical DASM problem/ failure. This SCSIbus0 channel is dedicated to the DASM. The components in this chain include:

- DASM
- SCSI cable (SGI carrier to DASM)
- SCSI terminator module (on DASM)
- LED/switch/SCSI PWA inside SGI carrier
- SCSIbus0 ribbon cable inside SGI carrier
- Ribbon-to-IP22 PWA inside SGI carrier
- IP22 motherboard (contains SCSI controller/termination)

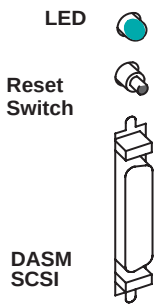


Figure 5-142 DASM LED, Reset Switch and SCSI Connector

Sometimes after a filming and/or **SCSIbus problem**/error, the DASM device can be confused and/ or out of synchronization with the host SCSI driver and/or platform DASM manager. Usually a second or third attempt at running **showdasm** will re-synchronize SCSI communications.

While the **Analog DASM** is in its idle test/loop or when an image has been sent to the DASM, the Video Output should have either a continuously changing pattern or the last image sent. This may be checked for the Analog DASM by connecting a short piece of coaxial cable from the DASM Analog Video Output connector to the Green Video input on one of the display monitors, after disconnecting the MG Video Input cables.

WHERE FILMING ERRORS ARE LOCATED

To investigate a filming problem, look at the following logs:

/usr/g/service/log/gessy*.log

/var/adm/SYSLOG*

/usr/g/ctuser/logfiles/prslog

4.1.7.2 DASM LEDs

Make sure the DASM power is applied (green power LED) and that the DASM power-up self-test completes successfully (flashing green CPU LED indicates idle heartbeat).

On analog VDB DASM only, the “RDY” and “XFR” LEDs should toggle back and forth when filming is running. This toggling indicates that film sheet images are being output by the DASM (“RDY”) and then captured by the camera video/analog input port (“XFR”).

4.1.7.3 Checking DASM SCSIbus Connection & Basic DASM Operation

A.) Use **hinv** to check that the DASM was present at the last OC boot-up. The DASM looks like a disk drive to the Irix OS.

DASM LINE FROM hinv OUTPUT:

```
(other output)
Disk drive: unit 1 on SCSI controller 1
(other output)
```

B.) Use **scsistat** to perform a “live” SCSIbus probe for the DASM device. Analog VDB and digital LCAM are shown separately, and the DASM firmware revisions should be as shown for LightSpeed Plus.

ANALOG VDB LINE FROM scsistat OUTPUT:

```
(other output)
Device 1 1  Disk     CDA      DASM-VDB         FW Rev: 1.0e
(other output)
```

DIGITAL LCAM LINE FROM scsistat OUTPUT:

```
(other output)
Device 0 1  Disk      ANALOGIC DASM-LCAM-3M     FW Rev: 1.3
(other output)
```

C.) Use **showdasm** to perform an extended inquiry from the DASM device. You must be 'root' with `ctuser` environment, as shown below, and the filming queue MUST be empty or fully paused or the **showdasm** will fail.

```
{ctuser@rhapby18}[1] showdasm
Could not initialize_scsi status = ffffffff
{ctuser@rhapby18}[2] su ENTER
Password:

{ctuser@rhapby18}[1] showdasm
Vendor: CDA  Device: DASM-VDB
Pif software rev: 1.0e  Krnl_rev: 2.1j
DRAM size: 1MB  SRAM size: 32KB I/O blocks: 2048  block size: 512
SCSI ID: 1   CMDBLK addr: 200000 Baud: 1200  RS232 ctl reg: hex 8e
Eprom checksum: hex 0038f90f       Internal checksum: hex 0038f770
RS232 Disabled DBUG Disabled           Power-on RAM tests Disabled
{ctuser@rhapby18}[2]
```

Any SCSIbus or device related errors will be logged to the shell window you're using, the OC console shell window, and will also be saved in the OC `/var/adm/SYSLOG*` Irix system log. The DASM device is `/dev/dasm1`, which is linked to `/dev/scsi/sc1d1l0` (Octane).

If the above functions work, the DASM power, SCSIbus connections, and the host side DASM operation are all working properly. If not, you may have a problem with 'reconfig' (camera

option, DASM type, etc.), SCSI cabling, or the DASM (it's usually NOT the DASM). Make sure you '**su**' from the '`ctuser`' shell and that the filming queue is empty or fully paused or the **scsistat** will show `EXCLUSIVELY OPEN` for the DASM line, and the **showdasm** will fail to open the DASM device, due to incorrect device permissions and environment variables.

4.1.7.4 DASM Status File

The LCAM Status file is used for ALARMS, ERRORS and other messages from the laser camera. Here are the error codes from `lc_msg_data.h`:

```
/*.......................str.................,num,sev*/
/* Status codes */
  ""                                          ,0,0,
  "1 Camera Is Ready"                         ,1,0,
  "2 Acquiring an image"                      ,2,0,
  "3 Opening the magazines"                   ,3,0,
  "4 Removing a film from supply magazine"    ,4,0,
  "5 Moving film to exposure area"            ,5,0,
  "6 Exposing film (no other operations can be performed)",6,0,
  "7 Closing the magazines"                   ,7,0,
  "8 Moving film to film processor"           ,8,0,
  "9 Unassigned status code"                  ,9,0,
/* Recoverable Alarm codes */
  "10 Supply Magazine Empty"          ,PRS_MEDIA_SUPPLY_EMPTY,ERR_FATAL,
  "11 Receive Magazine Full"          ,PRS_MEDIA_RECEIVE_FULL,ERR_FATAL,
  "12 Supply Magazine Full"           ,PRS_MEDIA_SUPPLY_MISSING,ERR_FATAL,
  "13 Receive Magazine Missing"       ,PRS_MEDIA_RECEIVE_MISSING,ERR_FATAL,
  "14 Supply Drawer Open"             ,PRS_MEDIA_SUPPLY_OPEN,ERR_FATAL,
  "15 Receive Drawer Open"            ,PRS_MEDIA_RECEIVE_OPEN,ERR_FATAL,
  "16 Top Cover Open"                 ,PRS_TOP_COVER_OPEN,ERR_FATAL,
  "17 Film Processor Not Ready"       ,PRS_FILM_PROCESSOR_NOT_READY,ERR_FATAL,
  "18 Docking Unit Not Ready"         ,PRS_DOCKING_UNIT_NOT_READY,ERR_FATAL,
  "19 Unassigned alarm detected"      ,PRS_UNDEFINED_ALARM_CODE_19,ERR_FATAL,
  "20 Film Transport Error..."        ,PRS_FIRST_FEED_ERROR,ERR_FATAL,
  "92 Camera Interface On Line ?"     ,PRS_CAMERA_MMU_NO_RESPONSE,ERR_FATAL,
  "99 MMU timer started (952)"        ,99,0,
/* Status codes */
  "200 Camera Interface On Line ?"            ,PRS_DASM_COMM_ERROR,ERR_FATAL,
  "201 Can't allocate camera after 15 mn Trying...",PRS_PRINTER_BUSY_TIMEOUT,0,
  "202 Your Film Was Queued Trying To Allocate Camera...",PRS_FILM_QUEUED,0,
  "203 Film Low..."                           ,PRS_MEDIA_SUPPLY_LOW,0,
  "204 Print Paused..."                       ,PRS_PRINT_PAUSED,0,
  "207 Camera Is busy at This Time Print Paused...Restart",PRS_PRINTER_BUSY,0,
 "208 Can't Process Print Request at This Time Print Paused...Restart"
,PRS_BAD_PARAM,ERR_FATAL,
  "209 Time_out Print ...Restart"             ,PRS_PRINT_CYCLE_TIMEOUT,0,
  "210 Failed acquire "                       ,PRS_FAILED_ACQUIRE,ERR_FATAL,
  "212 Unsupported Format"                    ,212,0,
  "301 OK"                                    ,PRS_STATUS_OK,0,
  "Unknown Error returned"                    ,LAST_LC_MSG,0
```

4.2 Scan Reconstruction Unit

4.2.1 Reconstruction Interface Processor (RIP)

4.2.1.1 Diagnostic Tests Overview

The Reconstruction Interface Processor (RIP), or Motorola Board, has built-in diagnostic routines that are executed by running either of two executable diagnostic scripts. These scripts are `diags` and `fulldiags`, and are called from a UNIX Shell window.

The `diags` test is a short board level diagnostic test (approximately 1 minute), and the `fulldiags` test is a longer test that performs more extensive, lower level testing of the board's RAM and VME3 channels (approximately 6 minutes). These executable scripts are located in the `/usr/g/ice/bin` directory of the OC - Octane.

Starting the diagnostic will reboot the Motorola Board into a diagnostics mode. When the tests are completed, the script will automatically return to the Octane `ctuser` prompt at the `/usr/g/ice/bin` directory level.

Note: Because the RIP Board is rebooted when these tests are launched, you must shut down Applications before running either of these tests.

4.2.1.2 Diagnostic Test Execution

Perform the following steps to launch either the short or long Motorola diagnostic tests:

1.) Perform an Application Shutdown.
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.

2.) Open a UNIX Shell.

3.) Change directory to `/usr/g/ice/bin`.
   At the ctuser prompt, type:
   cd /usr/g/ice/bin ENTER

4.) Launch either the short or long RIP diagnostic test.
   At the ctuser prompt, type:
   ice diags ENTER
   or
   ice fulldiags ENTER
   Each test starts RIP diagnostic testing at the VME `PPC1-Diag>` prompt level. Verify that all tests listed result in either a `PASSED` or `BYPASS` indication. The `diags` test takes approximately 1 minute to complete, and the `fulldiags` test takes approximately 6 minutes to complete. When the test routines complete, the routines automatically return the system to the ctuser prompt at the `/usr/g/ice/bin` directory.

5.) Close the Shell.
   At the ctuser prompt, type:
   exit ENTER

6.) Restart Applications.
   At the ctuser prompt, type:
   st ENTER

4.2.2 Scan Data Disk and SCSI Controller (Disk Subsystem)

4.2.2.1 Diagnostic Testing Overview

If disk subsystem should work correctly, if it passes the tests described in the sections that follow. Three simple questions are answered:

1.) Is the disk subsystem hardware recognized by the RIP "CPU".

2.) Does the RIP's operating system (Vx Works) recognize the hardware as a disk subsystem.

3.) Can data be written and read from the disk subsystem reliably.

Because of the tight linkage between a SCSI controller and a single disk drive, the tools used to identify resolve problems are similar.

Note: Before executing any of the VxWorks software commands, it's highly recommended that CT applications be shutdown. There's a potential for CT Applications becoming inoperable as a result of the system commands you execute. Thus requiring a restart anyway.

4.2.2.2 Recognition of SCSI Controller Hardware by the RIP Board

Verify the RIP board is able to identify the existence of the SCSI card. Perform the following steps to verify that the SCSI Board is being recognized by the Operating System:

1.) Shutdown Applications:
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.

2.) Connect to ICE Box (RIP Board), using one of the following methods.

Serial Connection:

a.) Open a Unix shell (as `ctuser`)

b.) At the ctuser prompt, type: **cd /usr/g/ice/bin ENTER**

c.) Type the following at the command prompt: **ice stop start connect ENTER**

Network Connection:

a.) Open a Unix shell and become root: **su - ENTER**

b.) Enter password: **#bigguy ENTER**

c.) Remote login into ICE box: **rlogin ice ENTER**

3.) Execute the VxWorks command to view the PCI Devices information:

`->` **pciDeviceShow ENTER**

The system will provide a text output page similar to the following:

```
-> pciDeviceShow
Scanning function 0 of each PCI device on bus 0
Using configuration mechanism 1
bus       device    function  vendorID  deviceID  class
00000000  00000000  00000000  00001057  00004801  00060000
00000000  0000000b  00000000  000010ad  00000565  00060100
00000000  0000000d  00000000  000010e3  00000000  00068000
00000000  0000000e  00000000  00001011  00000009  00020000
00000000  00000010  00000000  00001000  0000000f  00010000
00000000  00000011  00000000  00000001  00000001  00ff0000  <-- SCSI bd
value = 0 = 0x0
->
```

In the above example, the line of information in the printout (as marked) identifies the SCSI Board, and shows that it is properly recognized by VxWorks

4.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type the following to end a serial connection: **~. ENTER**

5.) The SCSI controller must be listed above in order to be recognized by the RIP board. If not, you most likely have a defective SCSI controller or PCI interface (RIP board). If recognized, proceed to next check (Section 4.2.2.3).

4.2.2.3 Recognition of SCSI Disk Subsystem by the Operating System

The operating system must see the existence of a SCSI disk drive, before software support is loaded. Perform the following steps to verify that the SCSI Board and disk properly recognized.

1.) Shutdown Applications:

a.) Click on the SERVICE DESKTOP.

b.) Click on the UTILITIES icon.

c.) Click on APPLICATION SHUTDOWN.

2.) Connect to ICE Box (RIP Board), using one of the following methods.

SERIAL CONNECTION:

a.) Open a Unix shell (as `ctuser`)

b.) At the ctuser prompt, type: **cd /usr/g/ice/bin ENTER**

c.) Type the following at the command prompt: **ice stop start connect ENTER**

NETWORK CONNECTION:

a.) Open a Unix shell and become root: **su - ENTER**

b.) Enter password: **#bigguy ENTER**

c.) Remote login into ICE box: **rlogin ice ENTER**

3.) Execute the following VxWorks command to list SCSI devices recognized by the operating system:

-> **scsiShow ENTER**

The system will provide a text output page similar to the following, depending on the make and model of disk drive recognized. *A disk drive must be listed, regardless of make and model.*

SEAGATE ST318404LW MODELS:

```
ID LUN VendorID    ProductID      Rev. Type  Blocks  BlkSize pScsiPhysDev
-- --- -------- ---------------- ---- ---- -------- ------- ------------
 1  0  SEAGATE  ST318404LW       0002   0  35843670    512    0x017dda88
value = 0 = 0x0
```

SEAGATE ST318451LW MODELS:

```
ID LUN VendorID    ProductID     Rev. Type  Blocks  BlkSize pScsiPhysDev
-- --- -------- ---------------- ---- ---- -------- ------- ------------
 1  0  SEAGATE  ST318451LW       0003   0  35843671    512    0x01bddb18
value = 0 = 0x0
```

4.) Inspect the output of the **scsiShow** command. Is a disk drive listed in the output? If no, the SCSI controller, cable or disk drive may be defective. You must correct this problem before proceeding. If listed, proceed onto next check (Section 4.2.2.5)

5.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type the following to end a serial connection: **~. ENTER**

4.2.2.4 Recognition of the Disk File system by the Operating System

There must be a file system on the disk drive. The file system on the disk is created during a software load. A file system must exist for CT applications to operate correctly. In the following check, you will very the existence of that file system.

1.) Shutdown Applications:
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.

2.) Connect to ICE Box (RIP Board), using one of the following methods.

   SERIAL CONNECTION:

   a.) Open a Unix shell (as `ctuser`)
   b.) At the ctuser prompt, type: **cd /usr/g/ice/bin** **ENTER**
   c.) Type the following at the command prompt: **ice stop start connect** **ENTER**

   NETWORK CONNECTION:

   a.) Open a Unix shell and become root: **su -** **ENTER**
   b.) Enter password: **#bigguy** **ENTER**
   c.) Remote login into ICE box: **rlogin ice** **ENTER**

3.) Execute the following VxWorks command to preform a listing of the directory `raw_data`:
   -> **ls "/raw_data"** **ENTER** (*remember to include the quotes)*

4.) You should get a listing of the directory `raw_data`, if it exists.

```
/raw_data/info_file
/raw_data/recovery
/raw_data/ex163.CT18.1003803242.952008
/raw_data/ex171.CT18.1003832725.458539
```

5.) Inspect the screen output.
   - If the "**ls**" command lists the contents of the `raw_data` directory, you're done and everything is okay. Proceed onto the next check (Section 4.2.2.5)
   - If you receive `file not found` or some other error message, the directory is defective.

4.2.2.5 Testing for Reliable Disk Subsystem Operation

To test the reliability of the disk subsystem (RIP Board, SCSI Controller, and Scan Data Disk), preform the following test:

1.) Shutdown Applications:
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.
2.) Open a UNIX Shell.
3.) Serial connect to the VxWorks prompt.
   At the ctuser prompt, type: **cd /usr/g/ice/bin** **ENTER**
   At the Octane ctuser prompt, type:
   ice stop start connect **ENTER**
4.) Launch the Scan Data Disk (HSD) test:
   -> **test_high_speed** **ENTER**

The system will proceed to transfer data to and from the High Speed Disk. If any errors are detected, they will be displayed on the terminal screen. If the test runs to completion without error, you can be assured that the High Speed Disk, SCSI Controller, and RIP Board are capable of performing acceptably well to handle the scan data save and restore operations that are utilized during normal scanning.

5.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type:
-> ~. **ENTER**

4.2.3 PMC DIP Board

4.2.3.1 System Operational Errors Commonly Associated with the DIP Board

The RIP board is a common place for san data acquisition system errors to be logged and reported. Scan data acquisition errors are reported to the RIP, using interrupts, real-time. This section attempts to sort out those failures so that the failing subsystem can be correctly identified.

Failures can occur almost anywhere along the scan data acquisition chain, including the DIP and RIP board. Error detection and correction schemes built into slip ring communications (**SRC**) are the first level of defense. To prevent lost/missing and/or corrupt data from being processed.

The first step is to identify the failing subsystem. Failures common to the SRC subsystem are FEC errors, serial data modem violations and view length errors. If you should receive any of these errors, the SRC subsystem should be thoroughly checkout first. If you receive data checksum or parity errors error messages, then the DIP and RIP board (ICE box subsystem) should be thoroughly tested.

Common SRC Errors

FORWARD ERROR CORRECTION (FEC) ERROR

FEC protects the integrity of the link between the DAS DCB and the DIP. Without any form of error correction, the system bit error rate is 10-12. This translates to a data error every one week of scanning. With FEC, the not correctable failure rate is reduced to 10-15 or a data error every 6 years. Therefore FEC virtually eliminates the possibility of a data error between the DCB and the DIP. In addition, the FEC on board the DIP will maintain a running count in the board status register, per scan, of the number of corrected bit errors. This register is readable from the RIP and can be used to maintain statistics and indicate potential problems.

SERIAL DATA MODEM VIOLATION

A SERIAL DATA modem violation is a very basic failure of the communication link, indicating that the link has broken.

VIEW LENGTH ERROR

A view length error is another very basic failure of the communication link, indicating lost data and that the link has been broken.

Common PCI Interface Errors

SRC errors indicate problems with the DAS to DIP communication link, not the DIP or the DIP to RIP interface. Since the PCI bus link in the ICE box is orders of magnitude more reliable than the SRC path, error correction is not used. However, error detection is used with the RIP's PCI interface to the DIP board. The following errors indicates a detection problem in either the DIP or the RIP board.

DATA CHECKSUM ERROR

A checksum for each view is generated by the DCB (in the DAS) and stored in the view data. View data is stored on the scan data disk by the DIP and RIP. The checksum is tested when view data is restored from disk. Any failure that generates a checksum error should have also generated one of the above mentioned SRC errors. If not, the error could have only occurred on the DIP board or during the transfer of data from the DIP to the RIP.

PARITY ERROR

The PCI interface uses parity error detection. A parity bit is generated for each scan data word transmitted across the PCI interface between the DIP and the RIP. Hardware on board the RIP checks parity and produces an abort condition when an error is detected. A parity error can only occur during the transfer of data from the DIP to the RIP.

Common DIP Board Errors

To isolate the DIP from the RIP board as the failing, the following should be done:

1.) **View the system error log**. FEC, serial data modem, or view length errors indicate a DAS to DIP error, not a DIP failure. PCI parity errors indicate a DIP to RIP error. Data checksum errors indicate a DIP, RIP or possibly a scan data disk error.

2.) **Run DIP BLDs**. These tests will run known data patterns through the DIP at full data rates, indicating problems on board the DIP or the DIP to RIP interface.

3.) **Run the system data path tests**. These tests will run known data patterns from the DAS to the RIP, through the DIP at full data rates. By monitoring the system error log as mentioned above, more information can be gathered to determine the failing FRU.

4.2.3.2 Diagnostic Tests Overview

If the DIP and RIP boards are to work correctly, they must be able to communicate reliably. Three simple questions must be answered first:

1.) Is the DIP board recognized by the RIP “CPU”?

2.) Can data be transferred from the DIP to the RIP board reliably?

3.) Is data received reliably from the slipring?

4.2.3.3 Recognition of DIP Board by the RIP

Performing the following steps to determine whether the RIP Board (VxWorks) sees the existence of the DIP Board through the PCI interface.

1.) Shutdown Applications:

   a.) Click on the SERVICE DESKTOP.

   b.) Click on the UTILITIES icon.

   c.) Click on APPLICATION SHUTDOWN.

2.) Open a UNIX Shell.

3.) Serial connect to the VxWorks prompt.

   At the Octane ctuser prompt, type:

   cd /usr/g/ice/bin ENTER

   At the prompt, type:

   ice stop start connect ENTER

4.) Execute the VxWorks command to view the PCI Devices information:

   -> **pciDeviceShow ENTER**

5.) Inspect the screen output. Verify the DIP board is recognized by the RIP through its PCI interface.

```
Scanning function 0 of each PCI device on bus 0
Using configuration mechanism 1
bus       device    function  vendorID  deviceID  class
00000000  00000000  00000000  00001057  00004801  00060000
00000000  0000000b  00000000  000010ad  00000565  00060100
00000000  0000000d  00000000  000010e3  00000000  00068000
00000000  0000000e  00000000  00001011  00000009  00020000
00000000  00000010  00000000  00001000  0000000f  00010000   <-- DIP bd.
00000000  00000011  00000000  00000001  00000001  00ff0000
value = 0 = 0x0
```

In the above example, the next to the last line of information in the printout (as marked) identifies the DIP Board, and shows that it is properly recognized by VxWorks

6.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type:

`->` **~. ENTER**

4.2.3.4 Testing DIP Board Functionality (DIP Diagnostics)

Diagnostics for the DIP board are located on the Service Desktop, under the Diagnostics Menu. There are two types of test selections available (quick and extensive), and two sources of data (internal loopback and external loopback).

If you wish to perform the external loopback tests, you will need to loop back data between the fiber-optic jacks (J2 and J3) on the DIP board. A suggested cable for this purpose is the fiber-optic cable used to connect the DIP Board to the rear access plate on the console. (Fiber-optic Cable Part Number is 2264931.)

1.) Click on the SERVICE DESKTOP.

2.) Click on the DIAGNOSTICS icon.

3.) Click on DIP DIAGNOSTICS.

A diagnostic GUI will appear on the console that will allow you to select the testing mode and the loopback mode. See Figure 5-143. If you select “external” for the loopback mode, a separate window will pop-up, reminding you of the need to install an external fiber-optic jumper.

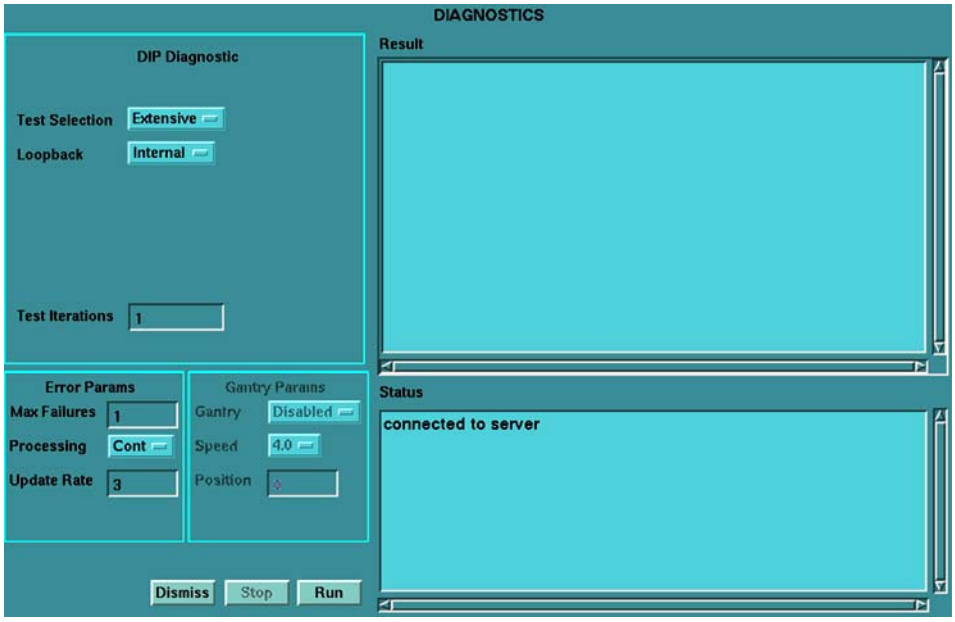


Figure 5-143 DIP Diagnostics GUI

4.2.4 Pegasus Image Generator Board (PEG-IG/PIG)

4.2.4.1 Diagnostic Overview

There are two (2) levels of Pegasus diagnostics:

- **Low level board diagnostics** - run from the service browser with applications shutdown. Used to test the functionality of the Pegasus board specifically.
- **High level Recon Data Path tests** - run from the service desktop at applications level. Tests the ability of the Pegasus board to communicate and operate with the rest of the system.

4.2.4.2 Low Level Board Diagnostics

TEST PROCEDURE

1.) On the `Service Desktop` page, click UTILITIES (circular button at the top menu bar), then click `Application Shutdown` in the left menu column. Wait for the "`Attention`" window to disappear and then open a shell. Within that shell, execute the following command to start the service browser (See Figure 5-144):

> **service_browser ENTER**

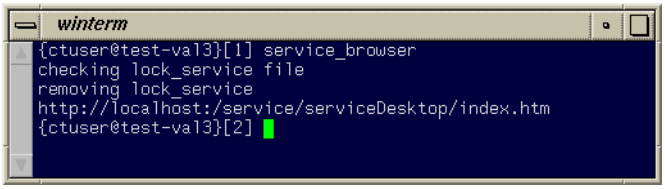


Figure 5-144 Initiating the Service browser

2.) With the service browser displayed, select the `Diagnostics` TAB (See Figure 5-145).

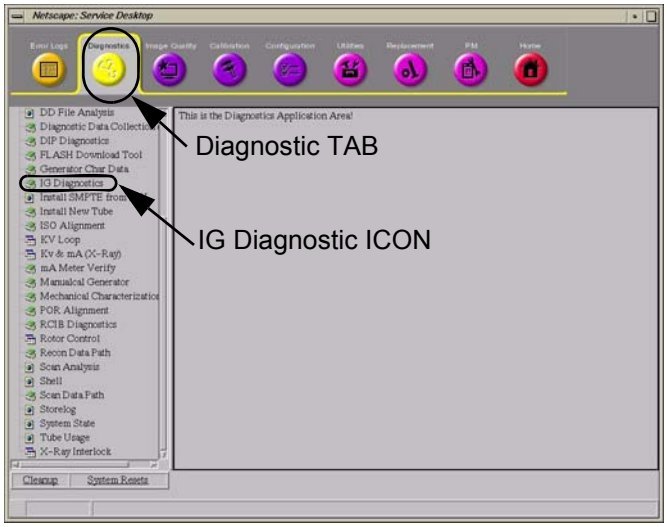


Figure 5-145 Service Browser - Diagnostic TAB

3.) Within the Diagnostic TAB, select the `IG Diagnostic` ICON in the file list menu on the left, by clicking on it. The IG Board level Diagnostic screen appears. (See Figure 5-146)

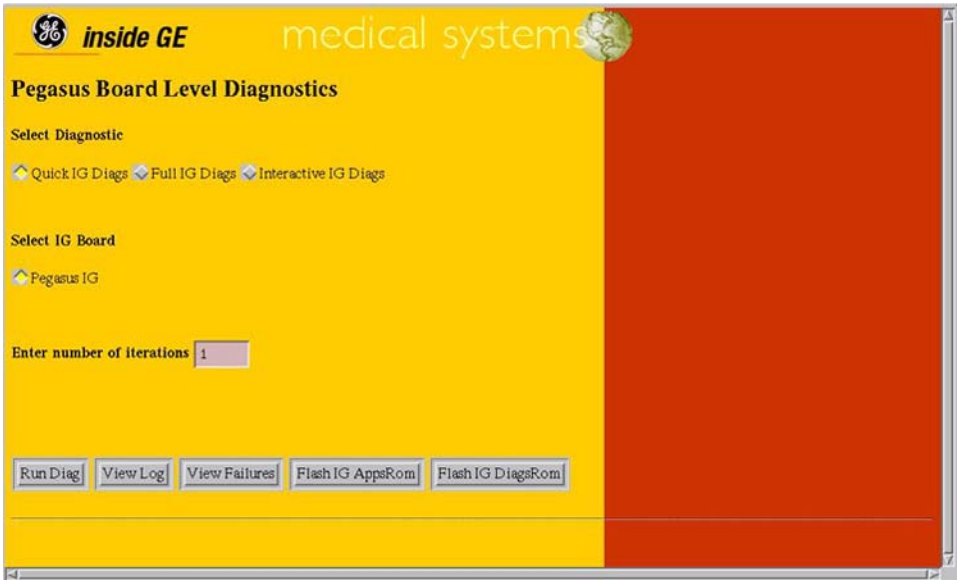


Figure 5-146 IG Board Level Diagnostic Screen

4.) Select either `Quick IG Diags` or `Full IG Diags` and `Enter number of iterations`.

5.) Select RUN DIAG. A shell window will open and the results of each test is displayed on-screen. See Figure 5-148 and Figure 5-149. When testing has completed, close the shell window before attempting to run any other tests.

6.) To exit testing, close all diagnostic windows. See Figure 5-151.

4.2.4.3 Tool Errors & Usage

TOOL ERRORS

On rare occasions, diagnostic tests may fail to execute or an error message will be displayed. Preform the following

1.) Close all open shell windows created by executing RUN DIAG. Diagnostics will not run with multiple windows opened by Run Diag.

2.) Shutdown console, restart and then re-run IG Diagnostics. On rare occasions, run diags cannot allocate the OS system resources necessary to execute diagnostics. When this occurs, you will see multiple `PTY` (pseudo TTY) errors reported.

None of the items identified above are related to the operation of the PEG-IG board. They're only related to the operation of the diagnostic tool itself.

TOOL USAGE

RUN DIAG is used to initiate the diagnostics chosen. Select RUN DIAG to begin test execution according to the parameters selected. First, select the diagnostic. Next, select the IG Board to be tested, Finally, enter the number of test iterations (1 is the default) desired.

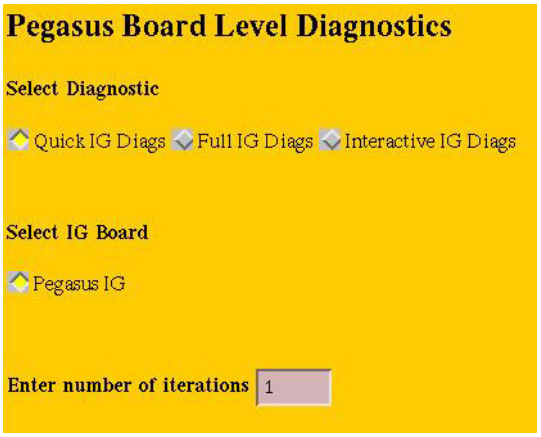


Figure 5-147 Board Level Diagnostic Parameters

A new window is displayed (spawned) with output from the test selected displayed.

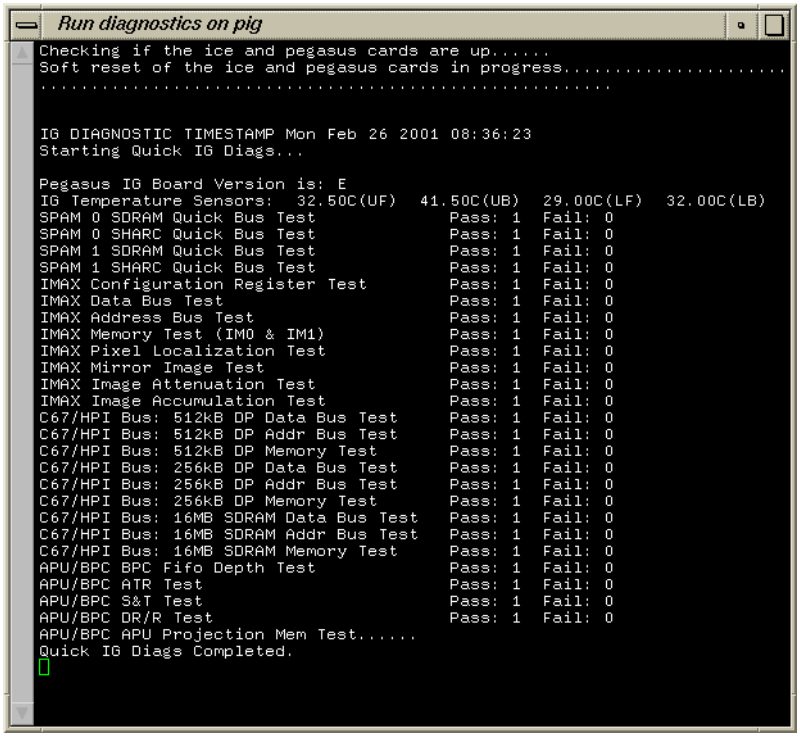


Figure 5-148 Quick Diags Screen

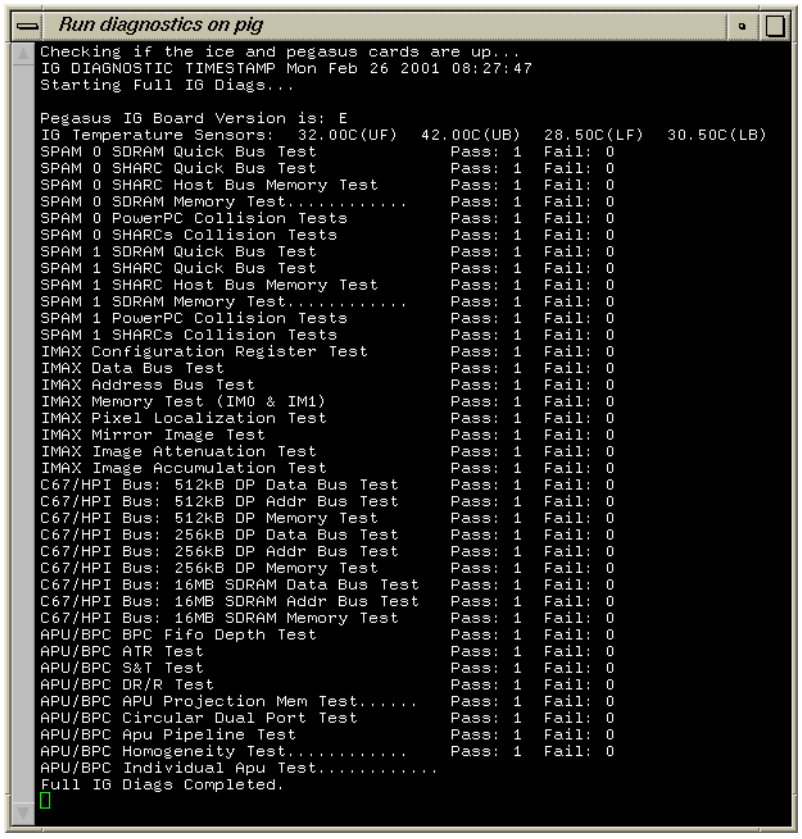


Figure 5-149 Full Diags Screen

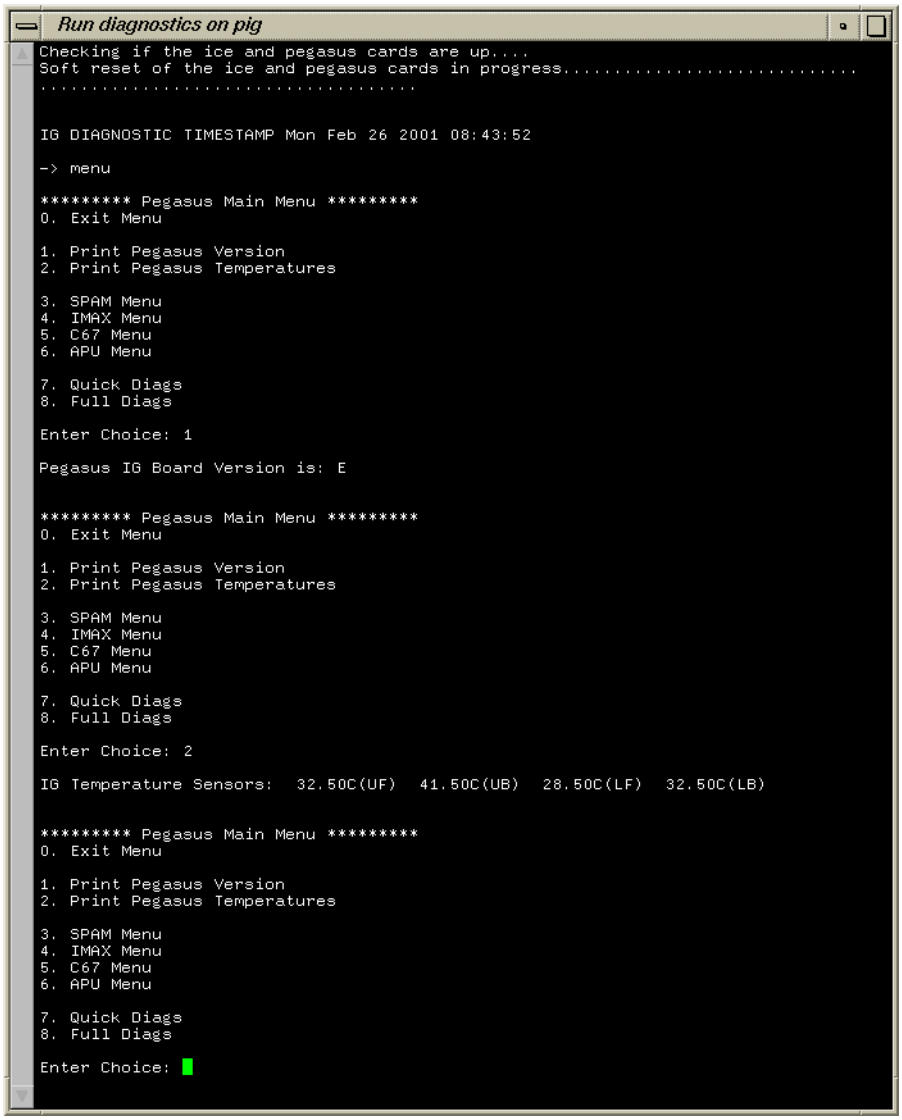


Figure 5-150 Interactive Diags Screen

Always close the test window after testing has completed. Double-click the square box in the upper left corner of the window with the minus sign.

Figure 5-151 Close Window ICON

VIEW LOG displays the entire contents of the `pig.log`. Located in `/usr/g/service/log` directory. The PIG.LOG cannot be viewed using the system browser tool located in the service desktop.

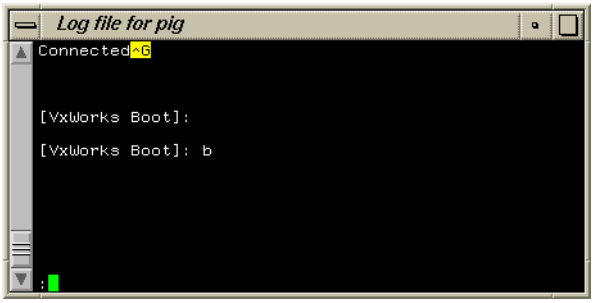


Figure 5-152 View Log Screen

VIEW FAILURES displays all the IG failures recorded in the `pig.log`. Located in `/usr/g/service/log` directory.

Figure 5-153 View Failures Screen

FLASH IG APPSROM & FLASH IG DIAGSROM is only use when instructed. Designed for manufacturing use only.

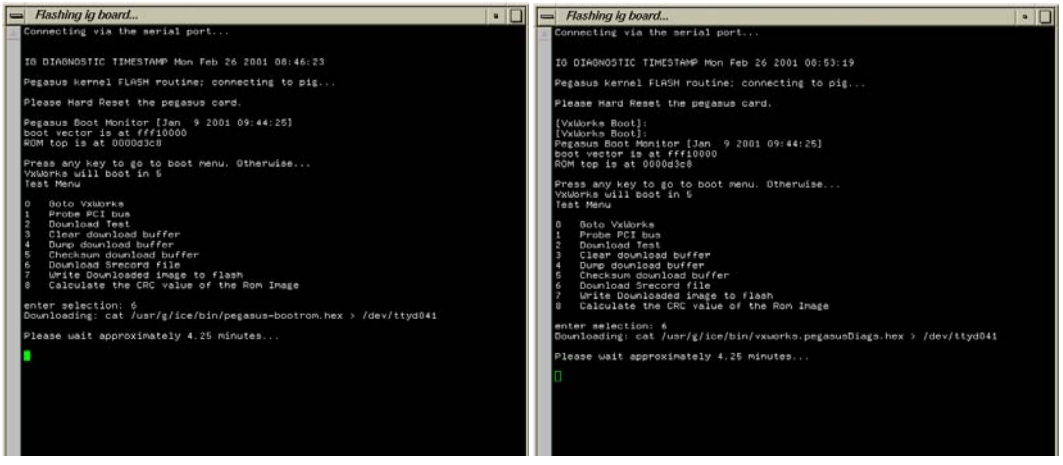


Figure 5-154 Flash IG AppsRom & DiagsRom Screen

4.2.4.4 Recon Data Path Test

CT Scanner applications must be up and running. If not, click on APPLICATION STARTUP, in the upper right corner of the screen. It takes about 3 minutes for applications to start. Applications are up when the a dialog window says that you need to run *fastcal*. Click OK.

1.) Go to the Service Desktop and select the `Diagnostics` TAB (See Figure 5-145).

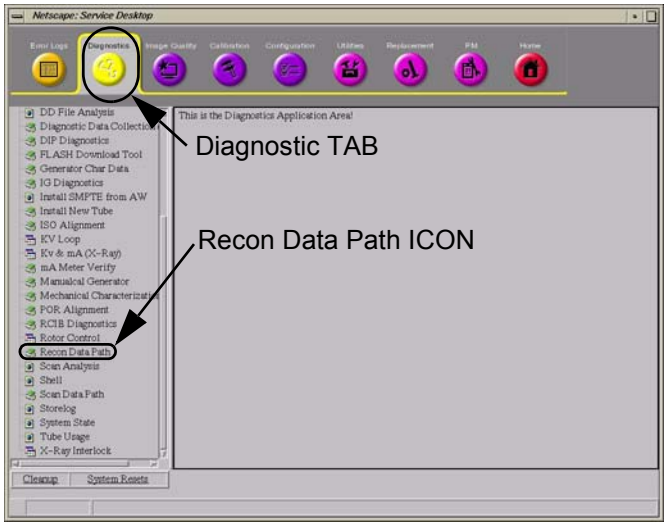


Figure 5-155 Diagnostic TAB Screen

2.) In the menu column on the left side of the Service Desktop page, click RECON DATA PATH icon (toward the bottom of the list). This brings up the Auto Recon page (10-15 sec. to appear).

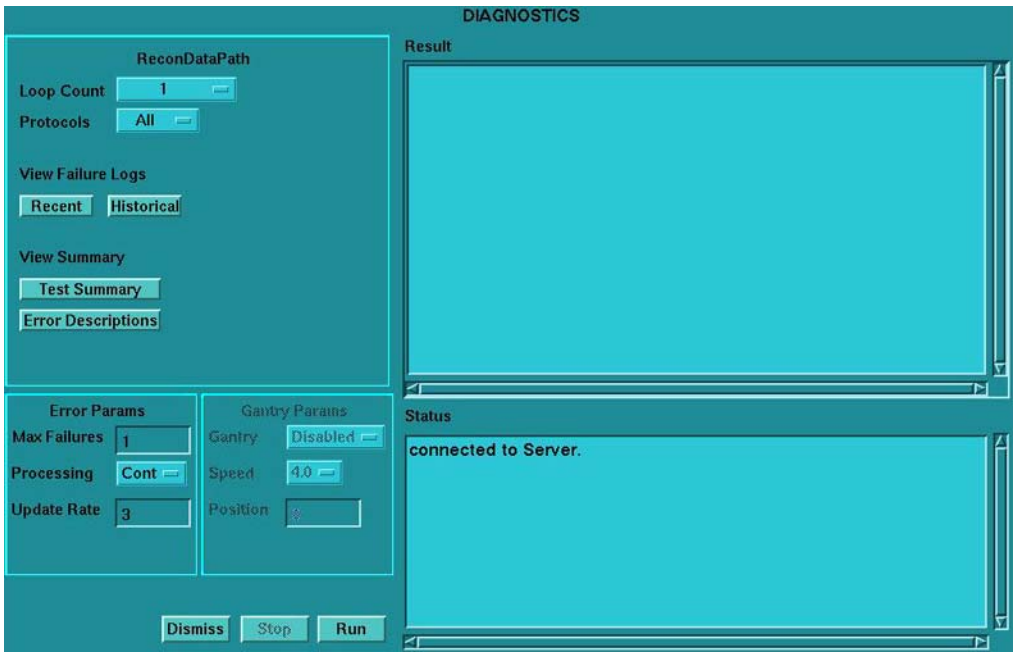


Figure 5-156 Recon Data Path Diagnostic Screen

3.) When the `Recon Data Path` page comes up, select a `loop count` of: 5, select ALL tests, then click RUN. This runs five loops of all tests; each loop generates 20 images, for a total of 100 images. This test checks the image output by comparing checksums of each image. *(takes about 4 minutes to run)*.

4.) When complete, click DISMISS.

4.2.5 SDC (Scan Data Corrections) Diagnostics

There is a tty vendor diagnostic available to test the SDC portion of the PEG-IG board called **rundmc**. The executable is located on the SBC in `/usr/g/bin`. Invoking the diagnostic will reboot vxWorks to a diagnostics mode on the Motorola (RIP) Board. Exiting the diagnostic does not reboot vxWorks back to Applications.

Restarting Applications, '**st**' will reboot vxWorks to the applications recon state.

Note: Because vxWorks is rebooted upon execution of this diagnostic, Applications must be shutdown before running diagnostics on the SDC portion of the PEG-IG board.

Perform the following steps to execute the diagnostic:

1.) From the Service Desktop select UTILITIES.
2.) Select APPLICATION SHUTDOWN.
3.) Open a UNIX Shell and enter the following commands:
   > **cd /usr/g/bin**
   > **rundmc**
4.) Menu Option [2] displays the main menu. Execute tests in verbose mode. Select **ENTER**.
5.) Enter your desired loop count; the default is [1] then select **ENTER**.
6.) vxWorks re-booting messages appear on the screen and the board level tests will appear as they are run. The tests for a single pass complete within a few minutes.
7.) When tests are complete, results with number of passes and failures is displayed.
8.) **ENTER** returns you to the Main Menu.
9.) If desired, select **4** to view the log.
10.) If desired, select **5** to view the help menu.
11.) Select **6** to Exit.
12.) Return to the OC prompt and startup Applications by entering "**st**"**.** Applications startup will re-initialize vxWorks.

Chapter 6
Table

Section 1.0
Table Theory

The functions performed by the electronics within the table include:

- Control of Gantry tilt
- Table elevation
- Table cradle longitudinal drives

Please refer to Figure 6-1, below, and Figure 6-2, on page 423, during the discussion of table theory.

Patient positioning is done manually through the gantry mounted operator controls. The drives provide horizontal and vertical positioning of the patient. Longitudinal motion of the cradle provides horizontal positioning through the scan plane. During scanning modes, longitudinal position is controlled by the ETC computer and control board. Longitudinal motion can also be controlled with console pushbuttons used to advance the patient to the next scan position. An additional feature is Prescribed Remote Tilt functionality.

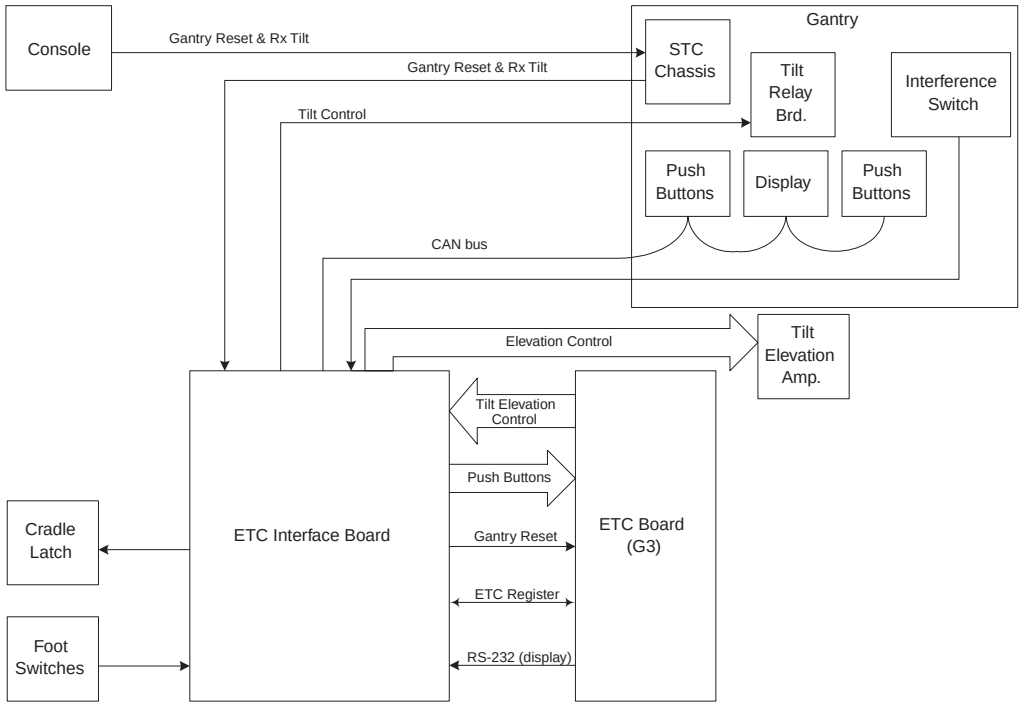


Figure 6-1 Table Block Diagram

1.1 Elevation/Tilt Operation

Control of this closed loop drive system is provided by the ETC computer, control and interface boards. Interlocks and enables are set by a table/gantry interference matrix and firmware. The drive amplifier is supplied with 170vdc and creates a three phase half wave rectified drive voltage that is pulse width mod-

ulated at a switching frequency of 17 khz. The resulting output is supplied through enable and motor select relays to the table elevation drive motor. The control circuit has no adjustments.

Elevation feedback is provided by a 6:1 geared encoder, which the ETC control board firmware converts to elevation information. The encoder turns one complete revolution over the entire table elevation range. Control signals are routed via the ETC-IF board and the signal enabling elevation is intercepted and another enable is created so that the interface board can also disable elevation if the interference sensor is in fault or interference is detected. Tilt control signals, forward and backward are decoded and routed to the tilt relay board via the ETC-IF. Tilt position feedback is provided by a 5-turn potentiometer.

WARNING **TABLE ELEVATION UTILIZE GAS SPRINGS TO ASSIST IN ELEVATION MOTION. GANTRY TILT USES HYDRAULIC CONTROL SYSTEM FOR GANTRY MOTION. ALWAYS FOLLOW THE DOCUMENTED REPLACEMENT PROCEDURES FOR COMPONENTS WITHIN THESE DRIVES SYSTEMS TO AVOID INJURY DURING THE REPLACEMENT OF THESE COMPONENTS.**

1.2 Cradle Operation

Control of this closed loop drive system is provided by a single chip motion controller, located on the ETC control board. The controller sets velocity, direction, acceleration, and position. The drive amplifier is supplied with 24vdc and creates a three-phase half-wave rectified drive voltage that is pulse width modulated at a switching frequency of 17 khz. The resulting output is supplied through an enable relay to the cradle drive motor. The motor turns a drive roller at the front of the table that the cradle rests on, thus causing the cradle to move.

Direction and speed feedback is supplied by an encoder and a 10-turn potentiometer driven by a cable and spool assembly attached to the cradle mounting hardware. The cradle encoder outputs approximately 10 pulses per mm of cradle movement and makes 8 full revolutions over the full cradle range. The potentiometer determines which of the 8 revolutions the encoder is in. A tachometer is used for additional stabilization of the control loop. There are no adjustments for this control loop.

1.2.1 Auto Move Correction

Once a patient landmark has been set, changing the table elevation by using the gantry mounted pushbuttons will result in the cradle moving in or out so that the position of the cradle in the gantry opening and patient landmark remain unchanged. This auto move correction does not occur if the elevation is changed with the foot switches or if a landmark has not been set.

1.2.2 Cradle Latch Control

Depressing the gantry mounted operator control cradle release switch will cause the cradle to float freely. This allows the operator to pull the cradle and patient back to the foot end latch position, in case of a patient emergency. Depressing the cradle release switch again will cause the drive to engage and enable the cradle to be driven away from the latched position.

1.3 Emergency Off Interface

The table provides an interface between the gantry mounted operator emergency off control and reset switches and the Power distribution unit. If an emergency off switch is depressed, table elevation, cradle longitudinal, gantry axial, HV primary supply, and gantry tilt drives are disabled and the reset light will begin flashing at a slow frequency. Depressing the reset switch will once again enable the drives.

1.4 LAN Communications

Firmware communicates position and other status information through this interface to the System Host Control.

1.5 Gantry Display

The Gantry Display Board is centered on top of the Gantry, directly above the table opening. It is controlled via a CAN network, located on the ETC-IF (Enhanced Table Controller Interface) circuit board.

1.6 Table Sync Generation

Table Sync Generation is used to inform the axial controller that the table has reached the start of scan position for scout scans.

1.7 CAN Network

The CAN network is the communications interface for the gantry display and control panels. The network will support four (4) control panels: two (2) each on front and rear gantry covers. The CAN network requires the gantry display and one (1) control panel for successful initialization. Upon power-up the ETC-IF tests communications to the gantry display and controllers. Faults are reported as node failures.

Additionally, a watchdog circuit will disable pushbuttons from going out of the ETC-IF board, if the microprocessor gets hung up. The watchdog will need to be reset every 150 ms. Reference Figure 6-2.

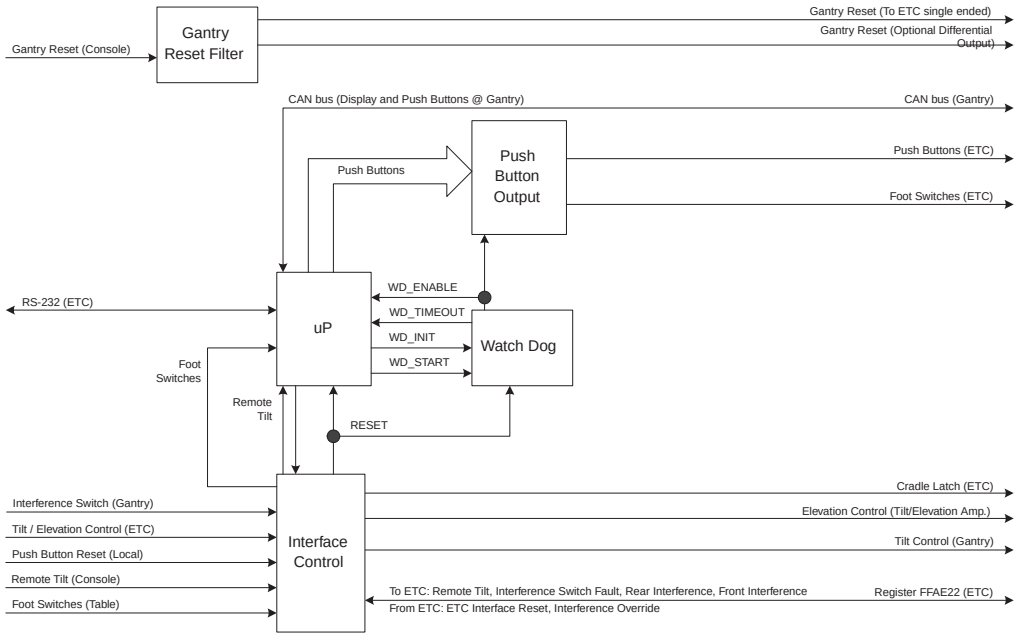


Figure 6-2 ETC-IF Functional Block Diagram

1.8 Switch Monitoring

1.8.1 Elevation and Cradle Limit Switches

Elevation switches are magnetic reed switches located at the top and bottom of the elevation linear actuator assembly. Cradle limit switches are mechanical switches located at either extreme end of cradle movement. Firmware ensures that these extreme positions are never achieved. The limit positions can be achieved during the characterization process or firmware/hardware failure.

1.8.2 Patient Interference Switches

Tape switches are located at positions where it is possible for patient extremity injury during positioning. If any of these switches are depressed, cradle longitudinal, table elevation, and gantry tilt drives are disabled and the gantry operator control panel reset light will flash at a fast frequency. Removing the table side covers will activate this circuitry as well. A jumper plug is provided under the side covers, to enable the drive circuits for service purposes. Depressing the gantry operator control reset switch will once again enable these drives.

1.8.3 Gantry Mounted Interference Touch Panels

Sensors are mounted on the front and rear of the gantry. When a sensor is not pressed, the impedance is 20 kOhms. When a sensor is pressed, the resistance becomes near Zero (0) Ohms. This signal will be decoded on the ETC-IF board, first to indicate that the maximum impedance of the sensor is 40 kOhms (fault condition). Second that the sensor is not a short circuit (interference condition). This is done for both front and rear sensors. If there is interference or a fault condition, both elevation and tilt will be disabled.

A green LED will indicate that the sensor is not shorted. A yellow LED will indicate that the sensor has more than 40 kOhms of resistance.

1.8.4 Gantry Mounted Operator Programmable Control Switches

The Gantry side pushbuttons are located on each side of the gantry. They give the operator manual control of the of drive operations for Patient Positioning and are monitored by the table ETC board via the ETC-IF CAN network.

1.8.5 Gantry Tilt / Table Elevation Interference Matrix Switches

Used as a safety back-up for a firmware controlled matrix that ensures that the table cradle and gantry never touch each other and any gantry angle, table elevation, or cradle position.

1.8.6 Remote Tilt Switches

These switches are located at the console SCIM keyboard. The function is Prescribed Remote Tilt, which means that these switches will only tilt the gantry to the prescribed RX position. This feature enhances the productivity of the technologist as they can more easily position the gantry between groups or series prescriptions. For patient safety, the Gantry Mounted Interference Touch Panels will disable gantry motion if any contact is sensed on the surface of these panels.

1.8.7 Elevation Foot Switches

The foot switches (up and down) come into the ETC-IF board at J8 directly from the foot pedals. The switches have inverse logic dual path input. When either enable for the foot switch is pressed, the enable (active low) line is sent to the microprocessor. When the up pedal is active, the up signal will be high into the processor. When the down pedal is active, the down signal will be high into the processor.

1.9 Gantry and Table Controls Functionality

1.9.1 Overview

The Gantry User Interface consists of a Gantry Display, Gantry Push buttons, and ETC-IF Controller (located on the ETC Interface Board). Each of these new components incorporates a Motorola 6808AZ60 microprocessor. Figure 6-3 illustrates the overall design of the Smart Controls.

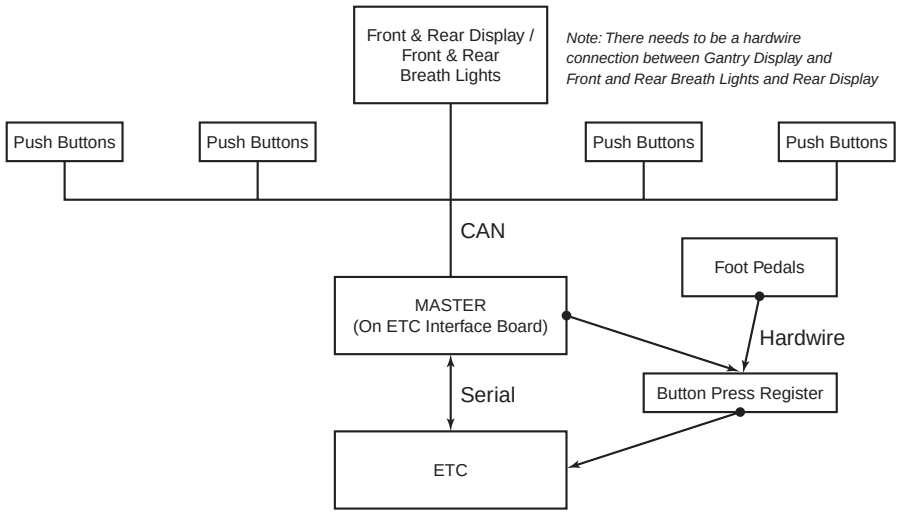


Figure 6-3 Gantry User Interface Design Block Diagram

1.9.2 Theory of Operation

DESIGN PHILOSOPHY

The Smart Controls system will be designed with the ETC-IF Controller being the interface between the ETC and the Gantry elements. The ETC-IF controller will be a slave to the ETC and the Gantry components will be slaves to the ETC-IF Controller.

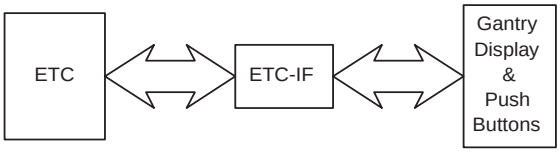


Figure 6-4 Smart Controls Design Block Diagram

Code Organization

The code on all three types of controllers will consist of boot code and application code (both residing in Flash Memory). The boot code will always be the first to be invoked on a reset. The boot code will check for valid application code through the calculation of a checksum, and if it is found, the application code will be started. If not, then the boot code will jump to the boot application loop. The boot application loop will have only one purpose and that is to download code to flash memory.

Common Application Functions

Several functions will be common between the three controllers. These functions are:

- Self Tests
- Processor Initialization

- Communication
- Downloading Code
- Firmware Revision and Board Revision Reporting
- Diagnostic LEDs
- Diagnostic Switches

Power-On Self Tests

At the time of power-up or reset, the micro-controller will perform two self tests:

- RAM Check: The micro-controller will search all RAM locations for any possible errors.
- Code Corruption Test: A checksum check will be performed on the application code to ensure code integrity.

1.9.3 General Design Information

The Gantry User Interface Network could include the following nodes, in the following quantities:

1.) ETC-IF (1)

2.) Push Buttons (5)

3.) Display (1)

1.9.3.1 Communications Protocol

Startup/Initialization

1.) Gantry Control

When any Node is reset or powered-up, it will begin sending the Gantry Control “I'm Alive” message to the ETC-IF on a periodic basis (every 500 ms). Once the ETC-IF receives that message, it will respond by broadcasting the Assign ID message to all Control nodes in which a specific board number, serial number and node Id will be embedded. Each Control node will check the message, and if it has its own board number and serial number, then it will assign that node id to itself. The node, once it receives the command, will acknowledge it with an ACK and stop sending the “I'm Alive” message. If more than one node has the same board number and serial number, the ETC-IF will log an error message, but will allow them to operate.

2.) Gantry Display

When the display is reset or powered-up, it will begin sending the Gantry Display “I'm Alive” message on a periodic basis (every 500 ms) to the ETC-IF. Once the ETC-IF receives that message, it will respond with the “Stop Alive Message” command that informs the Gantry Display node that its presence has been detected by the ETC-IF. The node, once it receives the command, will acknowledge it with an ACK and stop sending the “I'm Alive” message.

3.) Safety

The Gantry Pushbuttons and Display contain safety critical elements (start scan capability, X-ray On indicator) that require safety to be a major consideration in the CAN network design.

4.) CAN messages

CAN messages will be protected against corruption using several methods. First, a quadruple 8-bit filter algorithm will be used by the CPU to register only the messages that are being anticipated by that Node. Second, a sequence number will be embedded in all messages and will be checked by the ETC-IF (to make sure that new sequence numbers are sent) as it receives messages from the nodes to guard against CAN reflections. Finally, a checksum will be used in critical messages (such as button presses) to further validate their content.

5.) Display Indicators

The Display indicators will be validated by using an associated checksum on the packet to be sent to the Display Node. The Display Node will verify the checksum prior to setting the requested indicators and respond to the ETC-IF to acknowledge the receipt of the message.

6.) Reset Line

A Reset line will be available for the ETC-IF to set, if it deems that one or more of the nodes need to be reset to correct a problem.

7.) Display Messages

Display Messages will have to be acknowledged by the node that receives them, whether it is the Pushbutton Node or the Display Node. This is imperative to ensure that node has at least received the message correctly and verified it.

8.) Protocol Definition

The CAN protocol to be used is the CAN 2.0B(extended) protocol, which defines a packet as a 29 bit header and a 0-8 byte long message.

9.) Node IDs and Object IDs

Node IDs will be assigned to nodes either on startup from the ETC-IF, or by default in its code as follows:

- ETC-IF -> node ID 0
- Display -> node ID 1
- Controls -> node ID's 2-6

Object IDs are set as follows:

- ETC-IF ->0
- Control ->1
- Display -> 2

Note: If the Node Id or Device Id are not used in the message header, they are to be defaulted to 0xF.

1.9.3.2 Communication

The controllers will be initialized to operate using both the SCI port and the CAN port.

SCI

The SCI port will be initialized to operate at 9600 Baud Rate using an RS232 driver.

CAN

The CAN port will be initialized to operate at 250K Baud Rate. Each of the nodes will initialize its acceptance filters based on its device ID and node ID.

SPI

The SPI port is a synchronous serial communication port. This port will be used to communicate to an EEPROM resident on the board.

1.9.3.3 Firmware and Board Revision Reporting

Each microprocessor will be able to report its firmware number, firmware revision, board number, board revision, and board serial number. The firmware number and revision number will be embedded in the firmware code. The board number, revision and serial number will be read through the SPI port from an EEPROM located on the board.

1.9.3.4 Diagnostic LEDs

Each node will have four firmware controllable LEDs, operating differently during application code and boot code.

Application Code

- LED 0: Error Code -> This LED will blink an error code if an error exists. The tens digit will blink at 2Hz and then the ones digit will blink at 5Hz.
- LED 1: HeartBeat -> This LED will blink at 2Hz, as long as the firmware is running correctly.
- LED 2: Connected (for control and display) -> This LED will be on solid as long as the watchdog message between the ETC-IF and the node is not in violation.
- LED2: Button Pressed (for ETC-IF) -> This LED will be on solid whenever the ETC-IF is outputting a bitMask to the ETC with a button pressed.
- LED 3: StartProcessing -> This LED will be on solid from the point that the Begin Processing Packet is received until a reset occurs.

Boot Code

- LED 0: Invalid SREC -> This LED will be on solid from the point that an invalid packet has been received until a valid written packet has been received.
- LED 1: HeartBeat -> This LED will blink at 5Hz as long as boot is running and not downloading code. The LED will blink at 3Hz if the code is writing to FLASH.
- LED 2: Data Verification Failure -> This LED will be on solid from the point that a packet was not verified in FLASH correctly until a reset occurs.
- LED 3: Checksum Error-> This LED will be on solid from the point that an invalid checksum on an SREC packet has been detected until a reset occurs.

1.9.3.5 Diagnostic Switches

Each node will have four firmware readable diagnostic switches, operating as follows:

SWITCH NUMBER	DISPLAY FUNCTION	CONTROLS FUNCTION	ETC-IF FUNCTION
0	No function	No function	DO NOT USE
1	No function	No function	DO NOT USE
2	No function	Enable Button code display test	No function
3	Enable Display Test	Enable Display Test	No function

Table 6-1 ETC-I/F, Gantry Display, Gantry Control Panel Switches

1.9.4 Functional Description

The following described functions are related to some CAN or SCI port communication.

1.9.4.1 Code States

Application Code will have three states that it could be in: Init, Normal, Shutdown. All application code will start in Init mode, during which all startup initialization will occur. The transition to normal state occurs once the ETC-IF receives the Begin Processing Message and sends it on to the nodes. A node will enter the shutdown state once commanded to do so by the ETC-IF for being in a faulty state, such as too many resets in a short period of time.

1.9.4.2 ETC-IF

Overview

The ETC-IF will have the main function of controlling the Smart Control components and interfacing between the ETC and the components. The ETC-IF is configured to be able to connect to 5 button nodes and 1 display node at one time.

Note: Some system error messages refer to “TNC.” TNC stands for “Table Network Control” and refers to the ETC-IF.

Pushbutton Reporting

The ETC-IF will have the function of reporting the status of the pushbuttons to the ETC board. This will be accomplished by receiving a periodic message from the pushbutton nodes. The ETC-IF will have a wake up cycle (50 ms) triggered by the TIM module. When waking up, the ETC-IF will check for the Altera Time Out Bit, then will check the Button Status Database for any pressed buttons. The ETC-IF will further check the button pressed for possible illegal combinations. The ETC-IF will then check for the Foot Pedal inputs and the Remote Tilt input and again verify that no illegal combinations exist. Finally, the ETC-IF will output the final bitMask to the ETC. If any illegal combinations are detected, or more than one node has a pressed button, then the ETC-IF will set the bitMask to the default state. The following flow chart (Figure 6-5) further explains the process.

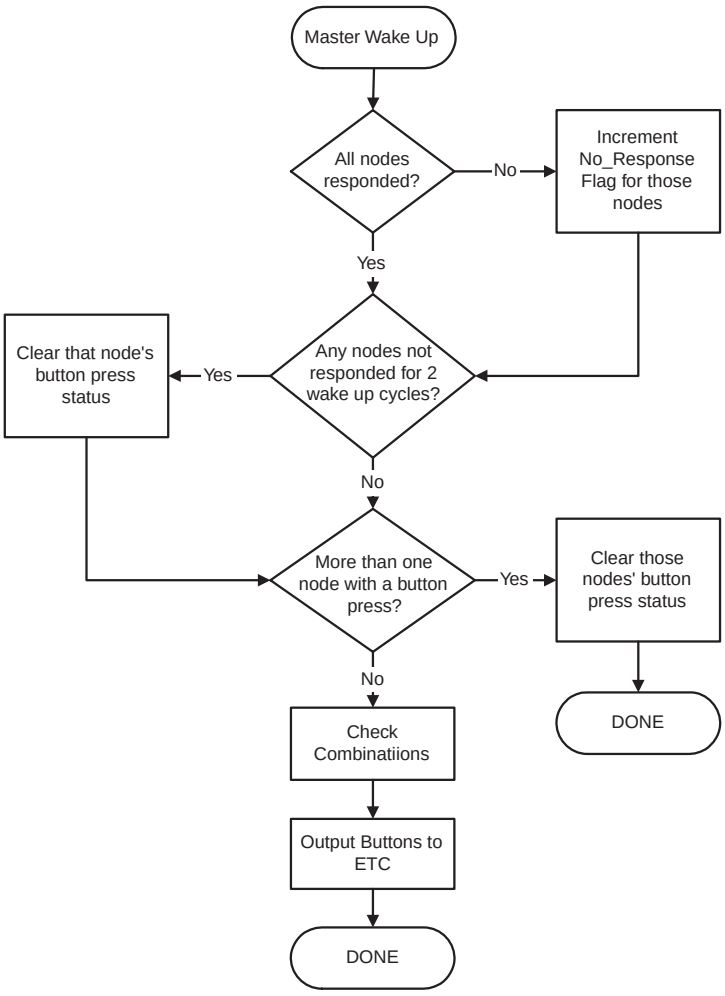


Figure 6-5 Pushbutton Reporting Flow Diagram

Node Watchdog

The ETC-IF watchdogs the nodes (display and pushbutton) at a 150 ms rate. The ETC-IF sends out a watchdog message and expects a reply from each node confirming its receipt of the message. If any node fails to respond 5 consecutive times, the ETC-IF considers it not alive, sets the appropriate fault bit to the ETC in the status query response, and updates its status in the node alive database.

Display Messages

The ETC-IF will also be responsible for commanding the display and pushbutton nodes to display information. The ETC-IF will be prompted to do so by the ETC via the serial line, at which point the ETC-IF will command the appropriate node (pushbutton or display) to display the required information. The ETC-IF will wait for either an acknowledge from that node or a time-out, and will then respond to the ETC with either an ACK or a NACK.

Revision Query

The ETC-IF will accept a revision query from the ETC. The revision query will be a sequenced event that will operate as follows:

1.) ETC sends revision query command.
2.) ETC-IF responds with its own revision information.
3.) ETC sends revision query command.
4.) ETC-IF queries the first alive node in its database for its information and responds to the ETC with the information.
5.) ETC loops on sending the revision query command and receiving the information.
6.) When done with all the nodes, the ETC-IF responds with a message code informing the ETC that all revision queries are done.

Status Query

A status query will be responded to with the following information:

1.) Status of the ETC-IF
2.) Number of alive nodes
3.) Number of connected nodes
4.) Fault Status of the Network

Node Database

The ETC-IF will keep a database of all nodes that were at one time connected. This database will contain the following information:

1.) Node ID
2.) Serial Number
3.) Board Number
4.) Alive Status
5.) Number of failing Watchdogs
6.) Number of Recent Resets
7.) Last Received CAN message Sequence Number

Expected Response Database

The ETC-IF will keep a database to track the message expected to be received by it and the required actions. This database is required due to the single-threaded nature of the code. This database will hold the following information:

1.) Message Code to be received
2.) Node ID to send the message
3.) Time Out Counter
4.) Ack to the ETC Required (Boolean)
5.) Number of Entries in the Database

Button Status Database

The ETC-IF will keep a database to track the status of all the button nodes. This database will keep the following information:

1.) Last Received Button Pressed Status
2.) Button Pressed (Boolean)
3.) Input Accepted (Boolean)

Error Status Database

The ETC-IF will keep a database of any errors that may occur. These errors will have to be queried and acknowledged by the ETC before they are removed. The ETC-IF will log the following errors:

1.) Message Time Out
2.) Too many nodes connected to the Network
3.) Possible Duplicate Node ID Scenario
4.) Node Fails the Watchdog
5.) Node Has Stuck Button
6.) Self Test failure
7.) Node Shutdown
8.) Altera Watchdog Timeout
9.) Pushbutton Time-out on Updating the ETC-IF
10.) 1Message Checksum Failure
11.) Invalid Command Received
12.) CAN errors
13.) Serial Errors
14.) EEPROM Read/Write Errors
15.) Spurious Interrupts
16.) Maximum Reset By one Node Surpassed
17.) Foot Pedals Stuck
18.) Invalid Reset Reasons
19.) Remote Tilt Input Stuck

1.9.5 Display

The Display will have the main function of updating its displays based on the commands received from the ETC-IF.

1.9.5.1 Display Specific Functions

Self Test

The Display node will run a display self test on any reset. It will set all its LEDs ON (including the Breath Lights and Rear Display). It will then cycle through flashing each of the elements for two seconds each. Once through this cycle twice, it will set all the LEDs on and stop the pattern. It will also stop when receiving the Begin Processing command from the ETC-IF.

Setting Displays

The Display node will incorporate the use of five 32-bit shift registers to set the displays. In order to change any of the displays, the microprocessor will translate the required data into bits and then shift it to the correct shift register. Once the data is sent to the shift register, the processor will enable the register, at which point it will move the data to the display segments. The shift registers will be designated as below:

Register 0: Indicators, Breath Lights, and X-display

Register 1: Tilt

Register 2: Elevation

Register 3: Cradle 3 MSD

Register 4: Cradle 4 LSD

The Display Node will wake up every 50 ms and update all of the display registers with the latest Bit Maps. The Display node will also control the blinking of any displays.

Display Faults

The Display will be determined to be in a fault state on one of three conditions: when it fails the watchdog, or reports a self-test error. If the display node is in a fault state due to a watchdog failure, the nodes will reconnect to the network, once it receives another watchdog message and responds to it. In the meantime, the node will display “ERR” as a visual indication of the problem. If the node experiences a self-test error, it will display “OFF” and shut itself down due to its unreliability.

1.9.5.2 Pushbuttons

The Pushbutton node will have the main task of reporting button presses to the ETC-IF, as well as setting its displays based on commands from the ETC-IF.

Setting Displays

The Pushbutton node will incorporate the use of a 32-bit shift register to set its displays. In order to change any of the displays, the microprocessor will translate the required data into bits and then store it into a global variable. Every 50 ms, the node will update the shift register with the latest information. The Button node will also control the blinking of any displays on its node.

Self Test

The Pushbutton node will check for any stuck buttons at the time of any reset. If a stuck button is detected, it will be deemed invalid by that node and will not reported to the ETC-IF as a pushed button until the next time the self-test is performed and the button passes.

Sending Button Status

The Pushbutton node will have a wake-up every 30ms to examine and send button press status. It will perform according to the flow chart shown in Figure 6-6.

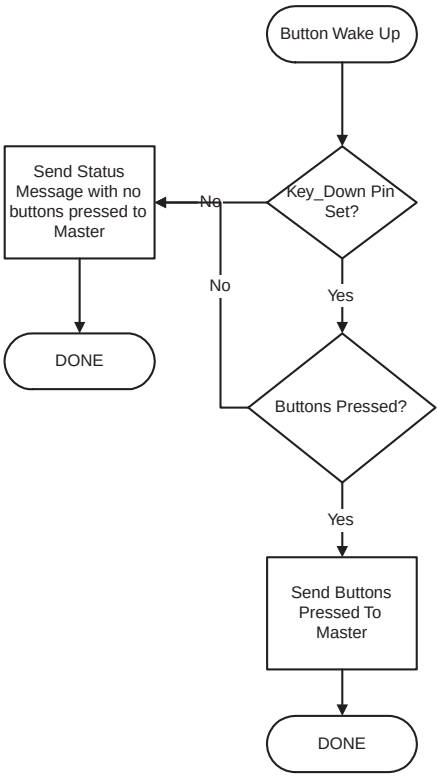


Figure 6-6 Button Status Flow Diagram

Pushbutton Faults

A Pushbutton node will be determined to be in a fault state in the following cases:

1.) Times out on a watchdog.
2.) Fails to report its button status for two consecutive TNC wake up cycles.
3.) Reports a self-test failure.
4.) Reset 5 times within one minute.

In case 1, the node will display “ERR” as a visual indication of the problem and try to reconnect. In case 2, the node's button status will not be accepted until it correctly responds to 5 consecutive cycles. In case 3, the node will display “OFF” and shut itself down. In case 4, the node will be commanded to be shut down by the TNC.

1.9.6 Gantry Display Indicator Lights and Numeric Displays

Figure 6-7 Gantry Display Panel

- **Interference** - Indicator - ETC CPU uses the interference matrix to determine this and controls the light accordingly.
- **Cradle Latch** - Indicator - Indicates the load home condition.
- **Alignment Light** - Indicator comes on when the alignment light button is pressed.
- **X-Ray "On" Indicator** - Indicates the KV at the x-ray tube is greater than 10 KV.
- **Cradle Unlatched** - Indicator - ETC turns this on when cradle unlatch was pressed or when emergency off button is activated.
- **Cardiac Gate Indicator** - Indicates the Cardiac Gating hardware is connected.
- **Respirator Indicator** - Indicates the Respirator hardware is connected.
- **Longitudinal** - Numerical Display - Continuously updated as table moves. Resolution is 0.5 mm relative to landmark. Display is blank if landmark is not established or cradle reference has been lost.
- **Elevation** - Numerical Display - Continuously updated as table moves. Resolution is 0.5mm, measured from ISO center. Display is blank until reference is found or lost.
- **Gantry Tilt** - Numerical Display - Continuously updated as gantry moves. Resolution is 0.5 degrees.

1.9.7 Gantry Mounted Control Panels

Figure 6-8 Gantry Mounted Control Panels

- Press to raise the table in slow speed.
- Press to lower the table in slow speed.
- Press to drive the cradle toward the gantry in slow speed.
- Press to drive the cradle away from the gantry in slow speed.
- Press and hold the center button at the same time to increase cradle and elevation speed by a factor of 2.
- Press to restore the gantry and table to the Home position. The gantry returns to the 0_ Tilt position, while the cradle drives all the way out of the gantry. After the gantry and cradle reach their home positions, the table lowers to the minimum height.
- Press to tilt the top of the gantry toward the table.
- Press to tilt the top of the gantry away from the table.

  Within ScanRx, a tilt to RX is required, one of the two tilt LEDs will flash indicating which button to press. Holding the button down will move the tilt to the prescribed angle, then the LED will turn off. If the tilt is moved off of the correct angle, then the correct LED will start flashing again.
- Press to turn ON the internal and external laser alignment lights.
  - Will cause gantry motion for correct rotational position as necessary.
  - Read the laser warning labels on the gantry.
  - Warn your patients to close their eyes before you turn on these potentially blinding lights.
- Press again to turn OFF the alignment lights.
- Press to designate the anatomy directly under the internal lights as the 0.0 mm scan location.The alignment lights intersect at the three dimensional isocenter. (Dim the scan room lights to improve alignment laser visibility.)
- Press to designate the anatomy directly under the external lights as the 240.0 mm scan location. After you prescribe the scan and initiate the scan sequence, the system prompts you to press the Advance to Scan button to move the cradle into position for the first scan.
- Press to latch or unlatch the cradle.
- Pressing the Reset Drives button when its LED is flashing will reset the drives. When the LED is solid, it will do nothing. If the LED is not on, then it is disconnected.
- Press and hold the Range Button will cycle through the allowable motion ranges on the gantry display.
- Pressing the Demo Button cycles through four steps of breath lights demonstration:
  - Flash Breath Light.
  - Hold Breath On w/ 30 sec. showing.

- 30 Second countdown on display.
- Breath Light on.

- Timer Display: The Timer displays the Prep Countdown, ISD Countdown and IGD Countdown. It also gives feedback for errors on the control panel by either flashing “ERR” (stuck button) or leaving “ERR” ON solid (loss of communications) or OFF (board is disconnected from Network and the ETC I/F board needs to be reset).

- Pressing the Stop Scan button at any time that a scan is prescribed will stop the scan. When its LED is on, X-rays are being emitted.

- Pressing the Start Scan button when its LED is flashing will start the prescribed scan sequence. If its LED is solid, the button functions as a resume button.

WARNING **USE OF THE START/STOP BUTTON ON THE GANTRY CONTROL CAN RESULT IN X-RAY EXPOSURE OF THE OPERATOR AS WELL AS THE PATIENT. KNOWLEDGE OF THIS FEATURE’S FUNCTIONALITY IS IMPERATIVE.**

1.9.7.1 Gantry Mounted Control Start/Stop Button Functionality

The Start and Stop exposure buttons function as follows:

1.) New Patient ScanRX Prescription is entered and accepted.
2.) Technician enters scan room and attends patient.
3.) Technician observes Delay time on Control Panel Timer Display and Start Scan LED flashing.
4.) Technician Presses Start Scan button.
Delay timer countdown begins.
5.) Technician press Stop Scan button for any reason.
a.) Timer Display goes blank.
b.) Start Scan LED becomes Solid ON (Resume Mode)
6.) Technician now presses Start Scan button.
a.) Start Scan LED begins flashing (Start Scan Mode)
b.) Timer Display is still blank.
IF THE START SCAN BUTTON IS PRESSED A SECOND TIME, XRAY EXPOSURE IS INITIATED.
7.) Technician should exit scan room and initiate exposure by pressing the flashing Start Scan on the console.

1.9.7.2 Table Elevation Foot Switch Functionality

When pressed continuously, the Table Elevation Foot Switch Pedal closest to the table will return the Cradle to the Home position, and then lower the table to minimum elevation.

When pressed continuously, the Elevation Foot Switch Pedal closest to the Gantry will elevate the table to approximately 180 on the Gantry Display, and then Advance the cradle to 100 mm.

These are values programmed related to table characterization. Future plans are to allow these values to be programmed explicitly within each Protocol.

Section 2.0
Procedures and Adjustments

2.1 Cradle Shimming

2.1.1 Tools

Straight Edge

2.1.2 Materials

Quantities are as needed to complete the task:

P/N	DESCRIPTION
46-196354P4 (or 2265863-2 for LCC)	0.015" (0.40mm) Shim
46-196354P1 (or 2265863 for LCC)	0.030" (0.80mm) Shim

Table 6-2 Cradle Shimming Materials

2.1.3 Overview

Cradle shimming is a function performed by manufacturing during the table assembly process. The purpose is to ensure that when the cradle is bolted to its carriage, the cradle bottom surface is in good contact with the pivoting pair of cradle drive rollers.

The two most common problems being resolved are that the free end of the cradle is:

1.) “Pointing” upward, so that the cradle does not get enough traction with the cradle drive rollers, or

2.) Being forced downward into the cradle drive rollers, which can cause the carriage to bind on the rails.

2.1.4 Procedure

1.) Refer to “Cradle Assembly,” on page 450 for cradle removal instructions. Remove the cradle and right, upper side cover.

2.) Release the carriage from the home latch, and slowly move the carriage all the way toward the cradle drive.

Note: Do not release the carriage. The encoder assembly will be damaged during the rapid unwind of the encoder cable spool.

3.) The carriage rides on two sets of rollers on the rails. The top set of rollers is engaged when the cradle is not cantilevered, that is, when most of the patient weight rests between the carriage and cradle drive. The bottom set of rollers is engaged when it is cantilevered, that is, when most of the patient weight is hanging beyond the cradle drive.

With the carriage close to the cradle drive, wedge the carriage upward so that it is resting against the bottom rollers on the bottom surface of the rails.

4.) Lay a straight edge across the two cradle drive rollers and the cradle-mounting surface of the carriage. By pivoting the cradle drive, you should be able to get the straight edge to touch both rollers and the carriage.

5.) Any gaps between the straight edge and the carriage are the points that need to be shimmed. Place shims as appropriate to fill these gaps. Locations for shims are, as needed, at each of the six cradle mounts on the carriage.

6.) Double stick tape (46-170106P1) may be used to aid in holding the shims in place to ease reassembly and later disassembly.

2.2 Elevation Characterization

1.) Remove upper right and lower right table covers.

2.) Locate the small L-shaped measurement block, stored on top of the bigger measurement block.

   a.) Remove the small L-shaped measurement block from its storage position.

   b.) Install it in its characterization position, at the right rear of the table.

   c.) Move the measurement plate, on the right side of table, to the **out** position.

   d.) Tighten the mounting screws for both plates.

3.) If you are not on the Service Desktop, click on the SERVICE DESKTOP icon.

4.) Click on the CALIBRATION icon.

5.) Select MECHANICAL CHARACTERIZATION**.**

6.) Select TABLE ELEVATION**.**

7.) Follow the Elevation Characterization instructions displayed on the screen. *Important - Take care to measure the exact elevation distances. Incorrect measurement results in Elevation Characterization failure*.

   Refer to Figure 6-9. Measure the elevation distance as vertically as possible. Measure between the bottom surface of the each measurement block and the center of the rear leg upper pivot pin.

8.) Return the measurement plates to the storage position.

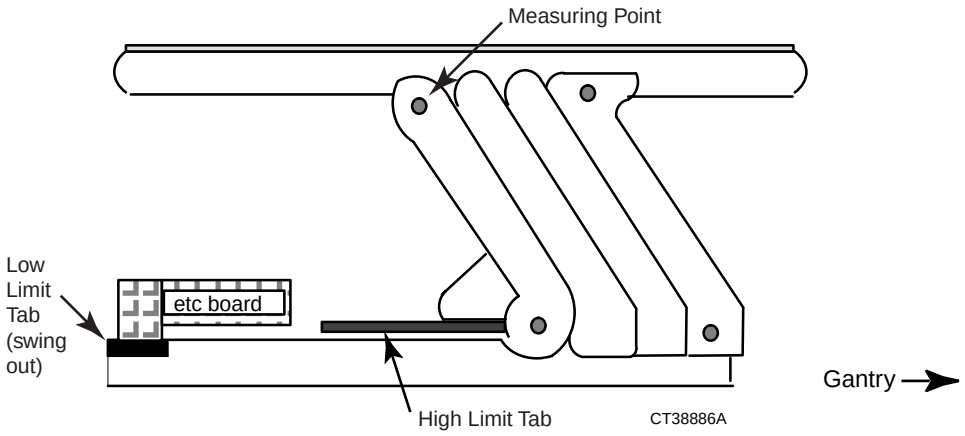


Figure 6-9 Measure Elevation Distance

2.3 ETC Board

Refer to Figure 6-10, below, for sections 2.3.1 through 2.3.3.

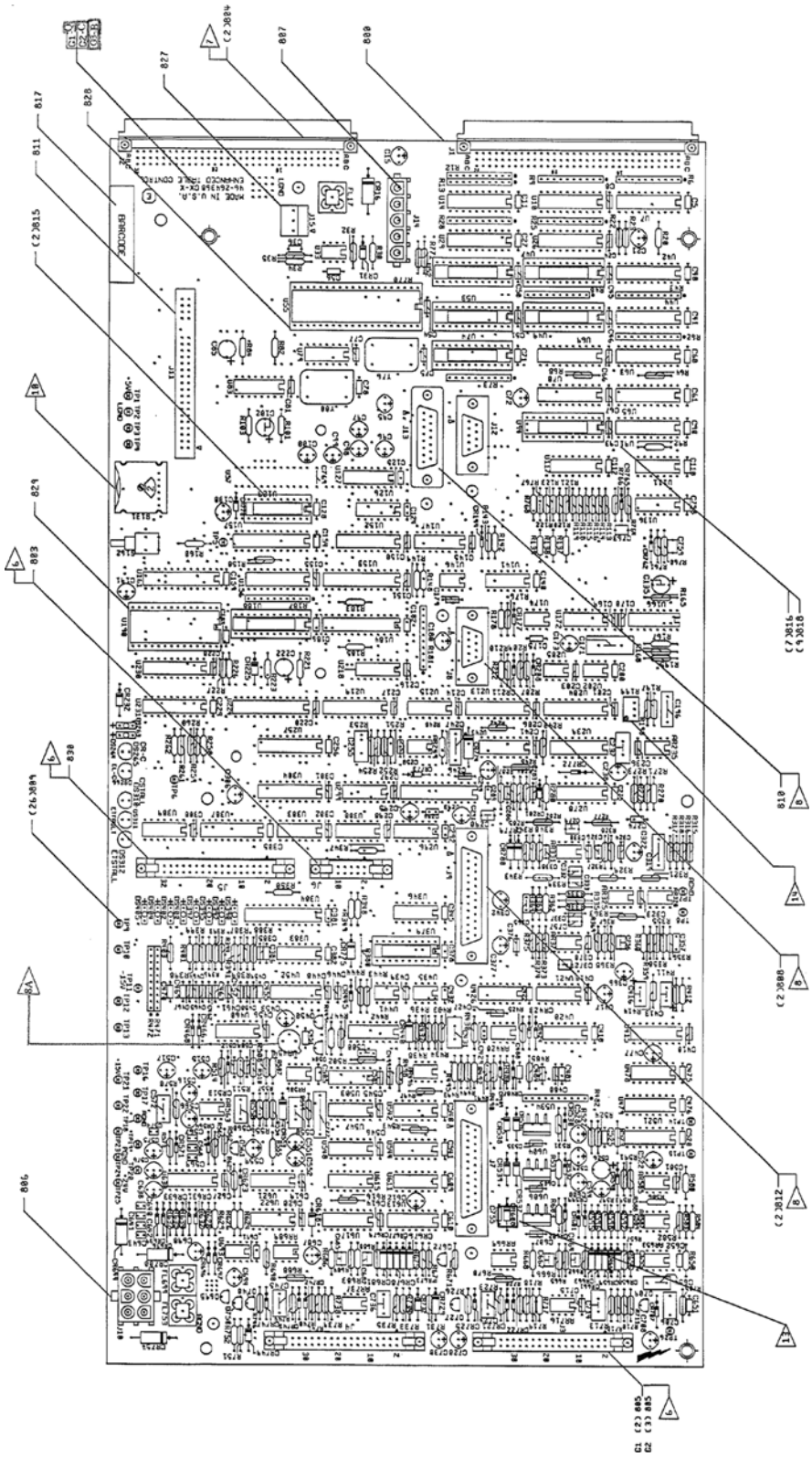


Figure 6-10 ETC Board Layout

2.3.1 ETC Board Test Points

TP1 +5V: (Digital +5 volts) Power Supply Test Point

TP2 LGND: (Digital LGND) Power Supply Test Point

TP3: (Digital ±12 volts) RS232 Table XMIT

TP4: (Digital ±12 volts) RS232 Table REC

TP5: (Digital +5 volts) Spare

TP6: (Digital 0 – 5 volts) Long Encoder CH C

TP7 AGND: (Analog) AGND Power Supply Test Point

TP8: (Analog ±15 volts) Cradle Tach (relatively noisy signal) Gain = 75 mm/sec = 6.3 volts at TP

TP9: (Digital 0 – 5 volts) Long Encoder CH B

TP10: (Digital 0 – 5 volts) Long Encoder CH A

TP11 –15v: (Analog –15 volts) Power Supply Test PointTP12: (Analog 0 – 10 volts) Elev/Tilt Pulse Width Modulation (PWM) Control, (controls AR689 pulse width) Gain =5 uSec pulse Width/volt command

TP13: (Analog +10 volts) +10 Reference

TP14: (Analog 0 – 15 volts) Cradle Current Integrator (averages out pulses from AR653) Wider pulses = more amp current = higher signal

TP15 –15V: (Analog 0 – 15 volts) Elev/Tilt Current Integrator (averages out pulses from AR563) Wider pulses = more amp current = higher signal.

TP16: (Analog 0 – 10 volts) Cradle Pulse Width Modulation (PWM) Control (controls AR669 pulse width) Gain = 5 uSec pulse Width/volt command Analog Signal

TP17: (Digital 0 – 15 volts) Cradle Pulse Width Modulation (PWM) sets output (v) of power amp. Volts out = Pulse width (uSec) * 24 / 56

TP18 AGND: (Analog Ground) Power Supply Test Point

TP19: (Analog ±15 volts) Elev/Tilt Motor Voltage Feedback (Filtered map pulse width modulation signal, fc = 39 cps, gain TP19/amp voltage =.05v/v)

TP20: (Digital 0 – 15 volts) Trigger SYNCH Signal PWM trigger for power amps (17.72 KHz)

TP21 +15V: (Analog +15 volts) Power Supply Test Point

TP22: (Digital 0 – 5 volts) Elev/Tilt Command Direction (+5V = Up/Forward)

TP23: (Digital 0 – 15 volts) Elev/Tilt PWM (sets output (v) of power amp. volts out = pw (uSec) * 160 /56)

TP24 PGND: (Analog Physical Ground) Power Supply Test Point

TP25 +24V: (Analog +24 volts) Power Supply Test Point

TP26: (Analog ±15 volts) Cradle motor voltage Feedback (filtered amp pwm signal), FC = 64 CPS Gain (TP26/amp voltage) = 0.41v/v

2.3.2 ETC Board LEDs

DS263 CR–A: Cradle Encoder A–pulse active

DS264 CR–B: Cradle Encoder B–pulse active

DS265 CR–C: Cradle Encoder C–pulse active

DS266 EL–C: Elevation Encoder C–pulse active

DS310 CSTALL: Cradle stalled when on

DS311 ETFAULT: Elevation/Tilt Amp fault elevation or tilt drive shorted when on

DS312 ETSTALL: Elevation/Tilt Amp stall or tilt drive stalled when on

2.3.3 ETC Board Switch Settings

S162: Reset

S131 Diagnostic: Set to **F**. Note this switch is checked during power up but is not used.

2.4 ETC CPU (Artesyn III) - GE Specific Settings

See Figure 6-11 for the following discussion of the ETC board. For the OBC CPU see Section 3.19, on page 773, and for the STC CPU, see Section 2.15, on page 596.

2.4.1 ETC CPU (Artesyn) Board Layout

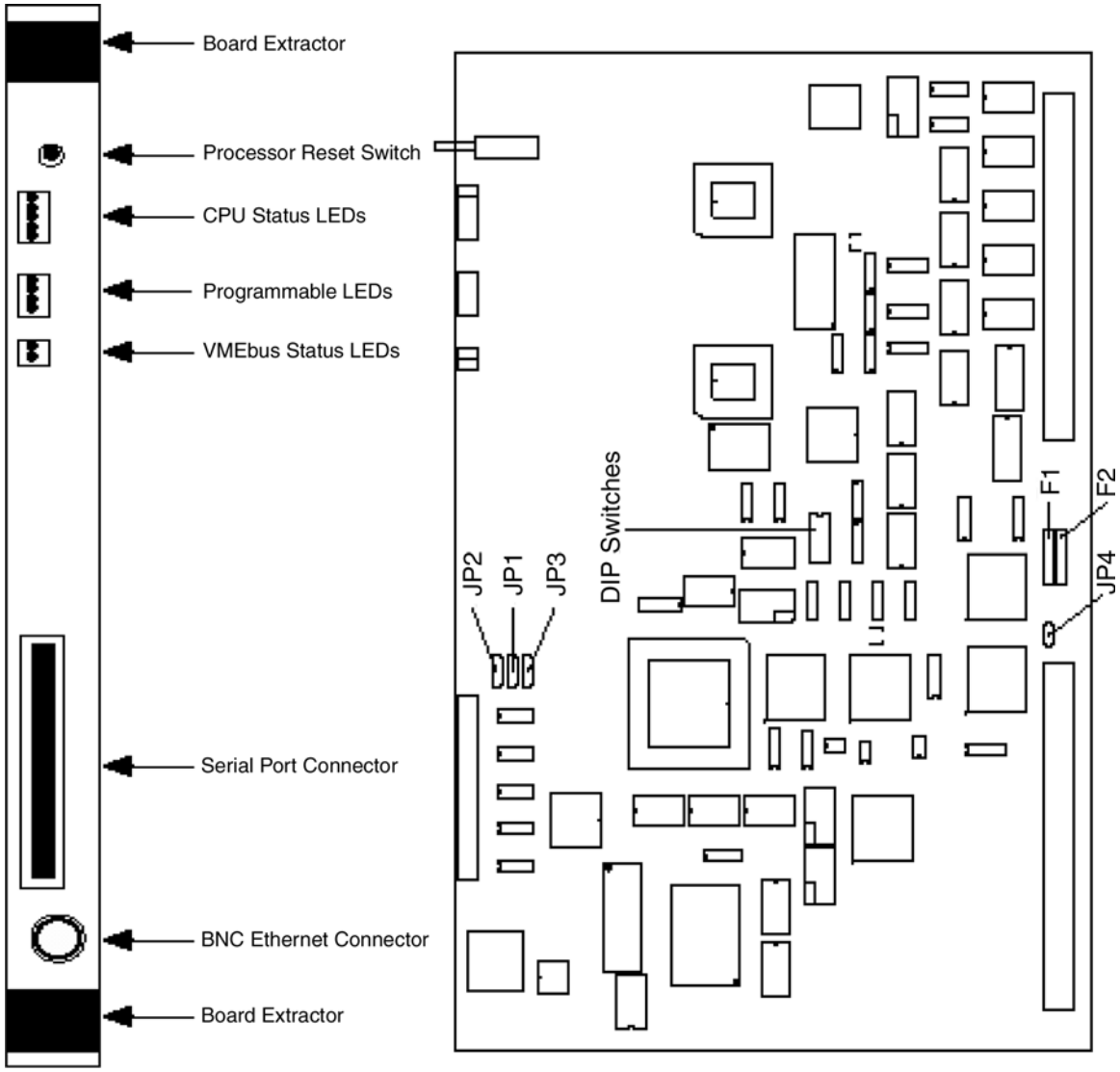


Figure 6-11 ETC CPU (Artesyn) Board Layout

2.4.2 CPU Board Jumpers

JUMPER	FUNCTION	GE CONFIGURATION	COMMENTS
JP1	Port A RI/DCD	J1:1-2	
JP2	Port B RI/DCD	J2:2-3	
JP3	RS-232 Handshaking	J3:1-2	
JP4	Watchdog Enable	removed	Watchdog Disable

Table 6-3 ETC CPU (Artesyn III) Board Jumper Settings

2.4.3 DIP Switch Settings

See board (Figure 6-11, on page 441).

SWITCH NUMBER	CONFIGURATION		FUNCTION	COMMENTS
1	OFF	OPEN	ETC node	Selects board for ETC Chassis
2	OFF	OPEN	ETC node	Selects board for ETC Chassis
3	OFF	OPEN	Primary Nodes	selects primary nodes
4	OFF	OPEN	n/a	Not applicable
5	ON	CLOSED	nbsClient view	View logs via nbsClient/LAN
6	OFF	OPEN	n/a	Not applicable
7	ON	CLOSED	Eprom Boot	Power-Up view EPROM Boot
8	OFF	OPEN	Test Disable	Self Test Mode disabled

Table 6-4 ETC CPU (Artesyn III) Board DIP Switch Settings

2.4.4 Power-Up Self Test

The CPU board will undergo a Power-Up Self Test, which lasts approximately 18 seconds. After the proper setting of the EPROMs, DIP switches and board jumpers, the CPU board will be placed into a VME chassis. A properly terminated Thin-net cable must be attached to the board's BNC connector. This cable is necessary for the Ethernet self tests to complete successfully. No other boards need to be present.

Upon power-up, the self test begins. The LED display is at the value 'E' and the test will perform the instruction Set and EPROM Checksum Test. When the test is done, the LED value will proceed to the next descending value, 'D', and will perform the RAM verification test. In the same manner, when this test is done, the LED value will proceed to 'C', then 'B', then 'A' and finally to '9'. After the test at '9', the self test is done.

When the test is completed, the LED values displayed will indicate if any tests have failed. If a failure is detected, the EPROMs, DIP-switch settings, Ethernet cable, and board jumpers should be rechecked to ensure proper setup. Then the self test should be rerun. The board must pass the test before shipment. See Figure 6-11, above, for location of the LEDs.

LED # 1234	LED HEX	LED ASSIGNMENT	DURATION
xxxo	E	Instruction Set and EPROM Checksum Test	1 second
xxox	D	RAM Verification	13 seconds
xxoo	C	CIO Unit Test	0.3 seconds
xoxx	B	Internal Loop Back	1 second
oxox	A	External Loop Back	1 second
oxxo	9	Transmit Test	1 second
x = on o = off			

Table 6-5 ETC CPU (Artesyn III) Board Power Up LEDS

2.4.5 Power-Up Self-Test Results

On Power-up, the ETC controller displays the results of its self tests. Power must remain off to a controller for at least 60SEC or Self-test may not be run or results may be inaccurate. This is because the dynamic RAM retains the CPON information. In this event, power-up tests are bypassed and the results of the last power-up test are displayed on LEDs.

1 2 3 4	HEX	LED ASSIGNMENT
• • • •	F	Not Available - - Do Not Use for a test
• • • o	E	Artesyn (see Table 6-7 for details)
• • o •	D	Artesyn (see Table 6-7 for details)
• • o o	C	Artesyn (see Table 6-7 for details)
• o • •	B	VME/LAN (see Table 6-8 for details)
• o • o	A	VME/LAN (see Table 6-8 for details)
• o o •	9	VME/LAN (see Table 6-8 for details)
o • o o	4	spare for GE future use
o o • •	3	spare for GE future use
o o • o	2	spare for GE future use
o o o •	1	spare for GE future use
o o o o	0	Not Available - - Do Not Use for a test

• = LED ON, o = LED OFF, 1 = LED MSB, 4 = LED LSB

Table 6-6 ETC Self-Test LED Outputs

2.4.5.1 ETC, STC & OBC (Artesyn) Tests

FUNCTION	LEDS	DESCRIPTION
Initialization	(F: • • • •)	Setup interrupt vectors & CIO
Failure	(E: • • • o)	CPU HALTS
Processor/PROM Checksum	(E: • • • o)	68000 Instruction set check (ram used) ROM Verified using CRC16 based polynomial
Failure	(E: • • • o)	CPU HALTS
Ram Verification -	(D: • • o •)	Each word of memory R/W 16 times
Failure	(E: • • • o)	CPU HALTS
CIO Verification	(C: • • o o)	Checks interrupts, timers, counters (no VME)
Failure	(E: • • • o)	CPU HALTS

• = “on” o = “off”

Table 6-7 Artesyn Board Related LED Readouts

At this point the type of node (ETC, STC or OBCR) determines the tests that are run.

2.4.5.2 ETC - VME/LAN Tests

FUNCTION	LEDS	DESCRIPTION
LAN controller tests	(B: • o • •)	Checks module present, controller & internal loops
Failure	(B: • o • •)	Flashes, possibly with other failures
LAN External loop-back	(A: • o • o)	Checks wire/ termination
Failure	(A: • o • o)	Flashes, possibly with other failures
TDR test	(9: • o o •)	Checks wire/ termination
Failure	(9: • o o •)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 6-8 ETC VME & LAN Related LED Readouts

2.5 ETC-IF Board

2.5.1 Power Supply Voltage Requirements

The ETC Interface board +5Vdc voltage margin will be:

Idle: 4.62Vdc - 5.50Vdc (7.6% -> +10.0%)

Active: 4.62Vdc - 5.50Vdc (7.6% -> +10.0%)

2.5.2 Diagnostic Jumpers

Four jumpers for diagnostics will be on board. They will be pulled up to VCC. When the jumper is installed, they will be shorted to ground.

Diag0 and Diag1 will be used to support remote tilt operation. No jumpers should be placed on the header for Diag0 and Diag1.

Diag2 and Diag3 are spare and will be used by firmware.

2.5.3 Reset and Power-Up Requirements

Power-up

All flip-flops will go to their default states and the cradle-latch relay will be in the latched state. Also sends reset through the CAN bus.

ETC initiated reset

This will reset everything except FFAE22 register and the cradle-latch state.

Pushbutton reset

The same as the power-up reset, except that the cradle-latch state is maintained.

Gantry reset

This reset does not reset the interface board. It is sent to the CPU card on the ETC board.

Applications requirement

Applications firmware must be updated once, using Flash Download procedures.

2.6 Gantry Display, Gantry Control Panel, ETC-I/F Switches

DIAGNOSTIC SWITCHES

Each node will have four firmware readable diagnostic switches, operating as follows:

SWITCH NUMBER	DISPLAY FUNCTION	CONTROLS FUNCTION	ETC-IF FUNCTION
0	No function	No function	DO NOT USE
1	No function	No function	DO NOT USE
2	No function	Enable Button code display test	No function
3	Enable Display Test	Enable Display Test	No function

Table 6-9 ETC-I/F, Gantry Display, Gantry Control Panel Switches

Section 3.0
Table Replacement Procedures

3.1 Gantry Display and Controls

Refer to "Display," on page 646.

3.2 AC/DC Power Switch Replacement

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the left base covers.
4.) Locate the Power Assembly:
    a.) Remove the screws from the outlet cover.
    b.) Move the cover aside, to gain access to the power switches.
    c.) Loosen the nut that fastens the defective power switch to the plate.
    d.) Remove the switch from the plate

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

5.) Loosen the screw terminals, and remove the wires from the defective switch.
6.) Transfer the wires to the same location on the replacement switch.
7.) Reassemble the Table, and replace the covers.
8.) Turn on the Table breaker in the PDU to restore power.

3.3 Actuator Cover

1.) Raise the table to maximum height.
2.) Remove the Base Covers, the right Table Side Covers and right Side Panels.
3.) Locate the Actuator cover:
    a.) Remove both of the clips that fasten the spring pin to the actuator cover.
    b.) Slide out the pin, to release the spring.
    c.) Remove the two screws that fasten the cover hinge to the U-bracket.
    d.) Remove the Actuator cover from the table.
4.) When you install the actuator cover:
    a.) Center the cover in the rear leg opening.
    b.) Tighten the hinge screws
    c.) Seat the spring in the notch on the spring pin.
5.) Reassemble the Table, and replace the covers.

3.4 Actuator Limit Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Base Covers.

4.) Remove the Actuator Cover, if you plan to replace or adjust the Upper Limit Switch. (Refer to Section 3.3, on page 446.)
5.) Remove the wires from the switch.
6.) To remove the Upper Limit Switch:
    a.) Loosen the screw that fastens the switch in place.
    b.) Slide the switch up, along the actuator until free.
    c.) Remove the wires from the terminals
7.) To remove the Lower Limit Switch:
    a.) Remove the screw and two washers from the switch.
    b.) The nut plate is trapped, but may slide down the actuator.
    c.) Remove the wires from the terminals
8.) To install either limit switch:
    a.) Slide the switch into place on the actuator.
    b.) Connect the wires to the W and C terminals.
    c.) Do not tighten the screw until you adjust the switch position.
9.) To adjust the Upper Limit Switch:
    a.) Locate the calibration plate, on the right side of the base frame.
    b.) Loosen the two Cal plate screws.
    c.) Move the plate to its horizontal position, and tighten the screws.
    d.) Restore power, and elevate the table until the distance between the bottom of the Cal plate, at the UPPER LIMIT SWITCH position, and the center mark on the upper rear leg pivot pin equals 33.62 ±0.03 inches.
    e.) Remove power, and attach a continuity device to the W and C terminals.
    f.) Loosen the clamping screw on the upper limit switch.
    g.) Slide the switch upward until at least 1 of the magnet tubes appears below the switch.
    h.) Slowly slide the switch downward until the switch opens, then tighten the screw.
10.) To adjust the Lower Limit Switch:
    a.) Locate the calibration bar on the right rear corner of the base frame.
    b.) Remove the Cal bar from its storage position.
    c.) Reposition the bar in the storage hole, to make it parallel to the rear surface of the base frame, then tighten the screw.
    d.) Restore power, and elevate the table until the distance between the bottom outer edge of the Cal bar and the center mark on the upper rear leg pivot pin equals 14.53 ±0.03 inches.
    e.) Remove power, and attach a continuity device to the W and C terminals.
    f.) Loosen the clamping screw on the switch, and slide the switch downward as far as possible.
    g.) Slowly slide the switch upward, until the switch opens, then tighten the screw.
11.) Return the calibration plate and bar to their storage positions.
12.) Reassemble the Table, and replace the covers.
13.) Turn on the Table breaker in the PDU to restore power.

3.5 Actuator Magnet Rod

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Base Covers, the right Side Panels and the Actuator Cover.

Refer to "Actuator Cover," on page 446.

4.) Remove the two nuts that fasten the Magnet Rod to its plate at the upper end of the actuator.

5.) Slide the Magnet Rod out of the actuator.

6.) Replace the Magnet Rod, and adjust the Upper and Lower Actuator switches.

Note: Because magnet strengths vary, follow the procedure that starts on page 446, to adjust both Actuator Limit Switches.

7.) Reassemble the Table, and replace the covers.

8.) Turn on the Table breaker in the PDU to restore power.

3.6 Table Elevation Actuator

WARNING PREVENT INJURY TO YOURSELF OR OTHERS. IF THE GAS SPRINGS CANNOT SUPPORT THE WEIGHT OF THE TABLE, THE TABLE COULD FALL. PLACE A SUPPORT BAR BETWEEN THE Z-CHANNEL AND FLOOR, OR ENLIST THE AID OF A SECOND PERSON TO MONITOR THE TABLE.

1.) Raise the table to maximum height.

Note: Remove all objects from the cradle before proceeding.

2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

3.) Remove the Base Covers, the right Side Panels and the Actuator Cover.

4.) Remove the Actuator Cover U-bracket.

Follow the Actuator Cover removal procedure, on page 446.

5.) Disconnect the motor wires and ground strap.

6.) Cut the tie-wraps, and remove the clamp that fastens the limit switch wires to the Actuator.

7.) The gas springs keep the Actuator under tension, even when you raise the table to maximum height. To remove tension from the Actuator:

- Raise the table past its upper height limit with a power supply, or by manually turning the hex drive on the end of the motor.
- Raise the table to fully extend the gas springs, while the lower gas spring remains at the back of the slot in the lower mounting block.

8.) Loosen and remove the lock nut from the upper Actuator mounting pin.

If you cannot easily remove the upper Actuator mounting pin, return to the previous step, and raise the table to remove the gas spring tension.

Note: Important: Loosen both actuator mounting pins before you remove either one.

9.) Pay attention to the positions of the two bumper washers and spacer when you remove them.

10.) Retract the Actuator with the power supply, or the hex drive, but do not let the Actuator fall when the rod end clears the upper mounting block.

Note: Do not over-shorten the Actuator.

11.) Remove, and keep, the E-ring from the lower mounting pin.

12.) Slide the pin out.

13.) Lift and remove the Actuator from the table.

14.) When you install the Actuator:

a.) Coat the lower pin with a thin layer of Molykote grease.

b.) Take care to install the E-ring correctly.

c.) Place one bumper washer on either side of the rod end of the Upper Mounting Pin.

- On the right side, the bumper washer fits over the shoulder on the hex-side of the pin.
- On the left side, the spacer fits inside the bumper washer, and spaces the rod end away from the mounting clevis.

d.) Torque the lock nut to 40 ft-lbs.

15.) Connect the motor wires to the corresponding terminals.

16.) Connect the wires to the corresponding W and C terminals of each switch.

17.) Tie-wrap the limit switch harness in place.

18.) Adjust the Upper and Lower Actuator Limit Switches.

The Actuator adjustment procedure begins on page 446.

19.) Reassemble the Actuator Cover.

Refer to Actuator Cover, Section 3.3, on page 446.

20.) Reassemble the Table, and replace the covers.

21.) If necessary, turn on the Table breaker in the PDU to restore power.

3.7 Cradle Drive Belt

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

3.) Remove the Cradle Drive Assembly, and set it on a work surface.

Cradle Drive Assembly procedure begins on page 451.

4.) Remove the belt from the pulleys:

a.) Loosen the four screws that fasten the motor in place.

b.) Slide the motor toward the drive roller, to remove tension from the belt.

c.) Remove the belt.

5.) After you install the new belt:

a.) Slide the motor away from the drive roller, until the belt deflects 0.050/0.060 inches with 4 to 6 ounces applied at its mid-span.

b.) Tighten the four screws, to fasten the motor, with tension on the belt.

6.) Replace the Cradle Drive Assembly.

7.) Reassemble the Table, and replace the covers.

8.) Turn on the Table breaker in the PDU to restore power.

3.8 Elevation Encoder Belt

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

3.) Remove the Base Covers and left Side Panels.

4.) Remove the elevation encoder belt from the sprockets:

a.) Loosen the two screws that fasten the Elevation Encoder Assembly to the base.

b.) Slide the encoder assembly toward the large sprocket, to remove tension from the encoder belt.

c.) Remove the belt.

5.) After you install the new belt:

a.) Align the splice on the belt with the mark on the large sprocket.

b.) Slide the Elevation Encoder Assembly away from the large sprocket, until the belt deflects 0.250 inches with 32 – 35 oz. applied at its mid-span.

c.) Tighten both screws, to fasten the encoder assembly in place, with tension on the belt.

6.) Loosen the coupler screw, and adjust the Encoder Table Elevation C-pulse.
- Encoder Table Elevation procedure begins on page 453.
- The C-Pulse adjustment procedure begins on page 453.

7.) Loosen and adjust the switch cam.
Table Interference Matrix Switch procedure begins on page 457.

8.) Reassemble the Table, and replace the covers.

9.) If necessary, turn on the Table breaker in the PDU to restore power.

3.9 50 Ohm BNC Feed-Through Connector

1.) Locate the Feed-Through connector near the SCA-LAN PWB, on the table ETC PWB.

2.) Rotate the knurled rings to remove, and install, the BNC Feed Through Connector.

3.) Use care to route the cables and BNC connectors out of harms way.

3.10 Cal Pin

There are two procedures: one with the Cal pin and one without.

1.) Use the Cal Pin to lock the cradle/carriage into position, at specific locations.
- Remove the right Table Side Covers, and Cradle Drive Cover, to access the Cal pin.
- Store the Cal pin in the bottom of the right z-channel, beneath the Cradle Drive Cover.

2.) The following procedures use the Cal pin:
- Home Switch: starts on page 456.
- Home Latch Assembly: starts on page 457.
- Longitudinal Encoder Assembly: starts on page 459.
- Longitudinal Limit Switch: starts on page 461.
- Longitudinal Encoder Pot Assembly: starts on page 461.

3.11 Cradle Assembly

1.) Raise the table to maximum height.

2.) Drive the Cradle/carriage to the latched, home position, before you try to remove the assembly.
An unlatched Cradle/carriage assembly could quickly move toward the gantry, and damage the longitudinal encoder assembly.

3.) Remove, and keep, the six plug buttons that cover the cradle bolt holes.

4.) Loosen and remove the six screws located beneath the plug buttons.

5.) Lift the Cradle upward, to remove the assembly from the table.

6.) To install the Cradle:

a.) Position the rear end of the Cradle over the carriage.

b.) Align the holes in the cradle to the threads in the carriage.

c.) Start, but do not tighten, all six screws.

d.) Look through the gantry bore at the end of table.

e.) Laterally position the Cradle on the drive rollers, until the same gap exists between the sloped sides of the Cradle and the guide rollers.

f.) Tighten the six screws to 13 ft-lbs.

g.) Replace the plug buttons.

7.) Make sure the cradle/carriage does not rest against the latch.

3.12 Cradle Drive Amplifier

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the four screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover and set aside.
6.) Locate the Cradle Drive Amplifier, toward the outside of the table:
    a.) Detach all of the wire connectors.
    b.) Remove the seven screws that fasten the Amp to its mounting bracket.
7.) Remove and replace the defective Cradle Drive Amplifier.
8.) Reassemble the Table, and replace the covers.
9.) Turn on the Table breaker in the PDU to restore power.

3.13 Cradle Drive Assembly

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the right Table Side Covers.
4.) Latch the carriage, and remove the Cradle Assembly.
    Cradle Assembly procedure begins on page 450.
5.) Loosen the two captive screws, and remove the Cradle Drive Cover.
    a.) Disconnect the ground strap from the Z-Channel.
    b.) Unplug the J21 wire connector from the left side.
    c.) Unplug the J18 wire connectors from the right side.

Note: An unlatched Cradle/carriage assembly could quickly move toward the gantry and damage the longitudinal encoder assembly.

6.) Move the carriage toward the gantry:
    a.) Hold the carriage in place with one hand.
    b.) Manually unlatch the carriage with the other hand.
    c.) Slowly move the carriage toward the gantry, until it meets the bumper stop.
7.) Remove the Cradle Drive Assembly:
    a.) Tilt the front roller of the Cradle Drive downward.
    b.) Lift the entire assembly up, then backward, and then down.
    c.) Gently remove the assembly from the bottom of the table.

Note: Take care not to disturb the Longitudinal Encoder cable.

8.) After you reassemble the Cradle Drive:
    a.) Center the Cradle between the guide rollers.
    b.) Torque the six screws to 13 ft-lbs.
    Cradle Assembly procedure begins on page 450.
9.) Reassemble the Table, and replace the covers.

10.) Turn on the Table breaker in the PDU to restore power.

3.14 Elevation Encoder Assembly

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Base Covers, and the left Side Panels.
4.) Locate the table harness at the rear of the ETC mounting panel:
    a.) Disconnect the J15 Encoder cable from the table harness.
    b.) Cut the tie-wraps, to free the cable.
5.) Remove the two screws that fasten the Elevation Encoder Assembly to the table base.
6.) Slide the Assembly toward the large sprocket, to relieve belt tension.
7.) Remove the belt from the encoder assembly.
8.) Remove the defective Encoder Assembly from the table.
9.) Install the replacement Elevation Encoder Assembly:
    a.) Replace the belt
    b.) Slide the Elevation Encoder Assembly away from the large sprocket, until the belt deflects 0.250" with 32 – 35 oz. applied at its mid-span.
    c.) Tighten both screws, to fasten the encoder assembly in place, with tension on the belt.
10.) Adjust the encoder C-Pulse position.
    - Encoder Table Elevation (C-pulse) procedure begins on page 453.
    - The C-Pulse adjustment procedure begins on page 453.
11.) Adjust the Table Interference Matrix Switch.
    Interference Matrix Switch procedure begins on page 457.
12.) Characterize the elevation axis. The Mechanical Characterization procedure begins on page 438.
13.) Reassemble the Table, and replace the covers.
14.) Turn on the Table breaker in the PDU to restore power.

3.15 Elevation/Tilt Amplifier

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the four screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover and set it aside.
6.) Locate the Elevation/Tilt Amplifier, toward the inside of the table.
    a.) Detach all of the wire connectors.
    b.) Remove the seven screws that fasten the Amp to its mounting bracket.
7.) Remove and replace the defective Elevation/Tilt Amplifier.
8.) Reassemble the Table, and replace the covers.
9.) Turn on the Table breaker in the PDU to restore power.

3.16 Table Elevation Encoder

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Base Covers and the left Side Panels.
4.) Locate the table harness at the rear of the ETC mounting panel:
    a.) Disconnect the J15 Encoder cable from the table harness.
    b.) Cut the tie-wraps, to free the cable.
5.) Locate the Elevation Encoder Assembly:
    a.) Loosen the screw on the encoder-side of the flexible coupling.
    b.) Loosen the two set screws that fasten the thumb wheel to the encoder shaft.
6.) Remove the encoder assembly:
    a.) Locate the three servo clamps that fasten the encoder to the mounting block.
    b.) Turn each servo clamp 1/2 turn ccw.
    c.) Pull the encoder away from the block.
    d.) Slide the thumb wheel and the spacer off the shaft.
    e.) Remove the encoder from the table.
7.) Install the replacement encoder assembly:
    a.) Place the spacer on the Encoder shaft.
    b.) Insert the shaft through the block and thumb wheel.
    c.) Firmly seat the encoder in the block.
    d.) Let the Encoder cable hang down (±45 degrees) while you tighten the three servo clamps.
    e.) Press the thumb-wheel against the spacer and the Encoder, while you tighten the two set screws in the thumb-wheel.
8.) C-Pulse Adjustment:
    a.) Locate the Calibration plate, on the right side of the base frame.
    b.) Loosen the two screws on the Cal plate, move the plate to its horizontal position, then tighten the screws.
    c.) Turn on the Table breaker in the PDU to restore power.
    d.) Restore table power, and elevate the table until the distance between the bottom of the Cal plate, at the C-pulse position, and the center mark on the upper rear leg pivot pin equals 27.52 ± 0.01 inches.
    e.) Turn the thumb-wheel to rotate the encoder shaft and light the C-Pulse LED on the ETC PWB.
    f.) Tighten the flexible coupler screw to clamp the Encoder shaft in the C-Pulse position.
    g.) Verify the C-Pulse LED remains lit.
    h.) Return the Cal plate to its storage position.
9.) Reassemble the Table, and replace the covers.

3.17 ETC Board

3.17.1 Required Tools

- Phillips #2 screwdriver
- Flatblade screwdriver
- 5/64” Hex Key
- ESD Wristband

3.17.2 Procedure Detail

NOTICE **Prevent permanent damage to the static-sensitive boards. Attach the anti-static wrist strap to your wrist and to a bare metal grounding point on the table before you continue.**

1.) Remove table base cover.
2.) Power off the table by flipping the three (3) switches opposite the ETC assembly.
3.) Use a flat-blade screwdriver to loosen the 2 screws that fasten the cover over the ETC Board.
4.) Use a flat-blade screwdriver to remove the screw on the floor of the table control area that allows the assembly to pivot.
5.) Pivot the assembly.
6.) Disconnect all connections to the Interface Board.
7.) Use a flat-blade screwdriver to remove 4 copper colored screws that secure Interface Board.
8.) Use a hex key to remove the three (3) screws that fix Interface Board above ETC Board.
9.) Lift off interface board.
10.) Disconnect all cables to ETC and Artesyn.
11.) Use a hex key to remove the eight (8) screws that hold the ETC Board.
12.) Use a hex key to remove the one (1) screw that holds the Artesyn Board.
13.) Remove the ETC and Artesyn Boards as one, and then separate the two boards.
14.) Connect the new ETC and Artesyn Boards.
15.) Install the new ETC and Artesyn Boards as one.
16.) Reassemble the table.

3.18 ETC-IF Board

3.18.1 Required Tools

- Phillips #2 screwdriver
- Flatblade screwdriver
- 5/64” Hex Key
- ESD Wristband

3.18.2 Procedure Details

NOTICE **Prevent permanent damage to the static-sensitive boards. Attach the anti-static wrist strap to your wrist and to a bare metal grounding point on the table before you continue.**

1.) Remove table base cover.
2.) Power off the table by flipping the 3 switches opposite the ETC assembly.
3.) Use a flat-blade screwdriver to loosen the 2 screws that fasten cover over the ETC Board.

4.) Use a flat-blade screwdriver to remove the screw on the floor of the table control area that allows the assembly to pivot.
5.) Pivot the assembly.
6.) DIsconnect all connections to the Interface Board.
7.) Use a flat-blade screwdriver to remove 4 copper colored screws that secure Interface Board.
8.) Use a hex key to remove 3 screws that fix Interface Board above ETC Board.
9.) Lift off interface board.
10.) Install the new board, replace screws and reconnect cabling.
11.) Pivot ETC assembly and secure in operational position.
12.) Restore power to table, and perform Flash Download, to load applications firmware.
13.) Verify hardware reset, gantry display and motion controls are fully functional.
14.) Install ETC assembly cover.
15.) Reassemble table

3.19 ETC Fan

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Base Covers.
4.) Unplug the Fan connector.
5.) Pay attention to the position of the Fan connector (lower left corner) and the direction of air flow (toward the CPU PWA).
6.) Remove three (3) screws that fasten the Fan to the power assembly bracket.
7.) Remove the two (2) screws that fasten the guard to the defective Fan.
8.) When you install the replacement Fan, position it with the connector in the lower left corner and the air flow indicator pointing toward the CPU PWA.
9.) Turn on the Table breaker in the PDU to restore power.
10.) Reassemble the Table, and replace the covers.

3.20 Servo Amp Fuse

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the four screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover, and set aside.
6.) Remove the plastic fuse cover, if present.
7.) Remove the defective fuse from its holder.
8.) Install the new fuse.
9.) Reassemble the Table, and replace the covers.
10.) Turn on the Table breaker in the PDU to restore power.

3.21 Gas Spring Replacement

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

Note: Important - Remove all objects from the cradle.

3.) Remove the Base Covers and the right Side Panels.
4.) The gas springs keep the Actuator under tension, even when you raise the table to maximum height. To remove tension from the Actuator:
   - Raise the table past its upper height limit with a power supply, or by manually turning the hex drive on the end of the motor.
   - Raise the table to fully extend the gas springs, while the lower gas spring remains at the back of the slot in the lower mounting block.
5.) Loosen and remove the lock nut from the upper Actuator mounting pin.

   If you cannot easily remove the upper Actuator mounting pin, return to the previous step, and raise the table to remove the gas spring tension.

Note: Important - Loosen both actuator mounting pins before you remove either one.

6.) Remove the E-Rings from the top and bottom Gas Spring mounting pins.
7.) Remove the pins from their mounting blocks.
8.) Remove both Gas Springs.

⚠WARNING DISPOSE OF GAS SPRINGS PROPERLY

DO NOT THROW DEFECTIVE GAS SPRINGS IN THE TRASH. COMPACTING A PRESSURIZED GAS SPRING MAY CAUSE IT TO EXPLODE. RETURN BOTH GAS SPRINGS TO:

GE HEALTHCARE RECYCLING CENTER, ACE WAREHOUSE
ATTN.: PAUL NEUMILLER
2200 E. COLLEGE AVE. BLDG. 11
CUDAHY, WI, 53110

9.) When you install the replacement Gas Springs:
   a.) Position the Gas Spring pressure chambers UP, or closest to the front table leg.
   b.) Take care to install the E-ring correctly.
10.) Reassemble the Table, and replace the covers.
11.) Turn on the Table breaker in the PDU to restore power.

3.22 Home Position Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the right Table Side Covers and Cradle Drive Cover, to access the Cal pin.
4.) Install and tighten the Cal pin to about one-half inch from the home position, to hold the carriage in place.

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

5.) Disconnect the wires from the Home Position switch terminals.
6.) Remove the nut that fastens the switch in place.
7.) Remove the defective switch from its bracket.

8.) Install the replacement switch.

Make sure you connect the wires to the COM and N.O. terminals.

9.) Adjust the position of the switch in the bracket:

a.) Loosen the two nuts that fasten the bracket in place.

b.) Move the bracket until the switch actuates when the carriage reaches 0.50 ±0.03 inches from the Home Position.

10.) Return the Cal pin to its storage position.

11.) Reassemble the Table, and replace the covers.

12.) Turn on the Table breaker in the PDU to restore power.

3.23 Home Latch Assembly

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

3.) Remove the right Table Side Covers and Cradle Drive Cover, to access the Cal pin.

4.) Install and tighten the Cal pin in the home position, to hold the carriage in place.

5.) Remove the Cradle Assembly and the right side Rail Cover.

Cradle Assembly procedure begins on page 450.

6.) Disconnect the harness at the terminal strip.

7.) Remove the four screws that fasten the Latch Assembly to the z-channel.

8.) Remove the defective Latch assembly.

9.) Install the replacement Latch Assembly, but do not tighten the four screws.

10.) Adjust the position of the entire Latch Assembly in its slots:

a.) Adjust the Latch assembly until the distance between the carriage latch block and the forward edge of the latch bar opening equals 0.050 ±0.005 inches.

b.) Maintain this distance while you tighten the four screws.

c.) Adjust the set screw in the latch clevis block, until the outer edge of the latch bar overlaps the outer edge of the carriage latch block by 0.050 ±0.00 inches.

d.) Maintain this distance while you tighten the jam nut.

11.) Make sure the solenoid plunger bottoms out:

a.) Adjust the position of the solenoid bracket, until the clearance between the outer edge of the latch bar and the outer edge of the carriage latch block equals 0.050 ±0.005 inches.

b.) Maintain this distance while you tighten the two screws.

12.) Adjust the position of the spring bracket, until the spring has 0.125 inches pre-load, when the latch bar rests against the set screw.

Maintain this distance while you tighten the two screws.

13.) Install the Cradle.

Cradle Assembly procedure begins on page 450.

14.) Return the Cal pin to its storage position.

15.) Reassemble the Table, and replace the covers.

16.) Turn on the Table breaker in the PDU to restore power.

3.24 Interference Matrix Switch

1.) Raise the table to maximum height.

2.) Remove the left Base Covers.

3.) Turn off the Table breaker in the PDU, to remove power from the entire table.
4.) Remove the Servo Amp Assembly.
5.) Remove the two screws that fasten the interference switches to the bracket.

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

6.) Detach the wires from the terminals of the defective switch.
7.) Remove the defective switch and install the replacement switch.
8.) Fasten the switches to the bracket, but do NOT tighten the screws.
9.) Adjust the switch-to-cam clearance:
    a.) Position the switches until the roller lever comes in contact with the switch housing.
    b.) Adjust the switch position until a 0.035/0.045 inch gap exists between the roller and the outside cam surface.
    c.) Maintain this distance while you tighten the two screws.
10.) Turn on the Table breaker in the PDU to restore power.
11.) Adjust the actuation point:
    a.) Locate the Cal plate, on the right side of the base frame.
    b.) Loosen the two Cal plate screws, move the plate to the horizontal position, then tighten the Cal plate screws.
    c.) Elevate the table until the distance between the bottom of the Cal plate (at the INT. MTX SWITCH S2 position) and the center mark on the upper rear leg pivot pin equals 26.03 ±0.03 inches.
12.) Adjust the cam:
    a.) Loosen the cam clamping screw.
    b.) Rotate the cam until switch S2 (closest to center of the table) rides on the outside surface of the cam.
    c.) Turn the cam CW (seen from the left side of the table) until S2 actuates.
    d.) Tighten the cam clamping screw, and verify the setting.
13.) Reassemble the Table, and replace the covers.

3.25 Intercom Speaker

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the right Side Panels.
4.) Remove the two nuts that fasten the speaker cover to the speaker.
5.) Remove the two nuts that fasten the Speaker and grill in place.
6.) Remove the defective speaker, and install the replacement speaker.
7.) Reassemble the Table, and replace the covers.
8.) Turn on the Table breaker in the PDU to restore power.

3.26 Tape Switch Jumper Plug

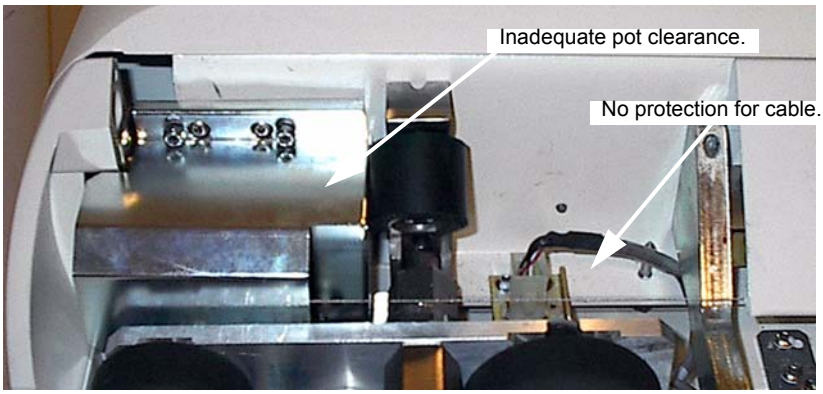
Use the Jumper Plug to simulate the presence of a Side Cover Tape Switch, when you remove the corresponding cover from the table.

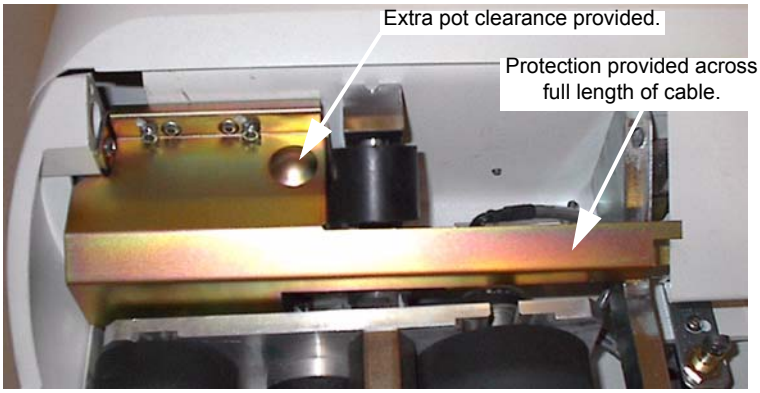
- Refer to the Table Side Covers procedures.
- The Table Side Cover descriptions begin on page 463.

3.27 Leg Tape Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the right Side Panels.
4.) Disconnect the Tape Switch from the harness.
5.) Remove the Tape Switch and the adhesive from the rear leg.
6.) Thoroughly clean the mounting surface with alcohol.
7.) Remove the protective strip from the adhesive, and press the switch firmly in place.
8.) Replace the Side Panels.
9.) Turn on the Table breaker in the PDU to restore power.
10.) Test the Tape Switch for proper operation.

3.28 Longitudinal Encoder Assembly





1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the right Table Side Covers and Cradle Drive Cover to access the Cal pin.
4.) Remove the Cradle Assembly and the right side Rail Cover.
Cradle Assembly procedure begins on page 450.
5.) Remove the two lock nuts that fasten the Longitudinal Encoder Assembly Cover in place.
6.) Remove the two screws that fasten the Front End Cover in place.
7.) Grasp the carriage with one hand, while you manually unlatch the carriage with the other hand.
8.) Slowly move the carriage assembly toward the gantry, until it rests against the bumper stop.

Note: If you let go of the Cradle/carriage assembly before it rests against the bumper stop, you could damage the longitudinal encoder assembly.

9.) Loosen the clamp that fastens the pot sprocket to the pot shaft.

10.) Detach the stranded steel cable from the carriage:

a.) Firmly hold the eyelet on the encoder cable.

b.) Remove the shoulder screw and spacer from the carriage.

Note: Maintain at least 2 pounds of tension on the cable. If you release tension, and allow the cable spool to unwind, you will damage the encoder assembly.

11.) Remove one turn of cable pre-load:

a.) Slowly pull the cable by the eyelet until it reaches the first hex spacer on the encoder assembly.

b.) Fasten the eyelet to the hex spacer with a ty-rap, to maintain the initial three turns of pre-load on the spool.

12.) Locate the right z-channel:

a.) Unplug the encoder J16 connector from the table harness.

b.) Unplug the pot connection at J17.

13.) Remove the two screws that fasten the Encoder Assembly to the table.

14.) Remove the defective Longitudinal Encoder Assembly.

15.) When you install the replacement Encoder Assembly:

a.) Make sure the cable maintains the initial three turns of pre-load on the spool.

Factory replacement assemblies arrive with the initial three turns of pre-load applied and the eyelet anchored to the hex spacer.

b.) Do not tighten the pot sprocket clamp at this time.

c.) Connect J16 and J17.

d.) Fasten the cable to the carriage with the shoulder screw and spacer.

e.) Slowly move the carriage to the home position, then install and tighten the Cal pin, to fasten the carriage in place.

16.) Turn on the Table breaker in the PDU to restore power.

Note: You will damage the pot if you turn it past the zero VDC position.

17.) Adjust the pot:

a.) Attach a DVM to terminals #2 and #1 (GND) of the pot.

b.) Turn the pot shaft with a small screwdriver, until the DVM displays 0.80 ±0.01 VDC.

c.) Maintain the voltage display, while you tighten the pot clamp.

d.) Do not remove the DVM at this time.

18.) Adjust the C-Pulse:

a.) Loosen the clamp that fastens the cable spool to the encoder shaft.

b.) Turn the encoder thumb-wheel to light the C-pulse LED on the ETC PWA.

c.) Tighten the clamp, and verify the C-pulse LED remains lit.

19.) Check for increase in pot voltage:

a.) Hold the carriage assembly in position with one hand, while you remove the Cal pin with the other hand.

b.) Continue to hold on to the carriage assembly, while you manually release the Home position latch.

c.) Watch the DVM display, while you slowly move the carriage toward the gantry.

d.) The pot voltage should increase as the carriage moves toward the gantry.

Note: You will damage the pot if you turn it past the zero VDC position.

20.) Characterize the longitudinal axis.

21.) Store the Cal pin, reassemble the Table, and replace the covers.

3.29 Longitudinal Limit Switch

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

3.) Remove the Cradle Drive Cover.

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

4.) Disconnect the wires from the limit switch terminals.

5.) Remove the nut that fastens the switch in place.

6.) Remove the defective switch from its bracket.

7.) Install the replacement switch.

Make sure you connect the wires to the COM and N.O. terminals.

8.) Adjust the position of the switch in the bracket with the two nuts, so that it actuates when the cradle/carriage is at its maximum travel position, as determined by the Cal pin.

9.) Return the Cal pin to its storage position. Refit the Side Cover and Cradle Drive Cover.

10.) Reassemble the Table, and replace the covers.

11.) Turn on the Table breaker in the PDU to restore power.

12.) Adjust the position of the switch in the bracket:

a.) Loosen the two nuts that fasten the bracket in place

b.) Move the Cradle/carriage assembly to the maximum travel position, and fasten into position with the Cal pin.

c.) Move the bracket until the switch actuates with the carriage in the maximum travel position.

13.) Return the Cal pin to its storage position.

14.) Reassemble the Table, and replace the covers.

15.) Turn on the Table breaker in the PDU to restore power.

3.30 Longitudinal Encoder Pot Assembly

1.) Raise the table to maximum height.

2.) Remove the Cradle Drive Cover.

3.) Install the Cal pin at the home position, then remove the Cradle Assembly.

Cradle Assembly procedure begins on page 450.

4.) Turn off the Table breaker in the PDU, to remove power from the entire table.

5.) Remove the two lock nuts that fasten the Longitudinal Encoder Assembly Cover in place.

6.) Remove the two screws that fasten the Front End Cover in place.

7.) Remove the pot assembly:

a.) Loosen the clamp that fastens the pot sprocket to the pot shaft.

b.) Disconnect the Pot Assembly from the table harness, at J17.

c.) Loosen the two servo clamps.

d.) Slide the defective Pot Assembly downward, and off the sprocket.

e.) Take care not to lose the plastic spacer on the pot shaft.

8.) After you install the replacement Pot Assembly:

a.) Make sure the sprocket comes in contact with the plastic spacer.
b.) Attach a DVM to terminals #2 and #1 (GND) of the pot.
c.) Turn the pot shaft with a small screwdriver, until the DVM displays 0.80 ±0.01 VDC.
d.) Maintain the voltage display, while you tighten the pot clamp.

9.) Return the Cal pin to its storage position.
10.) Reassemble the Table, and replace the covers.
11.) Turn on the Table breaker in the PDU to restore power.

3.31 Quad Output Power Supply

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.

Note: Pay attention to the location of the wires on the defective supply, before you remove them. Restore the wires to their original configuration on the replacement supply.

3.) Remove the Table Drive Power Supply:
a.) Locate the Quad Output PS (lower power supply).
b.) Disconnect the power input and out wires from the terminals.
c.) Locate and remove the 2 screws that fasten the Quad Output PS to the right side of the Power Assembly main bracket.
d.) Slide the defective power supply out of the assembly.
4.) Install the replacement Quad Output PS.
5.) Reassemble the Table, and replace the covers.
6.) Turn on the Table breaker in the PDU to restore power.

3.32 Elevation and Cradle Amplifier Relay

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the 4 screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover, and set aside.
6.) Slide the wire retainer to the side, and pull the defective relay from its socket.
7.) Install the replacement relay.
8.) Reassemble the Table, and replace the covers.
9.) Turn on the Table breaker in the PDU to restore power.

3.33 Right Base Cover

1.) Raise the table to maximum height.
2.) Turn each of four captive Dzus fasteners one-quarter turn CCW, to release the cover.
3.) Turn each of four captive Dzus fasteners one-quarter turn CW, to fasten the cover.

The screwdriver slot in the fastener appears horizontal when you successfully engage the fastener.

3.34 Table Side Cover (Left or Right)

1.) Raise the table to maximum height.
2.) Turn each of two Dzus fasteners one-quarter turn CCW, and remove, to release the cover.
3.) Tip the bottom of the cover outward slightly, then lift the cover upward to clear the four pins in the z-channel.
4.) If you plan to use any of the table drives:
    a.) Remove the Tape Switch Jumper Plug from its storage position.
    b.) Plug the Tape Switch Jumper into the harness connector.
5.) When you install the Side Cover:
    a.) Return the jumper plug to its storage position.
    b.) The screwdriver slot in the fastener aligns with the Side Cover when you successfully engage the fastener.
6.) Test the Side Cover Tape Switch operation.
7.) Reassemble the Table, and replace the covers.

3.35 Table Side Panels (Right or Left Rear, Right or Left Front)

1.) Raise the table to maximum height.
2.) Remove the Table Base Covers and Table Side Covers.

Note: Pay attention to the orientation of the ground strap terminal, before you remove it. Orient the terminal in the same direction when you replace it.

3.) Remove the ground strap connection from the z-channel.
4.) Each panel has two flat-head screws that fasten the Pivot Tube to its bracket.
    Remove, and keep, the flat-head screws.
5.) When you install the Side Panel, make sure the pivot points move without interference. If the pivot points cannot move freely:
    a.) Loosen the two screws that fasten the upper mounting bracket in place.
    b.) Slide the bracket in its slots, until the side panel pivot points move freely.
6.) Reassemble the Table and replace the covers.

3.36 Table Drive Power Supply

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Base Covers.
4.) Remove the power supply hold down bracket.
5.) Remove the screws attaching the outlet cover and move the cover aside to gain access to the power supplies.
6.) The Table Drive PS is the upper power supply. Disconnect the wires from both ends of the power supply.
7.) Remove the upper two attaching screws from the right side of the Power Assembly main bracket attaching the Table Drive PS, and slide the power supply out.
8.) To install the Table Drive PS, reverse above steps, making sure to connect the wires correctly.
9.) Refit the Base Covers.
10.) Reassemble the Table, and replace the covers.

11.) Turn on the Table breaker in the PDU to restore power.

3.37 Table Side Cover Tape Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the PDU, to remove power from the entire table.
3.) Remove the Table Side Covers.
4.) Remove the two shoulder screws that fasten the connector to the bracket in the Side Cover.
5.) Remove the terminals from the connector.
6.) Cut the tie-wraps that fasten the Tape Switch wire to the four brackets.
7.) Remove the Tape Switch.
8.) When you install the replacement Tape Switch:
    a.) Orient the shorter wires toward the connector bracket, when you route the wires through the holes in the cover.
    b.) Slide the tape switch into the channel.
    c.) Do not remove the protective strip from the adhesive.
    d.) Replace the side cover.
9.) Turn on the Table breaker in the PDU to restore power.
10.) Test the Tape Switch operation.

Section 4.0
Retest Matrix

REPLACEMENT VERIFICATION AND RETEST

TABLE COMPONENTS	TASK	VERIFICATION TEST
DC Power Supply (±15 volt, +24 volt)	Measure loaded voltages	Perform System Scanning Test, see page 660.
DC Drive Power Supply (+24 volt)	Measure loaded voltages	1.) Confirm full cradle travel and Gantry tilt capability. 2.) Perform System Scanning Test, see page 660.
Longitudinal (Cradle) Pot Assembly (page 461) Encoder cable	Replace, Install or Adjust (page 461)	1.) Remove the Pot (page 461) 2.) Install the Pot (page 461) 3.) Check Pot Voltage (pages 459 & 461) 4.) Perform System Scanning Test, see page 660.
Longitudinal (Cradle) Encoder	Replace, Install or Adjust (page 459)	1.) Remove the Encoder. (page 459) 2.) Install the Encoder. (page 459) 3.) Adjust C-Pulse. (page 459) 4.) Check Pot Voltage (pages 459 & 461) 5.) Perform System Scanning Test, see page 660.
Cradle Drive Amplifier	Replace faulty board, (see page 451)	Perform System Scanning Test, see page 660.
Cradle Assembly	Replace cradle (page 450)	Perform System Scanning Test, see page 660. Repeat with maximum weight
Cradle Drive Assembly	Replace Cradle Drive Assembly (page 451)	1.) Characterize cradle 2.) Perform System Scanning Test, see page 660.
Elevation Encoder or Timing Belt	1.) Replace Elevation Encoder (page 452) 2.) Set C-Pulse (page 453)	1.) Characterize Elevation 2.) Perform System Scanning Test, see page 660.
Actuator (Elevation) Limit Switch	Replace, Install or Adjust (page 446)	1.) Characterize Elevation 2.) Perform System Scanning Test, see page 660.
Table Elevation Actuator	Replace, Install (page 448)	1.) Characterize Elevation 2.) Perform System Scanning Test, see page 660.

Table 6-10 Table Component Replacement Verification

TABLE COMPONENTS	TASK	VERIFICATION TEST
ETC board	Replace, install faulty board (page 454)	1.) Check Characterization Limits (for tilt and table elevation interference) 2.) Perform System Scanning Test, see page 660.
ETC-IF board	Replace, install faulty board (page 454)	1.) Verify gantry controls initialize correctly. 2.) Exercise Elevation, Cradle and Tilt functions
DC Power Supply (+170 Volt)	Measure unloaded and loaded voltages (supply located on the base of table).	Exercise elevation function.
Interference Matrix Switch (Elevation Limit Switches)	Replace, install faulty switch (page 457)	1.) Check Characterization Limits (for tilt and table elevation interference) 2.) Perform System Scanning Test, see page 660.
Gas Springs	Replace, install both Springs (page 456)	1.) Clean excess oil from springs, and exercise table elevation full range with maximum load. 2.) Perform System Scanning Test, see page 660.
Home Latch Assembly	Replace, Install assembly (page 457)	1.) Verify Cradle latches and unlatches. 2.) Perform System Scanning Test, see page 660.
Table Side Cover Tape Switch	Replace, Install Assembly (page 464)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 660.
Leg Tape Switches	Replace, Install faulty switch (page 459)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 660.
Left or Right Top Cover	Replacement or removal during installation (page 463)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 660.
Left or Right Side Panel	Replacement or removal during installation (page 463)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 660.
ETC Artesyn Board	Replace, Install faulty board	1.) Verify ETC Node DIP switch 2.) Perform System Scanning Test, see page 660.

Table 6-10 Table Component Replacement Verification (Continued)

Section 5.0
Troubleshooting - Table Velocity Errors

5.1 Problem

Occasionally, CT Scanner owners have reported cradle velocity errors.This occurs while driving into the gantry, and with the cradle loaded down by a patient. There have also been reports of a potentiometer to encoder correlation error, but this error is more likely caused by a problem with the longitudinal encoder assembly, specifically the pot. or pot. drive belt and sprockets.

The most likely cause for the velocity error is an out-of-adjustment clutch on the cradle drive assembly. This clutch is adjusted to slip when a force of 36–39 pounds is exerted horizontally on the cradle while driving into the gantry. When the clutch slips, the velocity of the cradle will be far enough out of normal range to trigger an error, which stops the drive. Ideally, this would not occur within the normal operating range of less than 36 pounds. However, when the clutch is out of adjustment, it will slip at lower drive forces that are within the normal range of operation. A one–direction roller-clutch, inside the clutch assembly, prevents any slipping when driving out of the gantry.

Although traction problems between the drive roller and cradle could exist, they are unlikely due to the rough bottom surface of the cradle, and due to the weight of the patient maintaining the contact between the cradle and roller. Another unlikely cause would be roller smoothness; the harder cradle surface is intentionally molded with a rough surface, which slightly distorts the roller's softer rubber surface, creating the high coefficient of friction. Generally, traction problems only occur when there is no patient weight to keep the cradle in contact with the roller. In this case, the shimming between the cradle and the carriage should be reviewed.

5.2 Solution

During the manufacturing of the clutch friction discs, a burr on the inside diameter of the disc (which relaxes after a period of time) was created, causing the clutch to go out of adjustment after leaving the factory. One of two courses of action can be followed, depending on the amount of time available for repair, availability of new parts, and availability of a force gauge:

- The existing clutch can be adjusted. This is the quickest procedure, since it does not require the cradle drive to be removed from the table. However, this is a two-person procedure, and requires a force gauge. Also, since the burrs have not been removed, the adjustment may not be maintained for a long period of time.
- The clutch can be disassembled, the burrs removed, and the clutch then reassembled and adjusted. This is the most time consuming procedure, but does not require a new clutch. However, this is a two-person procedure, and requires a force gauge and cradle drive removal.

5.3 Tools Required

5.3.1 Clutch Adjustment

- Push force gauge, 0-50# or 0-100# (P/N 46-308109P2)
- 5/64” and 1/8” hex key wrenches
- 1 1/4” open-end wrench or channel-lock pliers with this capacity
- Loctite 242

5.3.2 Clutch Repair

- Push force gauge, 0-50# or 0-100#
- 5/64” and 1/8” hex key wrenches
- 1-1/4” open-end wrench or channel-lock pliers with this capacity.
- Loctite 242
- Sandpaper, 220 grit

5.4 Procedures

Figure 6-12 is provided as a reference drawing for the clutch assembly. Please review Figure 6-12 to familiarize yourself with the various parts of the clutch assembly before beginning any procedure.

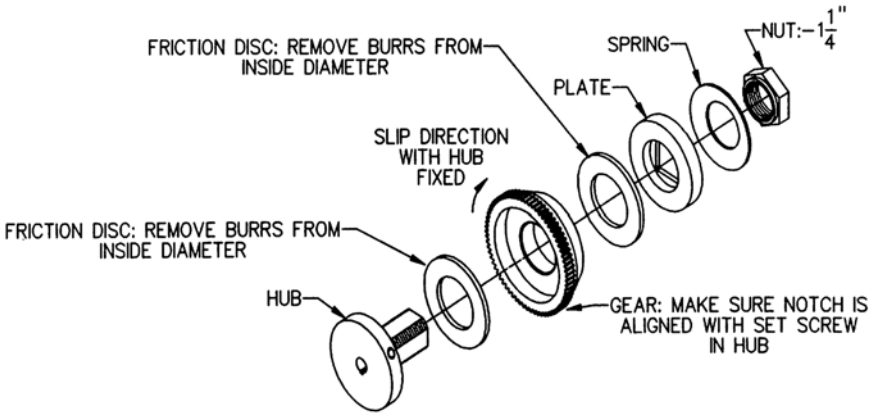


Figure 6-12 Table Clutch Assembly

5.4.1 Clutch Adjustment

1.) Place at least 100 lb on the cradle, toward the gantry end.

2.) Remove the cradle drive cover from the bottom of the table.

3.) Locate the clutch on the left end of the drive roller. Loosen the two set screws securing the 1¼” hex nut with the 5/64” hex wrench. If necessary, release and move the cradle to rotate the drive roller and clutch, to gain access to the set screws.

4.) Position the cradle about 3 feet from home. Tighten the hex nut a small amount (1/4 flat), and then measure the driving force into the gantry with the force gauge. Drive the cradle with the table-side controls at the fast speed, while the FE reaches through the gantry with the force gauge pushing on the end of the cradle. Push hard enough for the clutch to slip, and note the reading on the gauge. Insure that the drive roller is stationary (i.e., not slipping on the cradle bottom), and that the end of the clutch (i.e., hex nut) is rotating when the measurement is taken. If the roller is slipping on the cradle, then add more weight to the cradle.

5.) For proper adjustment, the gauge reading should be as close to 40 lb as possible, but must **not** exceed 40 lb. An ideal range is 36-39 lb. Repeat step 4 until the correct force is measured. Loctite and tighten the set screws and verify the reading again.

6.) A check must now be made to see if the cradle releasing solenoid and gear rack are properly adjusted. Removing the cradle will make this check easier to perform, and more accurate; follow the procedure in Section 3.11, on page 450, for removing the cradle.

When the solenoid is energized, the gear rack is engaged in the clutch gear and allows the cradle to be driven. The engagement of the rack in the gear must not have any backlash, nor can the solenoid plunger be excessively extended out of the solenoid body. When correctly set, the solenoid plunger will be within 0.010" of bottoming-out in the body, when there is no backlash at the rack/gear interface.

Adjust the solenoid bracket so that the plunger is bottomed when the solenoid is energized, and then move the bracket forward (toward the gantry) until there is no backlash between the rack and gear, as checked at four, 90 degree apart, positions on the gear. The solenoid should be energized so that all the looseness is removed from the linkage; if energizing is not possible, be sure to push on the plunger itself (not the pin or link) when checking the adjustment.

7.) Refit the cradle drive cover.

5.4.2 Clutch Repair

1.) Follow the procedures in Sections 3.12 and 3.13 for removing the cradle drive from the table.

2.) Locate the clutch on the left end of the drive roller. Loosen the two set screws securing the 1¼" hex nut with the 5/64" hex wrench. Remove the hex nut from the clutch, along with the spring washer, hub plate, friction washer, gear with one-way bearing, and the second friction washer. Do not remove the clutch hub itself.

3.) Inspect the inside diameter of both friction washers for burrs. Remove any burrs with the sandpaper. Clean the dust and particles from the washers and then reassemble in reverse order; hand tighten the hex nut. Note that the friction washers are centered by the roller clutch that is pressed into the gear.

4.) Refit the cradle drive assembly according to the procedures in Sections 3.12 and 3.13.

5.) Position the cradle about 3 feet from home. Tighten the hex nut a small amount (1/4 flat), and then measure the driving force into the gantry with the force gauge. Drive the cradle with the table-side controls at the fast speed, while the FE reaches through the gantry with the force gauge pushing on the end of the cradle. Push hard enough for the clutch to slip, and note the reading on the gauge. Insure that the drive roller is stationary (i.e., not slipping on the cradle bottom), and that the end of the clutch (i.e., hex nut) is rotating when the measurement is taken. If the roller is slipping on the cradle, then add more weight to the cradle.

6.) For proper adjustment, the gauge reading should be as close to 40 lb as possible, but must **not** exceed 40 lb. An ideal range is 36-39 lb. Repeat Step 4) until the correct force is measured. Loc-tite and tighten the set screws and verify the reading again.

7.) A check must now be made to see if the cradle releasing solenoid and gear rack are properly adjusted. Removing the cradle will make this check easier to perform, and more accurate; follow the procedure in Section 3.11, on page 450, for removing the cradle.

When the solenoid is energized, the gear rack is engaged in the clutch gear and allows the cradle to be driven. The engagement of the rack in the gear must not have any backlash, nor can the solenoid plunger be excessively extended out of the solenoid body. When correctly set, the solenoid plunger will be within 0.010" of bottoming-out in the body, when there is no backlash at the rack/gear interface.

Adjust the solenoid bracket so that the plunger is bottomed when the solenoid is energized, and then move the bracket forward (toward the gantry) until there is no backlash between the rack and gear, as checked at four, 90 degree apart, positions on the gear. The solenoid should be energized so that all the looseness is removed from the linkage; if energizing is not possible, be sure to push on the plunger itself (not the pin or link) when checking the adjustment.

8.) Refit the cradle drive cover.

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GE Healthcare

LightSpeed 2.X

Service Manual - General

OPERATING DOCUMENTATION

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Book 4 of 6:

- Chapter 7 (DAS/Detector)
- Chapter 8 (Gantry)

Pages # - 670

Effectivity

The information in this manual applies to the following GE Healthcare LightSpeed 2.X CT Scanners:

- LightSpeed Plus (SDAS)
- LightSpeed QX/i (SDAS)

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Chapter 7
Detector and DAS

Section 1.0
Theory

1.1 Detector - Architecture

The primary function of the Detector is to convert X-ray photons into electric current, which is sent to the Data Acquisition System (DAS) for signal amplification and analog to digital conversion, before being sent to the Scan Recon Unit for image reconstruction.

The x-rays pass through the patient (or object being scanned) and are attenuated by the density of material. The remaining energy of x-rays pass through to the detector. The detector is composed of tungsten collimator plates, to differentiate the signals to individual channels, and tungsten wires, to differentiate to individual cells of a channel.

Once the x-ray beam is collimated into cells/channels, the photons hit the scintillator pack, which causes it to emit light. The scintillator pack is made up of cast material and a GE exclusive material called Lumex. Lumex is a more efficient x-ray-absorbtion-to-light-output material, with less afterglow characteristics. The light from the Scintillator pack is then picked up by a photodiode array. The photodiode array converts the emitted light into an electric current, which is then passed through to the DAS. The current strength is dependent on the amount of x-ray energy absorbed into the lumex, which corresponds to the light energy output. There is a photodiode output from each detector cell.

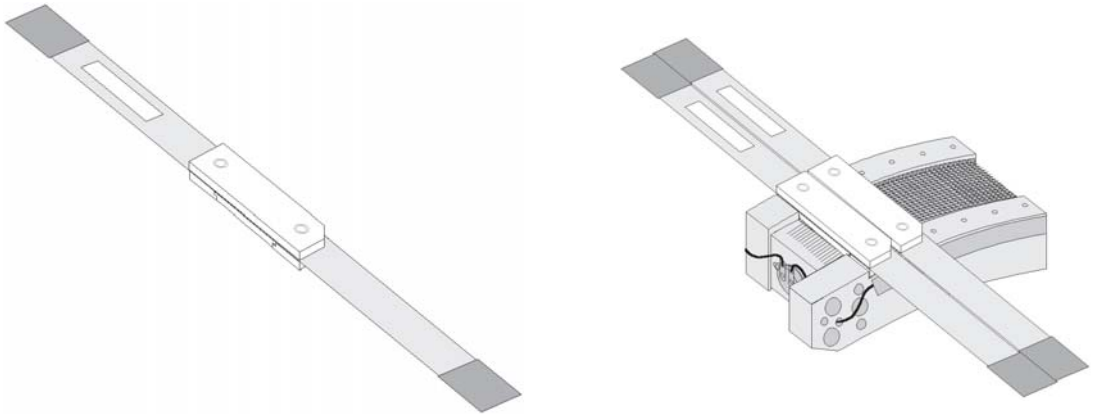


Figure 7-1 Detector Modules

The LightSpeed Detector assembly houses 57 **Detector Modules** (Figure 7-1). Each module has two sides—an **A-side** and a **B-side** (refer to Figure 7-3, “LightSpeed Detector Module”)—with eight (8) diodes or **cells** per **channel** per side. Cells are labeled **D1** through **D8**, for a total of 16 cells per channel (both A and B sides). There are 16 channels per module.

Each module uses two **flex** connections to the Data Acquisition System (DAS). The flex connectors cannot be removed from the module. The flex end is connected to the DAS via an **elastomer**, with 64 signal lines, 15 FET control lines, 1 mechanical ground and 1 signal ground.

The individual modules have separate mechanical and signal grounds. The module mechanical ground is isolated from the detector housing. The detector housing is a mechanical connection to

the gantry mounting plate, and is also an electrical connection. The photodiode control circuitry also has an electrical ground (FET logic ground DGND) and a FET bias. The FET bias was designed to allow a +1V bias to be applied to the FET to reduce or eliminate leakage. The current design is to connect this line to electrical ground (FET logic ground DGND).

Detector module temperature is regulated by the electrical resistance heater and the thermistor shown in Figure 7-2. The heater and thermistor are incorporated into the detector assembly. The overall mass of the assembled detector system ranges between 14 and 16 Kg.

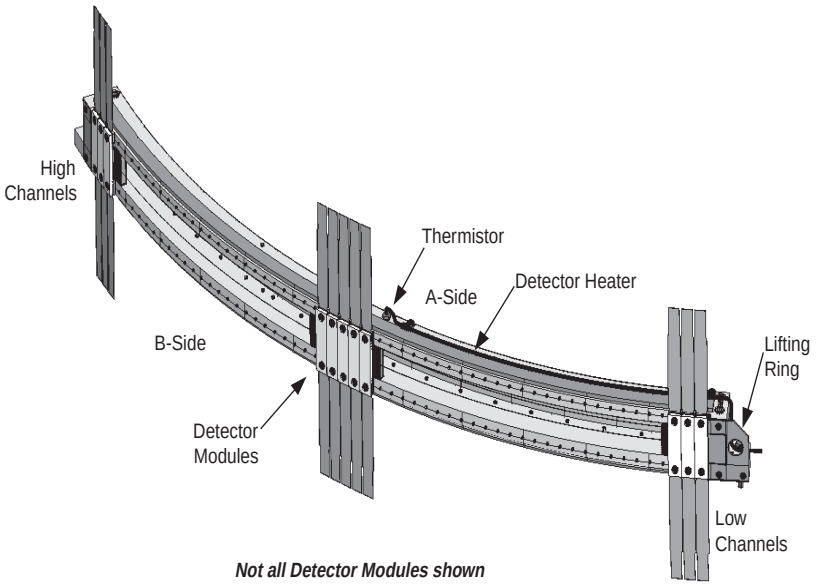


Figure 7-2 Detector Layout

1.1.1 Detector Module

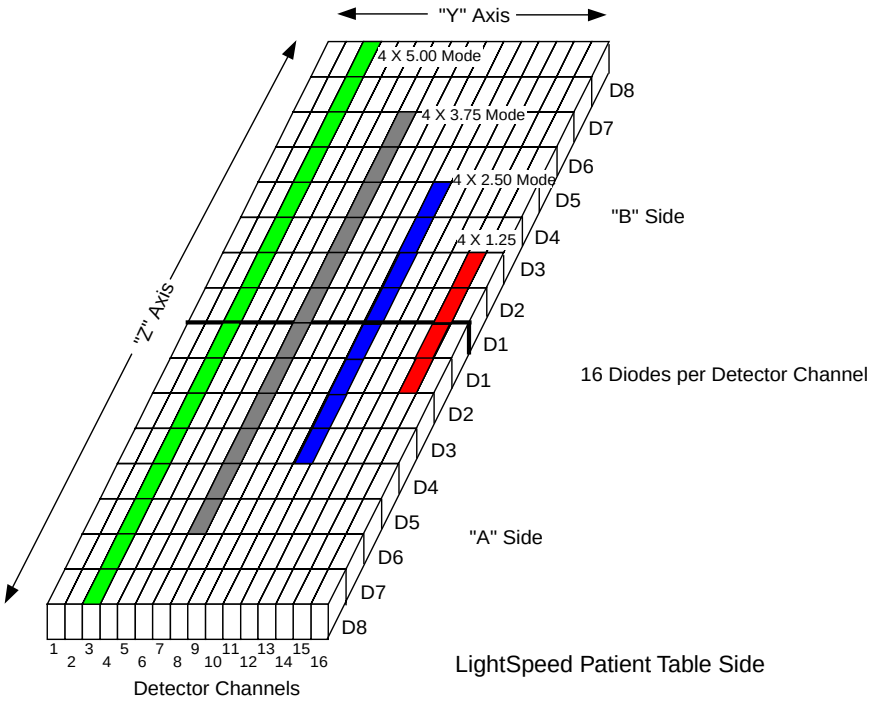


Figure 7-3 LightSpeed Detector Module

Detector Module: A detector module consists of 16 detector channels.

Detector Channel*:* A detector channel consists of 16 diodes arranged in the "Z" direction. In total, there are 912 detector channels on a detector. A single channel is 1mm in width, in the azimuthal direction. A detector channel is sometimes referred to as a **Detector Column**.

Detector Row*:* A row of 16 cells across all detector channels designated by Diode Number AND Side. (Ex. Detector Row D2, Side "A").

Note: A Detector Row is *not* the same as a **Scan Slice**. A detector row is 1.25mm deep (Z-Direction).

Cell*:* A cell is a single photodiode, and is 1/16 of a Detector Channel. In other words, there are 16 cells, or diodes, per Detector Channel.

Side A/B*:* There are 2 "sides" to a Detector, Side "A" and Side "B". The sides divide the Detector width in half, with 8 Rows per side. Side "A" is closer to the front of the Gantry (or Table side) and Side "B" is toward the back of the Gantry.

1.1.2 Z-Axis Cell Summation

The detector is segmented into cells in the Z dimension. Post–patient collimation is provided by the segmentation of the detector cells, not by a separate post–patient collimator (see Figure 7-4). The post–patient collimation, along with summation of cells in the Z direction by the detector FET array, determines the Z–axis slice thickness of the scan data.

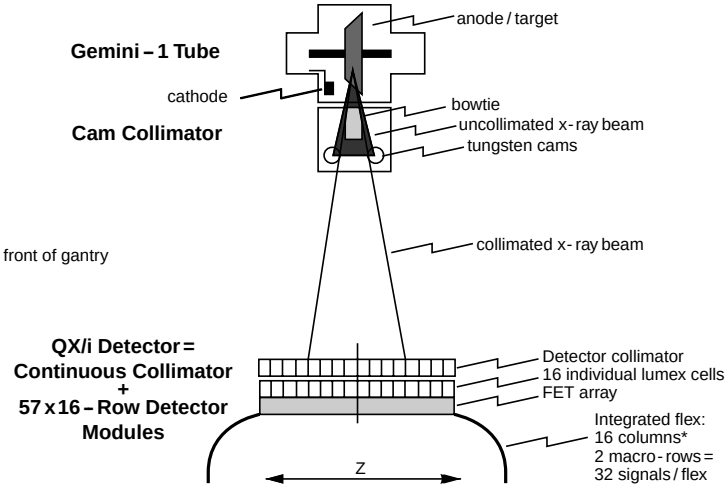


Figure 7-4 Detector Theory - X-Ray Collimation

The Z dimension extent of each cell is 1.25mm at ISO center. Cells are summed in Z to produce a **macro cell**. One, two, three or four cells may be summed to form the macro cell.

All macro cells in the same Z plane form a **macro row**. A macro row is the detector row or combination of rows that is used to generate a post-collimation slice thickness. A macro row consisting of a single cell in each column produces scan data with a thickness of 1.25mm at ISO center. A macro row consisting of 4 summed cells in each column produces scan data with a thickness of 5.0mm at ISO center. There can be up to four macro rows, labeled 2A, 1A, 1B and 2B.

Each flex transmits two macro cells to the DAS per column x 16 columns per detector module = 32 data channels per flex.

1.1.3 Post Collimation: Z-Axis Beam Profile Considerations

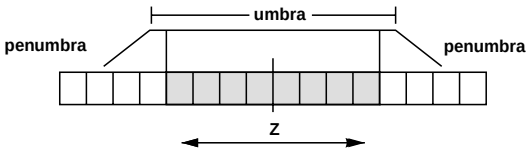


Figure 7-5 Z-axis X-ray Beam Profile, 4 x 2.5mm Detector Configuration

The collimated beam has a Z–axis profile that consists of the umbra (essentially flat) and the penumbra (sloped) (see Figure 7-5, highly idealized). In order to avoid image artifacts, the system must always operate with the umbra region completely covering the detector cells contributing to the selected macro rows. During gantry rotation, the position of the beam moves a small amount in the Z direction, due to various mechanical sags in the gantry, tube, collimator, etc. To ensure that the detector cells are completely covered by the umbra region, the Z dimension extent of the umbra is increased so that the detector is covered regardless of Z–axis beam motion (see Figure 7-5). Detector reference cells are used to estimate the actual position of the x-ray beam on the detector, and real-time feedback is provided to the collimator to compensate for beam motion.

1.1.4 Detector FET Control

The Detector FETs (Field Effect Transistors) are used as switches to combine detector rows, to achieve the prescribed slice thickness. These FETs are physically located in the detector assembly.

NOTICE **FETs are EXTREMELY ESD SENSITIVE. ALWAYS use ESD precautions when handling the Detector or Detector flexes. A bad FET will require the entire Detector to be replaced.**

After a Scan prescription is entered at the Host Computer, the Scan Rx parameters are sent to the appropriate controllers. For slice thickness, the parameters are sent to both the Collimator control board, to select the proper Collimator CAM positions, and the DAS Control Board (DCB), to select the macro row width.

There are three (3) sets of FET Control lines driven by the DCB. Each set consists of five (5) lines used as a binary value that gets decoded in the Detector and finally controls Detector Diode selection. The three (3) sets of FET Control are described in Table 7-1.

FET	DESCRIPTION	CHANNELS
Inner FET	FET control lines used by the Center DAS Chassis	DAS Channels 225 through 544
Outer FET	FET control lines used by the Left and Right Chassis (except Z-Ref Chs).	DAS Channels 1 through 224 & Channels 545 through 762
Z-FET	Only used for the 12 Z-Ref Channels	DAS Z-Ref Channels 1 -12

Table 7-1 FET Control Matrix

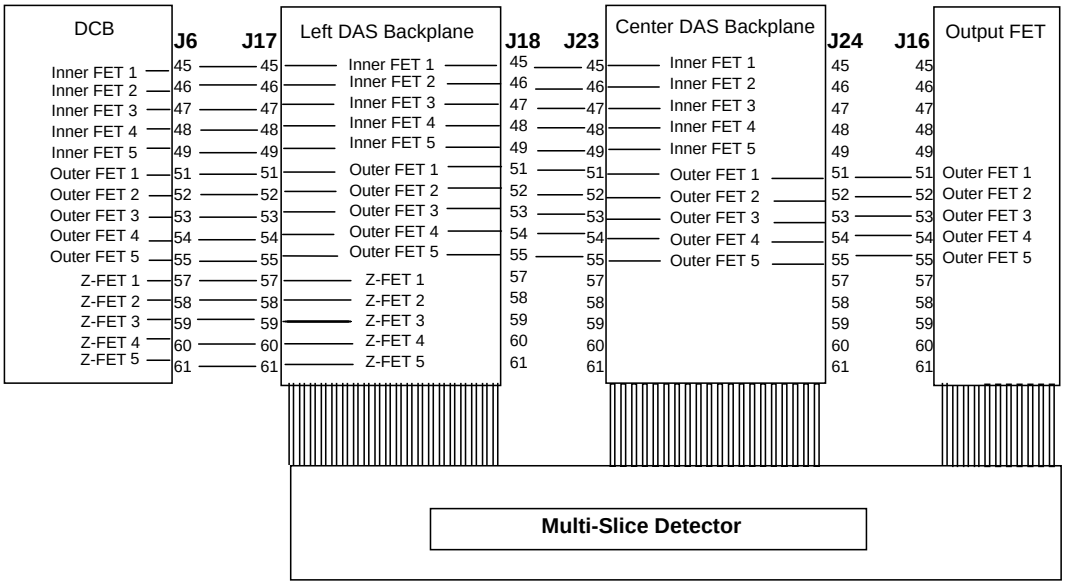


Figure 7-6 FET Control Interconnect

The DCB uses four quad SPST analog switches (U13-U16), which are used to drive the FET_BUS. A logic “0” on the input of any switch turns the switch ON, connecting the output to analog GND. A logic “1” turns the switch OFF, allowing the external pullup resistor to pull the output to -5 volts (Refer to Table 7-2).

FET5	FET4	FET3	FET2	FET 1	MODE	ROW 2A	ROW 1A	ROW 1B	ROW 2B
0	0	0	0	0	4 x 1.25mm	D2	D1	D1	D2
0	0	0	0	-5.0	4 x 2.50mm	D3+D4	D1+D2	D1+D2	D3+D4
0	0	0	-5.0	0	4 x 3.75mm	D4+D5+D6	D1+D2+D3	D1+D2+D3	D4+D5+D6
0	0	0	-5.0	-5.0	4 x 5.00mm	D5+D6+D7+D8	D1+D2+D3+D4	D1+D2+D3+D4	D5+D6+D7+D8
0	0	-5.0	0	0	Cal 1	D3	D2	D2	D3
0	0	-5.0	0	-5.0	Cal 2	D4	D3	D3	D4
0	0	-5.0	-5.0	0	Cal 3	D5	D4	D4	D5
0	0	-5.0	-5.0	-5.0	Cal 4	D6	D5	D5	D6
0	-5.0	0	0	0	Cal 5	D7	D6	D6	D7
0	-5.0	0	0	-5.0	Cal 6	D8	D7	D7	D8
0	-5.0	0	-5.0	0	Cal 7	D1	D8	D8	D1

Table 7-2 Photodiode Control Matrix

1.1.5 Detector FET Switching

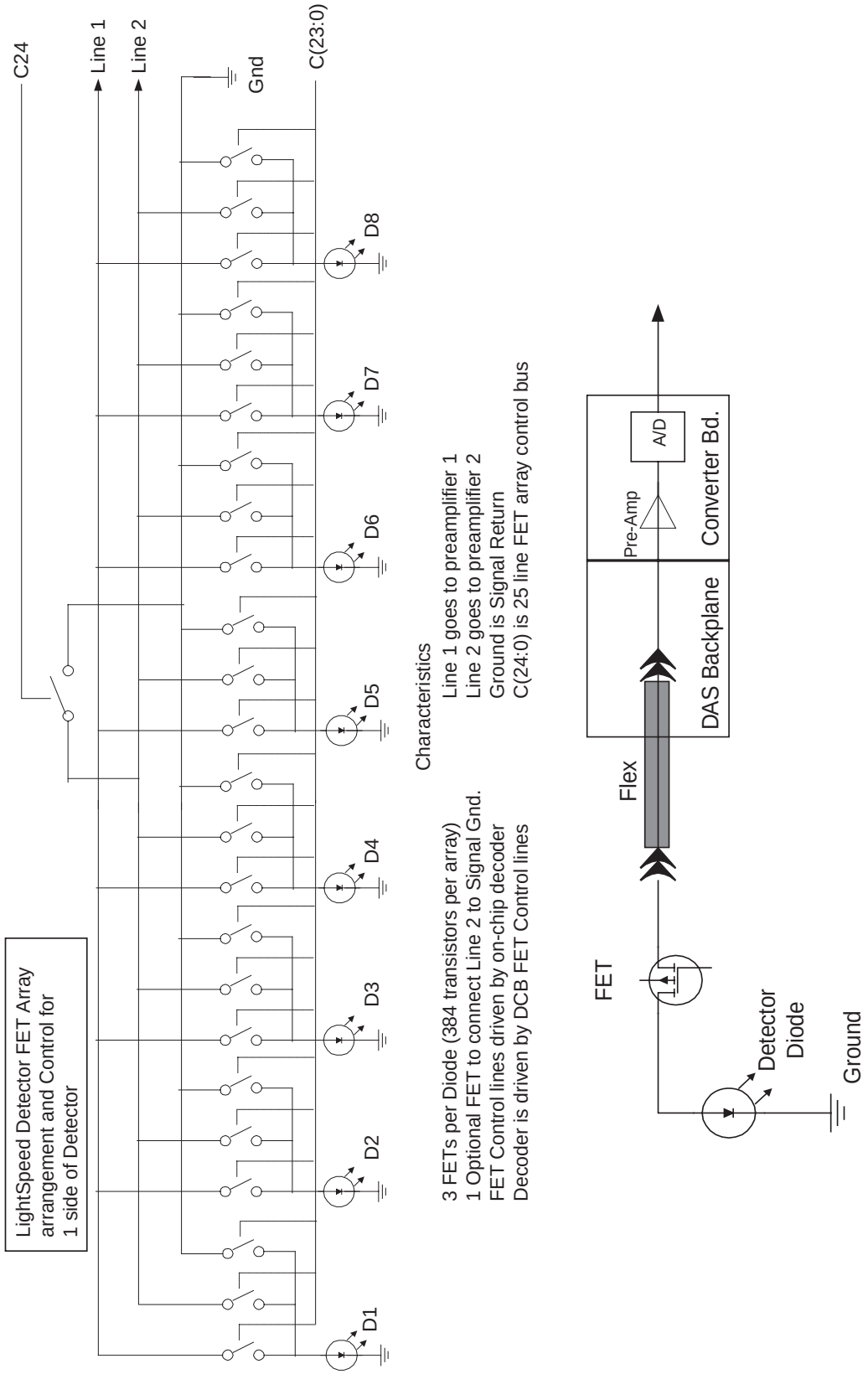


Figure 7-7 SDAS FET Array Arrangement

1.1.6 Detector Output Bus to DAS Data Flow

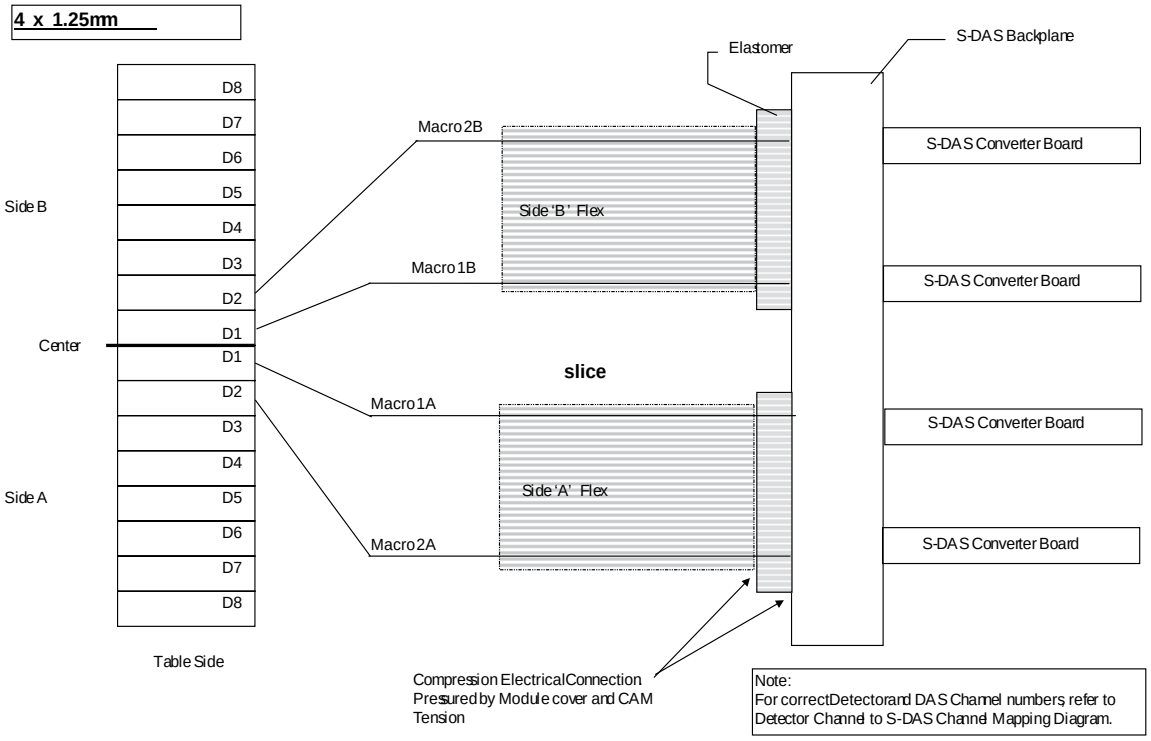


Figure 7-8 4 x 1.25mm Slice

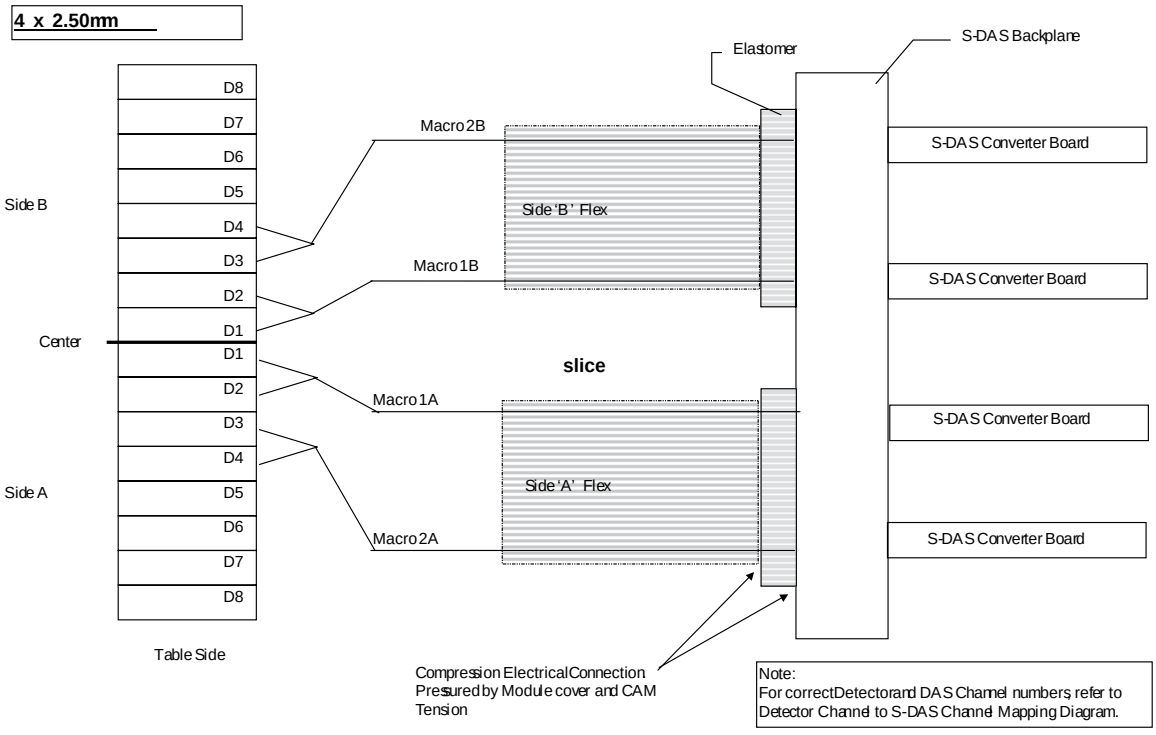


Figure 7-9 4 x 2.50mm Slice

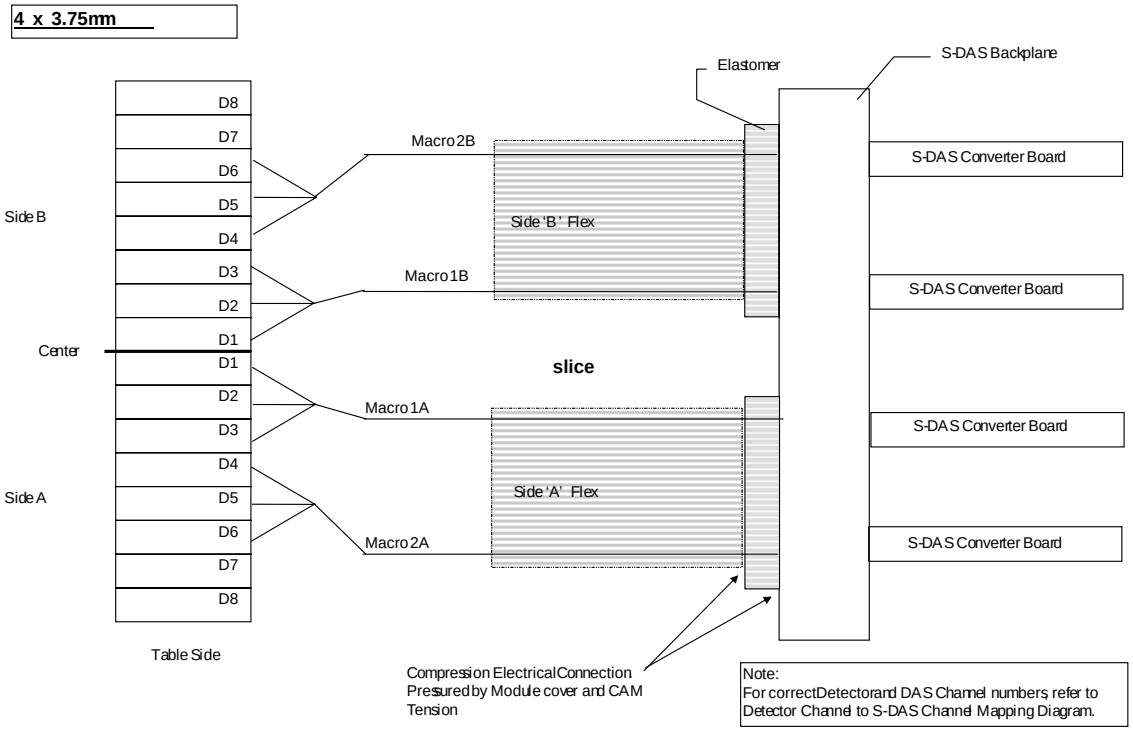


Figure 7-10 4 x 3.75mm Slice

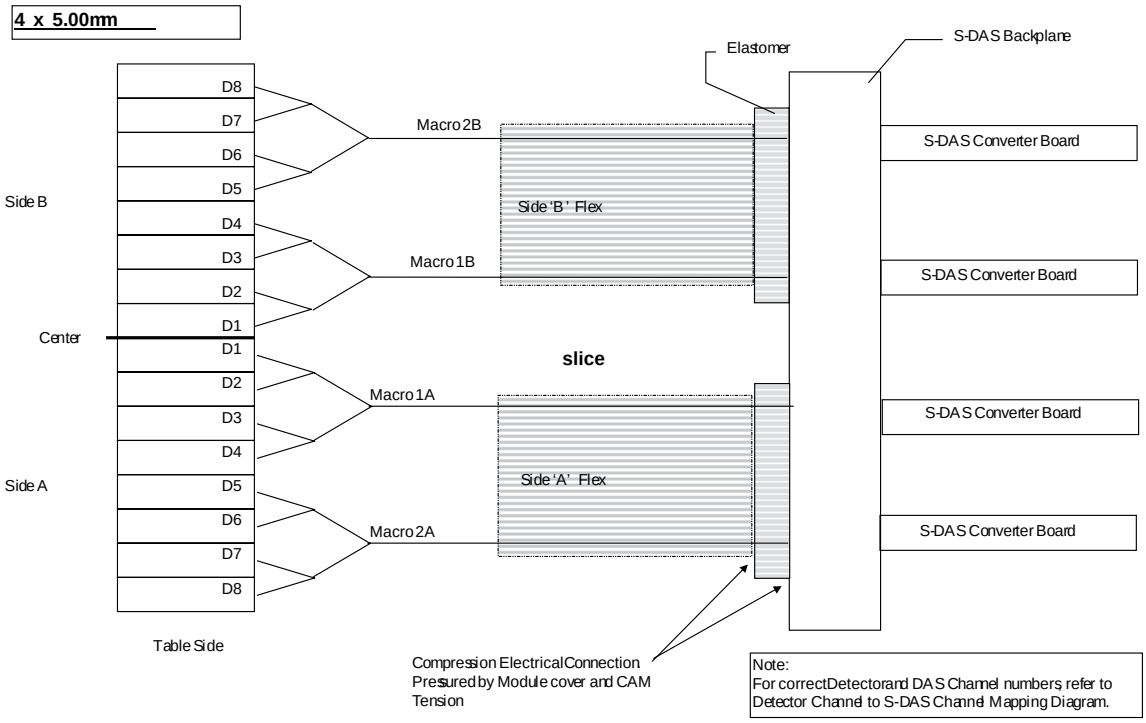


Figure 7-11 4 x 5.00mm Slice

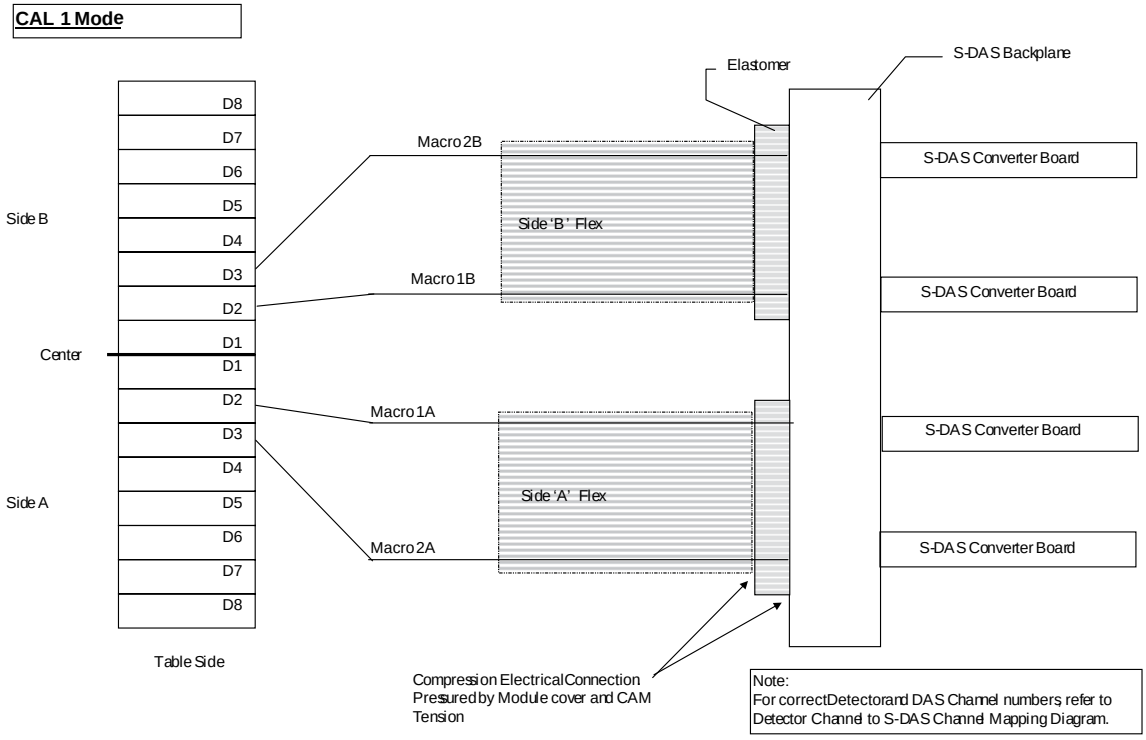


Figure 7-12 CAL 1 Mode

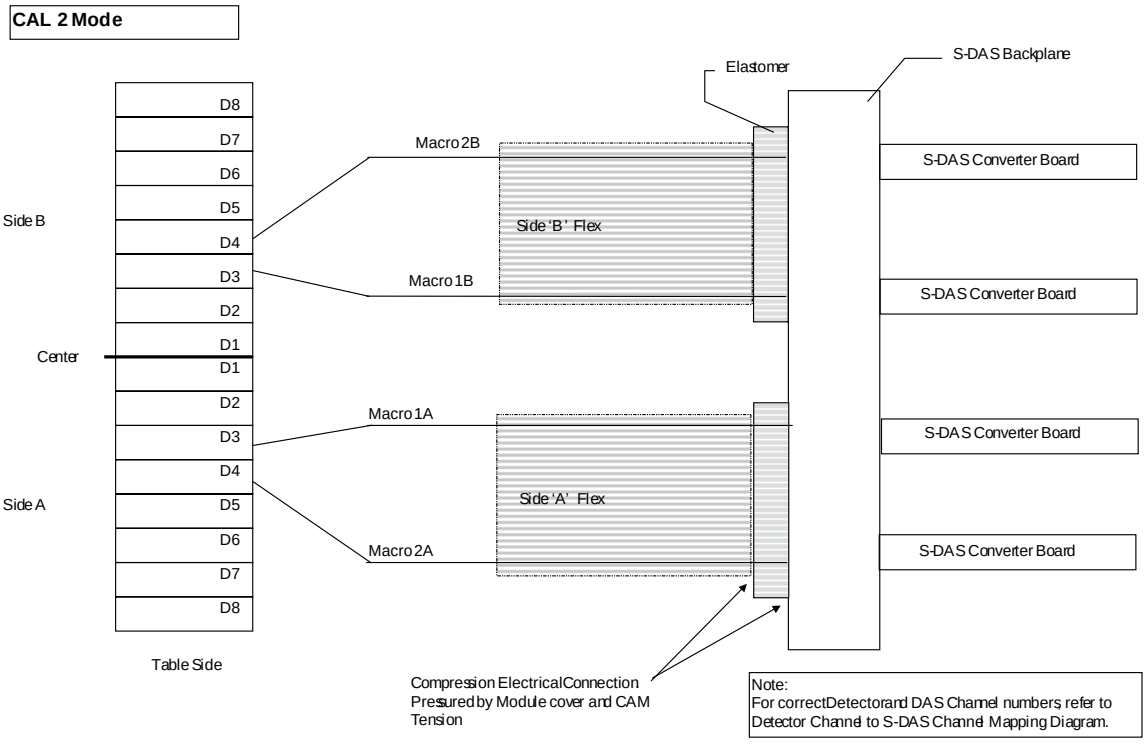


Figure 7-13 CAL 2 Mode

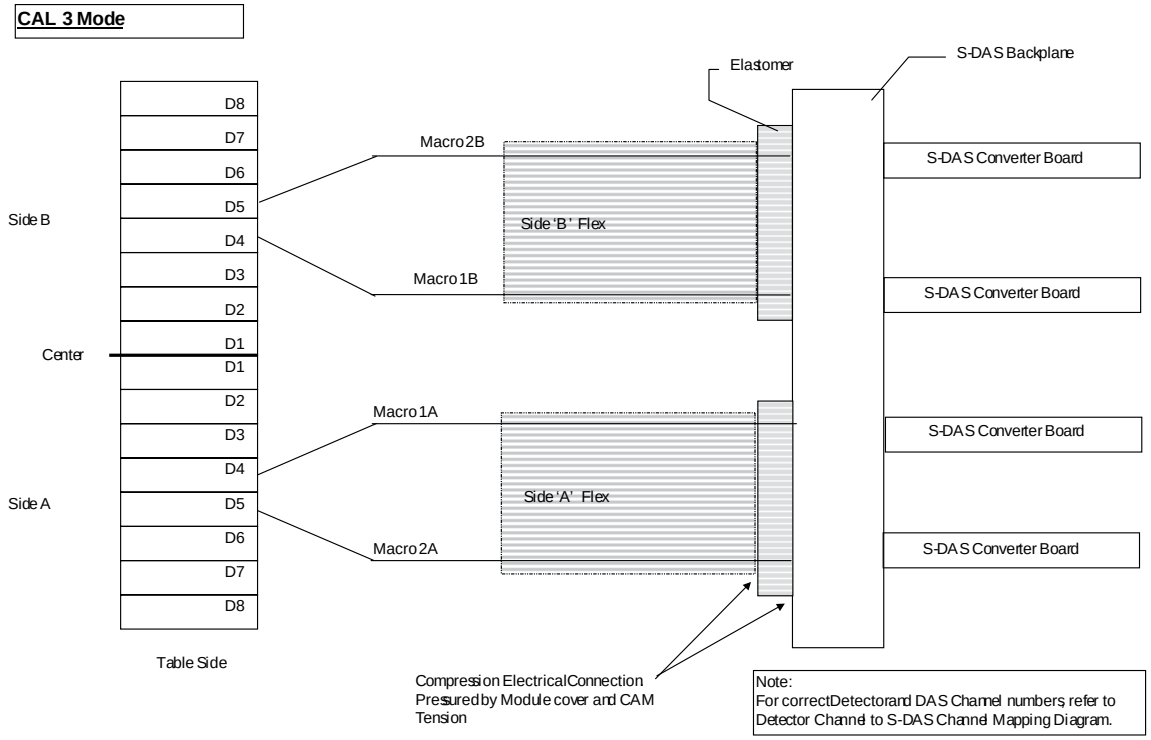


Figure 7-14 CAL 3 Mode

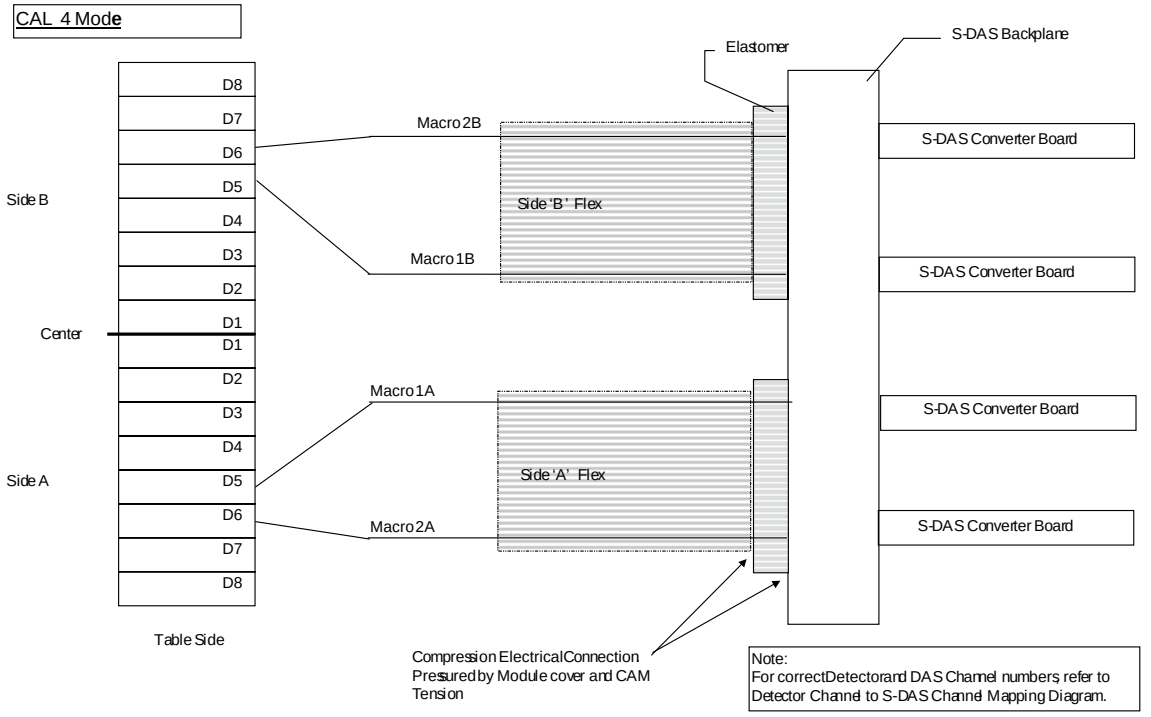


Figure 7-15 CAL 4 Mode

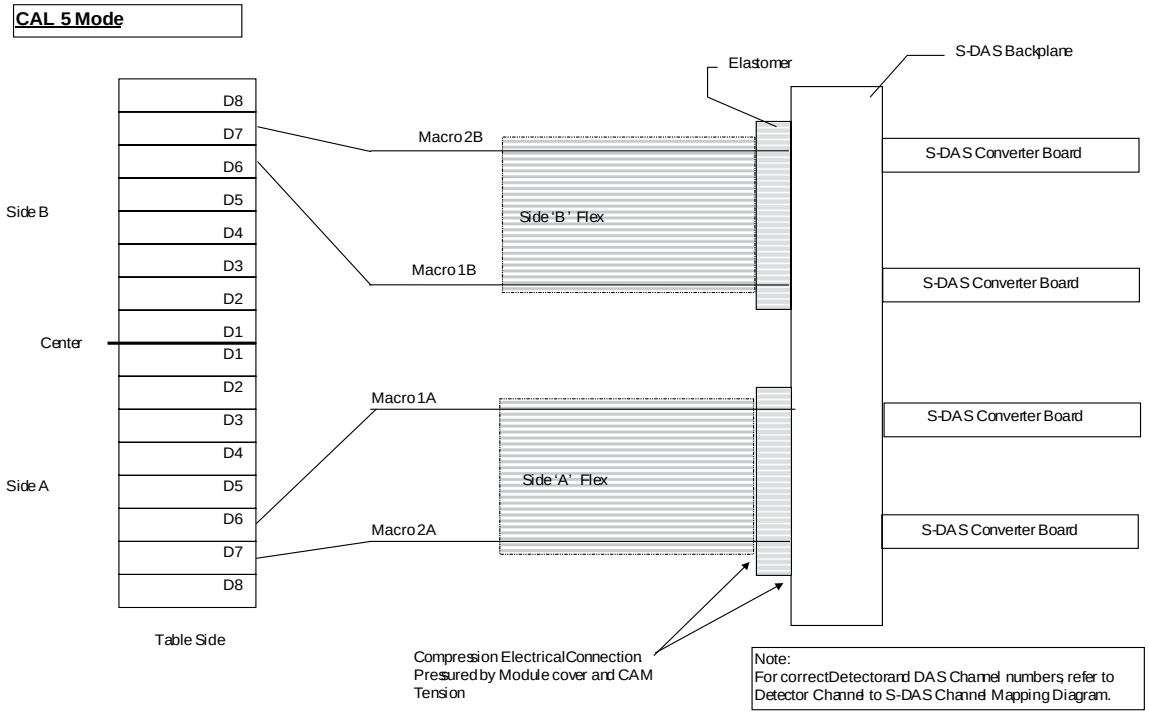


Figure 7-16 CAL 5 Mode

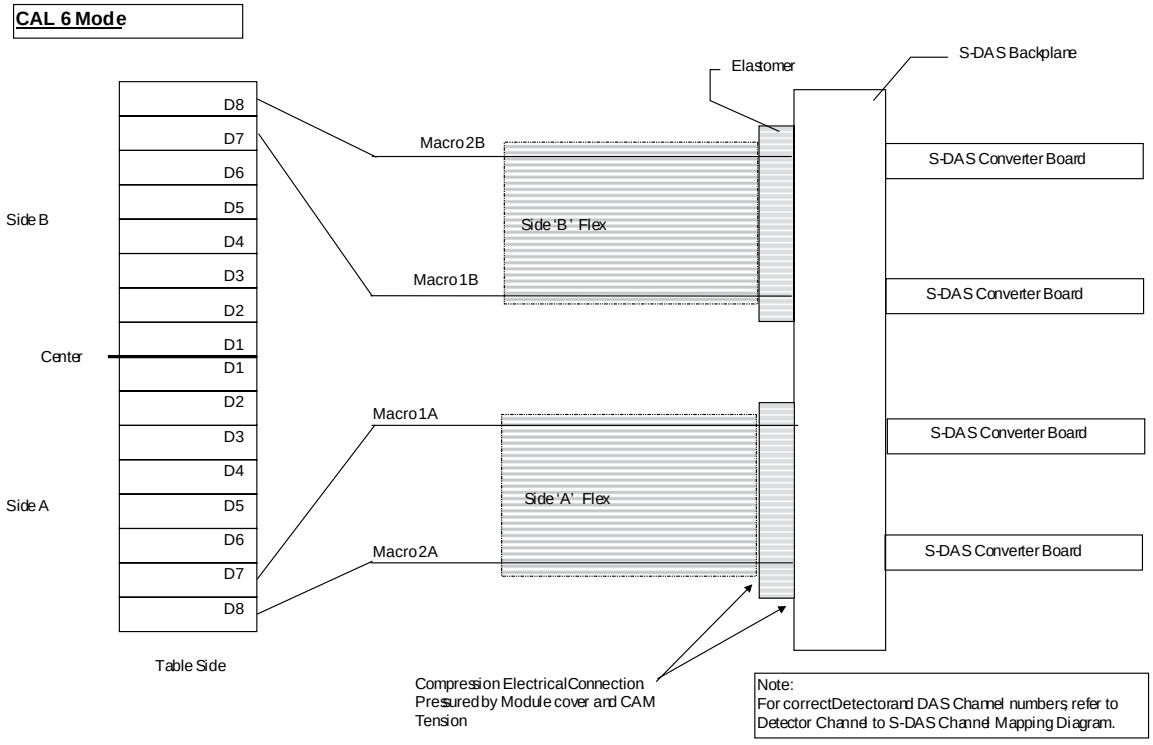


Figure 7-17 CAL 6 Mode

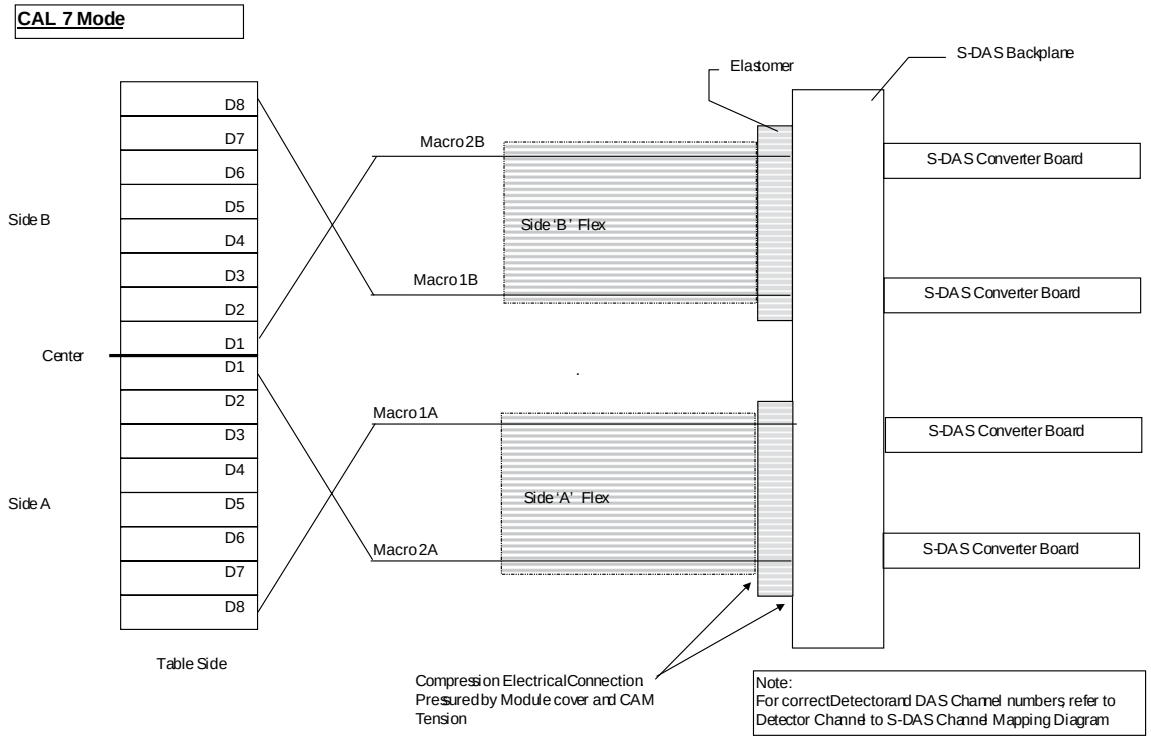


Figure 7-18 CAL 7 Mode

1.1.7 Detector Cell to Output Channel Organization

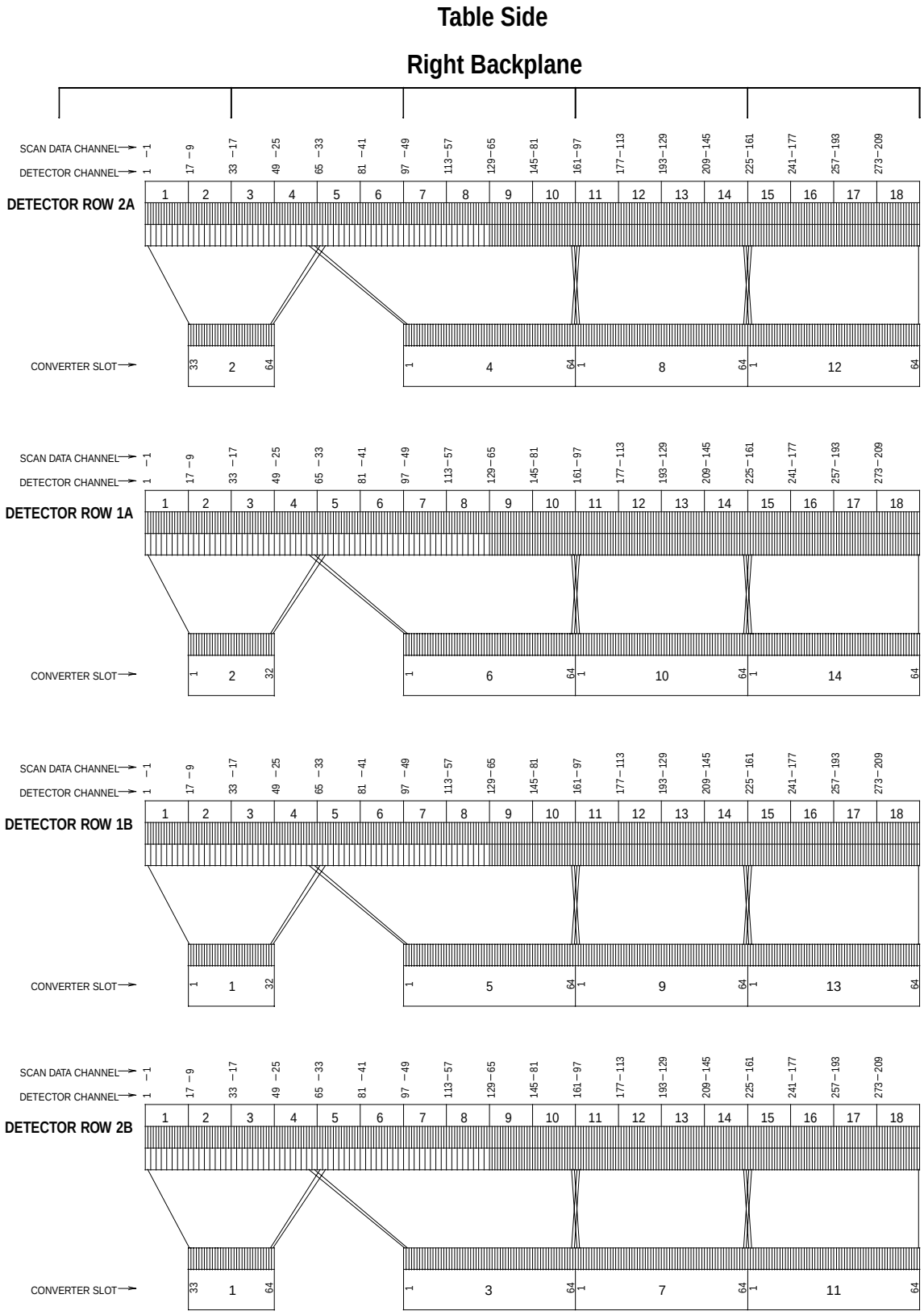


Figure 7-19 SDAS Right Back Plane Detector to DAS Map

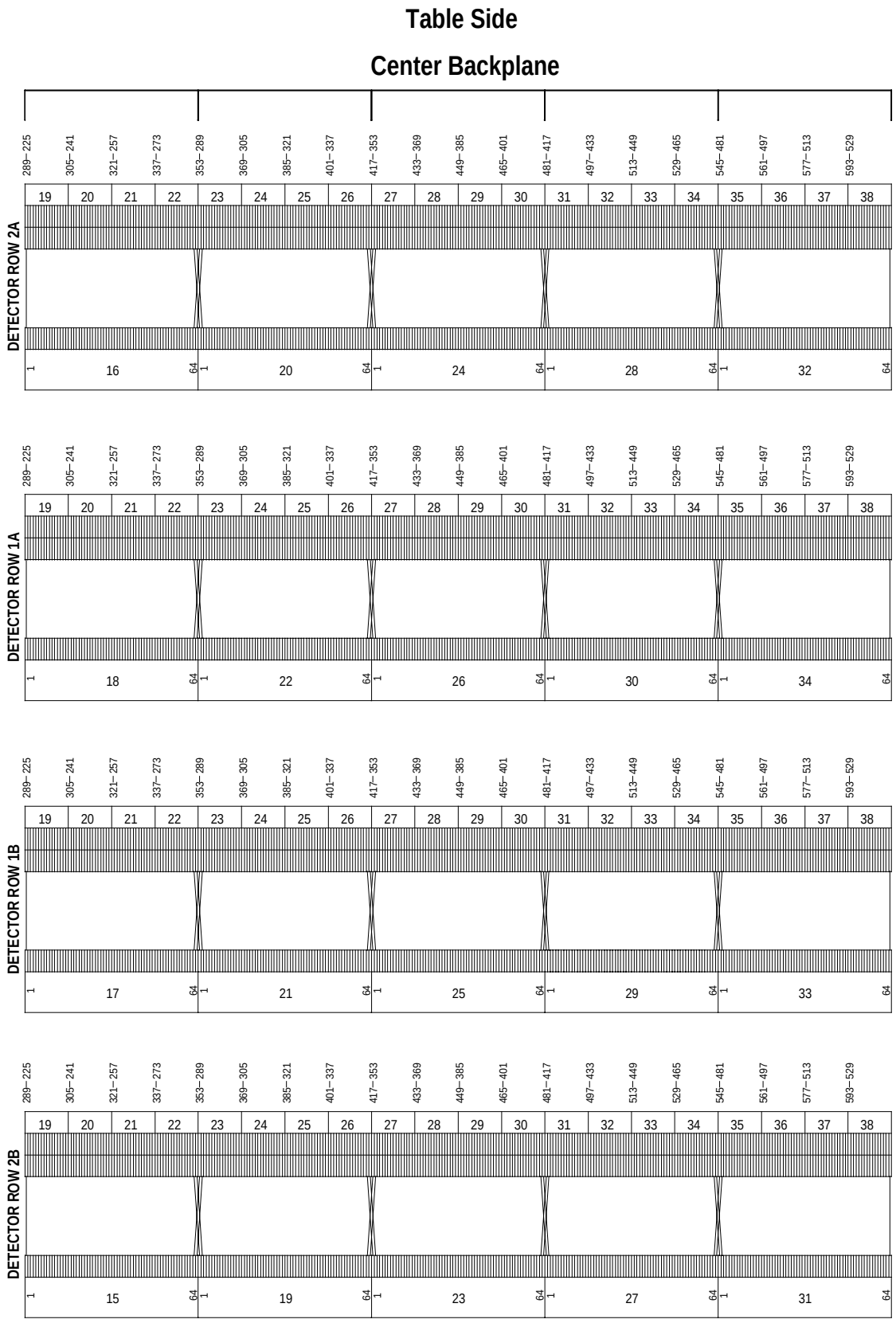


Figure 7-20 SDAS Center Back Plane Detector to DAS Map

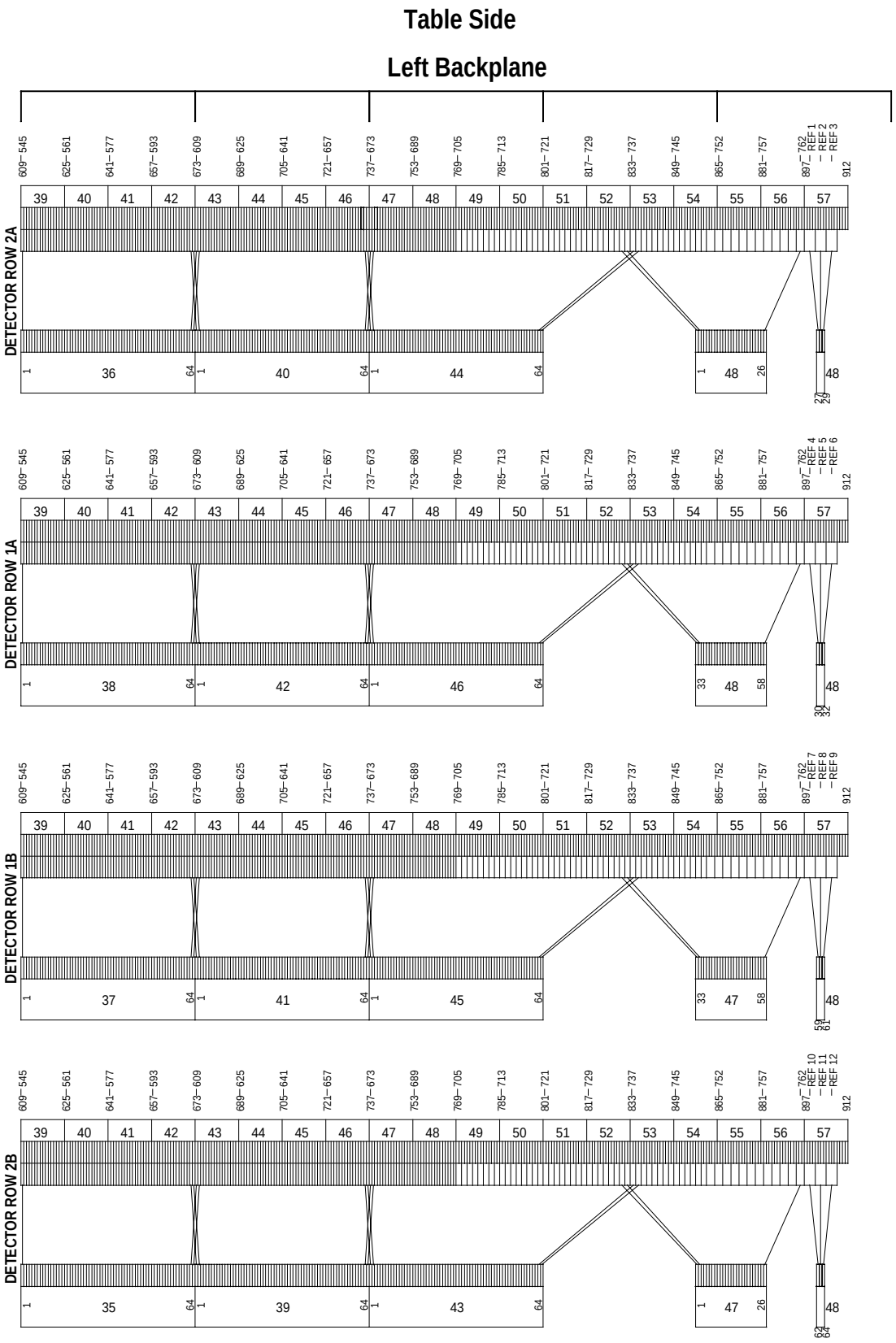


Figure 7-21 SDAS Left Back Plane Detector to DAS Map

1.1.8 Detector Heater

In order to obtain consistent and accurate results, the detector must be kept at a constant temperature. The detector temperature is maintained by hardware circuits on the DCB, along with an external power supply that powers a heating element in the detector itself.

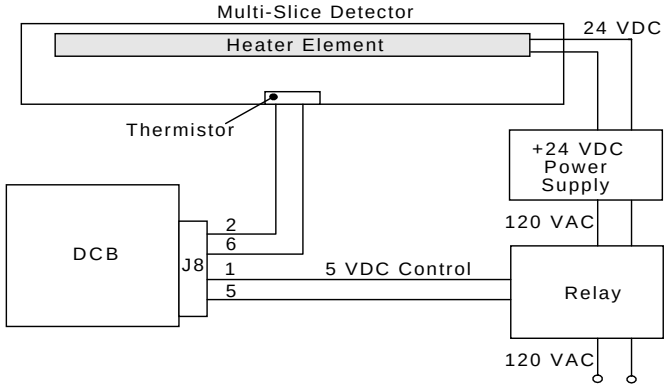


Figure 7-22 Multi-Slice Detector

The DCB monitors detector temperature via a thermistor embedded in the rail of the detector. Hardware circuits on the analog section of the DCB convert the thermistor resistance into a digital value that represents the detector temperature. These digital values are kept in the Detector Heater Analog Aux channel register. This register may be monitored by software in order to obtain the current detector temperature. The temperature value is averaged with the previous 16 samples, and the output is compared with an upper limit register (Detector Heater OFF Temp Set Point Register), and a lower limit register (Detector Heater ON Temp Set Point Register). When the temperature value goes below the lower limit, the DCB enables the heater power supply via the HTR_ON signal. When the temperature value goes above the upper limit, the DCB turns the heater power off. In this way, the DCB can keep the detector at a constant temperature.

The modules in the detector system are maintained at a temperature of 36 ± 3 degrees C (module to module variation) and to 36 ± 1 degree C (near thermistor).

1.2 S-DAS

1.2.1 Block Diagram

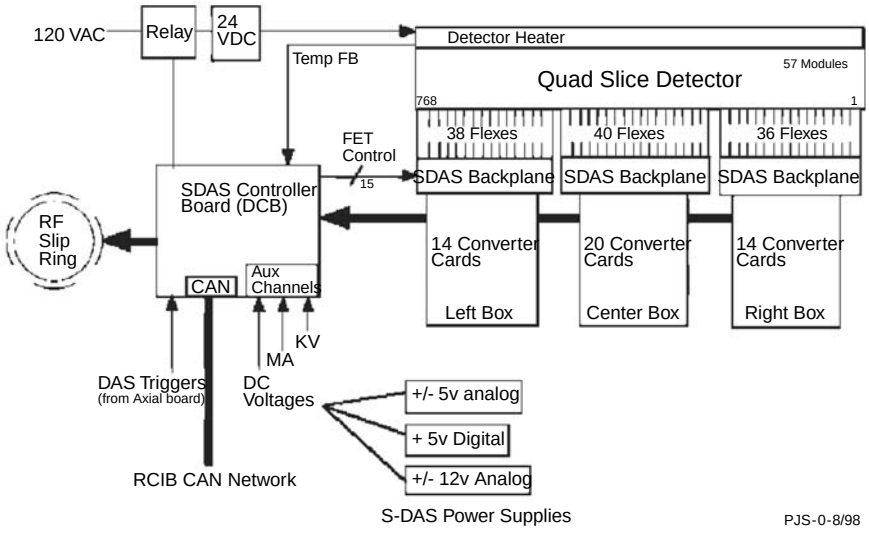
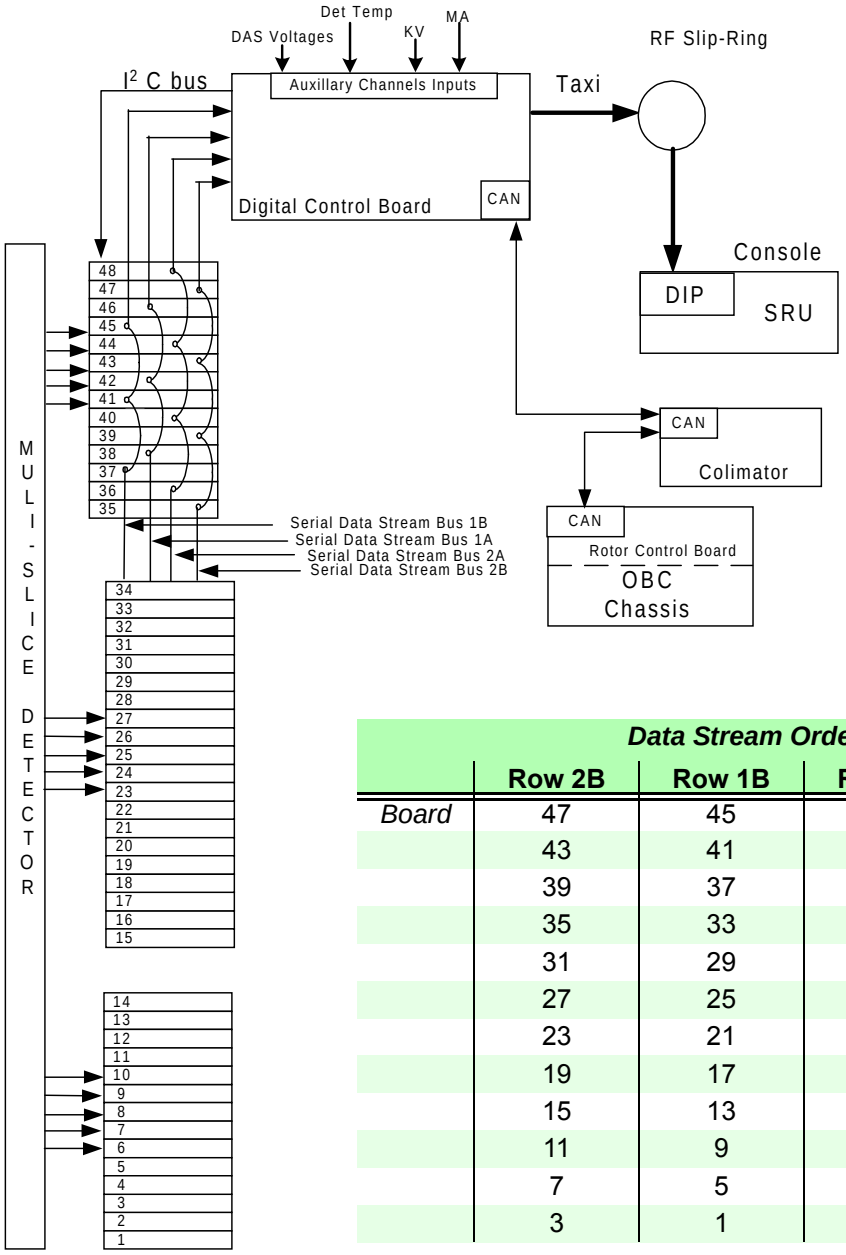


Figure 7-23 S-DAS Block Diagram

1.2.2 Data Flow (to DCB)



Data Stream Order				
	Row 2B	**Row 1B**	**Row 1A**	**Row 2A**
Board	47	45	46	48
	43	41	42	44
	39	37	38	40
	35	33	34	36
	31	29	30	32
	27	25	26	28
	23	21	22	24
	19	17	18	20
	15	13	14	16
	11	9	10	12
	7	5	6	8
	3	1	2	4

Figure 7-24 Data Flow

1.2.3 Converter Boards

1.2.3.1 Architecture

- The Converter Board processes low current, analog data from 64 Detector outputs and converts these inputs into two digital serial streams. One of these streams is for even numbered DAS channels (0, 2, 4, … 60, 62) and the second stream is for the odd channels (1, 3, 5, … 61, 63). Also included are an input anti-aliasing filter, an A-to-D converter, control circuitry and a digital I/O section.
- The individual interfaces to the x-ray detector outputs are termed DAS channels. The front-end preamplifier structure for a single DAS channel is shown in Figure 7-25. The structure is an integrate-and-dump anti-alias filter, with selectable gain.

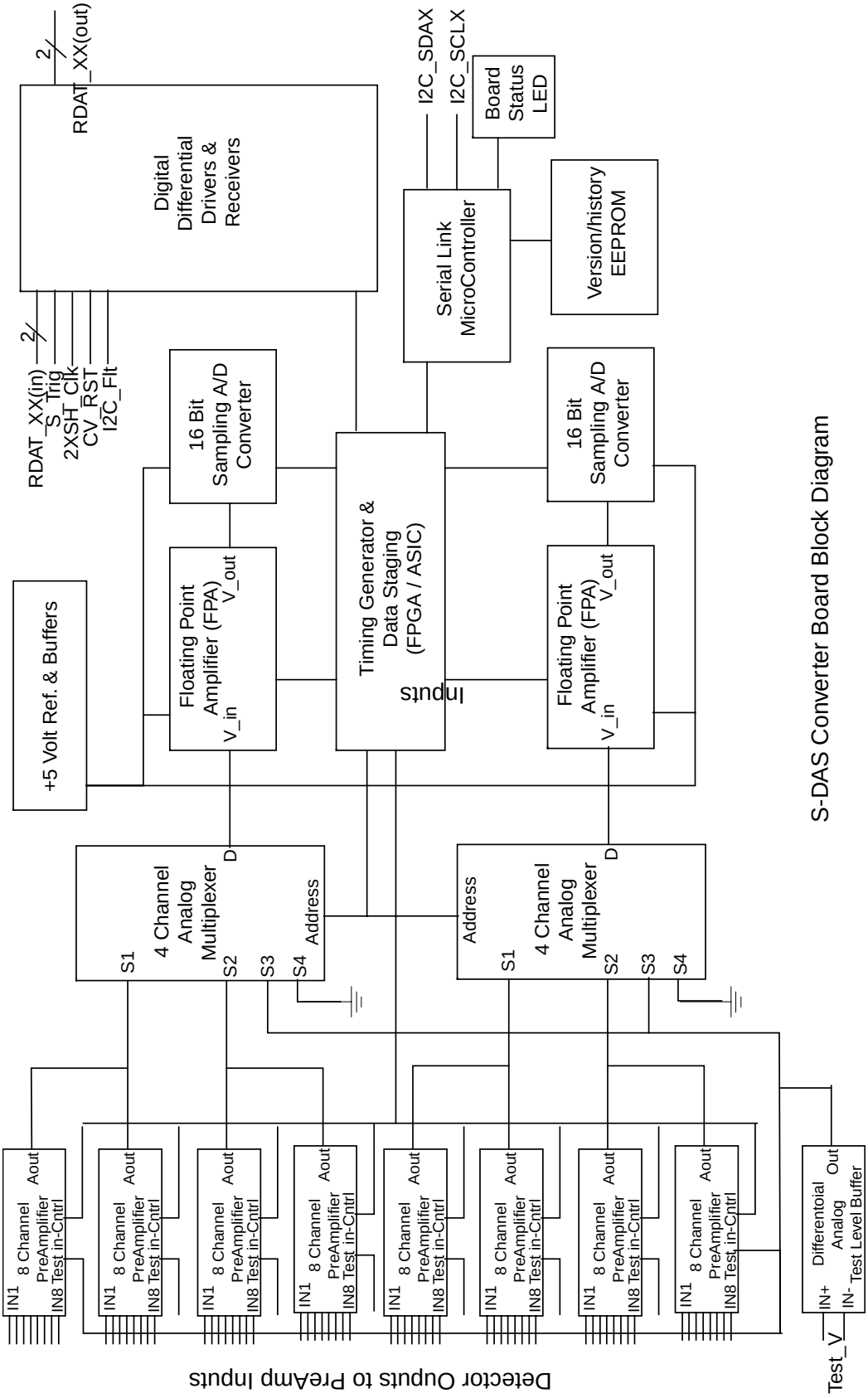


Figure 7-25 Converter Board Block Diagram

1.2.3.2 Signal Interfaces

X-Ray Detector Output Signals

- The smallest element of the detector matrix is a detector cell. The detector cell, as presented to the DAS, is a zero-biased photodiode whose current output (photo-current I_p) is proportional to the incident X-ray flux.
- With respect to applications other than the Plus detector, the converter board is compatible with a source capacitance as large as 450 pfd and a source resistance as low as 20 Meg-ohm. These numbers are for an unganged (single cell) detector output configuration. The S-DAS shall also be compatible with configurations of up to three cells ganged together.
- Normal detector cell aperture (azimuthal direction) is 1 mm. However, some cell outputs are electrically connected or ganged in either pairs or triplets to form 2 and 3 mm cells. Because of the different source impedance associated with these cells, DAS performance is affected as noted elsewhere in this document. However, the Converter Board preamplifier circuit is designed to be stable under worst case source impedance conditions.
- The Converter boards will receive the detector output signal on the same backplane connector as the rest of the DAS control and power connections.
- The maximum DC offset applied by the converter on the photodiode is within ± 2.0 mV DC under normal operating conditions.

Data Acquisition

The converter board is controlled by using 13 signals:

- S_TRIG (Differential, view trigger signal). The nominal frequency band of this signal will be 984Hz to 1408Hz continuous. It is synchronized with 2XSH_CK. S_TRIG will be used by the Converter Board to initiate a timing cycle that is approximately 0.7 - 1.0 mS long.
- 2XSH_CK (Differential, output data shift clock) is an input signal that is used with S_TRIG to generate all timing signals for the Converter Board. It is 2 times the frequency of the clock used to shift A to D data off the Converter Board to the Digital Control Board, and is free running. Anticipated frequency of this clock is 26.8 MHZ.
- CV_RST (Converter Board Reset) is a level active signal that is activated by the DCB (Digital Control Board) that is a hard reset for the Converter Board. This reset puts the board in operational mode so that it may acquire data.
- I^2C_SDA and I^2C_SCL (I^2C Serial Data and Clock Signals) needed to implement the control bus for the Converter Board. These signals are compliant with the Philips I^2C electrical and software protocol. I^2C_SDA is the data signal and I^2C_SCL is the clock signal.
- CV_FLT(I^2C Bus Fault Detect) This is an open collector or open drain signal that is activated by the Converter Board I^2C interface (the SCC) whenever it detects (from the Converter Board side) that the I^2C interface is defective. This signal is received by the DCB (Digital Control Board) and processed.
- TEST_V (Differential, Converter Board Test Voltage) is a voltage that is generated by the DCB that is used to test the Converter Board by injecting an input at the preamp or at the input multiplexer of the FPA (Floating Point Amplifier)
- DIAG_ACT (Diagnostic Activate) is an input signal used to activate diagnostic mode for board test purposes by the board manufacturing vendor.
- DIAG_SNS (Diagnostic Sense) is an output signal used to determine whether diagnostic tests have successfully completed execution. This is used for board manufacturing tests.
- ADDR 5:0 (Board Address) is a 6 line input bus that is used by the board to determine its I^2C bus address. These inputs are wired with the appropriate addresses on the SDAS backpanels.

Data Inputs and Outputs (Converter Output Data Shift Chains)

- D_INA, D_INB (input data for even and odd shift chains) – Each board is connected to two shift register chains that are 12 bits deep. The bits to be shifted out of the board are stored in two D-type flip-flops. Conceptually, 12 boards are connected so that these flip-flops form a 12 bit long parallel loadable shift register. These flip-flops are loaded on all converter boards at the same time (there are 8 of these shift chains: 4 odd and 4 even).
- D_OUTA, D_OUTB (output data for even and odd shift chains) – These are the output signals of the 2 even and odd D flip-flops on a converter board that are connected to the inputs of the flip-flops on the next board, downstream in the shift chain.

Converter Board Data Format

The channel data output by these two serial outputs are 20 bit values. These 20 bit values are made of 4 elements. The first element is a dummy bit that has been added to make the total number of the channel data bits even. The Second element is a 16 bit unsigned mantissa, the third is a two bit exponent value that represents one of four gain values. The fourth field is an odd parity bit that is calculated on a 19 bit value made of the dummy bit, the mantissa, and the exponent.

The dummy bit is the first bit to be shifted out. This bit has no value other than to make sure that the number of bits that parity is to be calculated on is odd. This is to insure that the most common case of failures, which is the data being all ones or all zeros, can be detected. It is also assumed that these all one and all zero failures are most likely to be the result of an open pin on the data bus.

The mantissa is a 16 bit unsigned binary. The board shall output a mantissa code of 0000H for the minimum value of input Voltage, 8000H for mid scale, and FFFFH for the maximum value of voltage. Note: The mantissa is shifted out in order of descending bit value, i.e., the MSB is the first bit shifted out, with the last being the LSB.

Next, the two exponent bits are then appended to the mantissa, with the MSB of the exponent being shifted out immediately following the LSB of the Mantissa. The LSB of the exponent is the next bit shifted out, following the exponent MSB. The gain value for the FPA for a zero in this exponent field is 1; the gain value for a 1 in this field is 4; the gain value for 2 in this field is 16; and the gain value for a 3 in this field is 128.

Finally, the last bit to be shifted out is a parity bit. Parity is odd; that is, the parity is set to 0 if the dummy bit, mantissa and exponent have an odd number of bits set. If the number of bits set in the dummy bit, mantissa, and exponent are even, the parity bit is set to 1.

Dummy Bit	Exponent		Mantissa															Parity
	MSB	LSB	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	

Figure 7-26 Converter Board Data Format

1.2.3.3 Voltage References

The Converter board provides its own voltage references for the A/D conversion and Floating point amplifier range selection.

1.2.3.4 Backplane Connector

The Converter Board uses a 128-pin (Position), 4x32, gold-plated two piece connector. It is equivalent to an AMP 106739-4, DIN 41612, IEC 603-2, right angle pin assembly for the board side. The mating back panel connector is equivalent to an AMP 216415-4 vertical receptacle assembly.

1.2.3.5 Power Requirements

The converter board is designed to use the following power supply voltages: +5 volt digital, +5 volt analog, –5 volt analog, +12 volt analog, and –12 volt analog. Power consumption is kept under 50 mW per channel. Table 7-3 summarizes the power supplies' characteristics:

CHARACTERISTICS	+5V ANALOG	-5V ANALOG	+12V ANALOG	-12V ANALOG	+5V DIGITAL
Maximum supply current	3.0 A	3.0 A	3.0 A	2.0 A	6.5 A
Maximum peak-to-peak noise and ripple (1)	5.0 mV	5.0 mV	5.0 mV	5.0 mV	5.0 mV
Maximum rms noise and ripple (2)	20 µV	20 µV	-	-	-
Maximum line regulation	0.1%	0.1%	0.1%	0.1%	0.1%
Maximum load regulation	0.1%	0.1%	0.1%	0.1%	0.1%
Maximum temperature coefficient	0.03%/°C	0.03%/°C	0.03%/°C	0.03%/°C	0.03%/°C
Minimum adjustment range	±5%	±5%	±5%	±5%	±5%
Over voltage limitation	6.9 VDC		18.0 VDC		6.9 VDC

Table 7-3 Power Requirements

1.2.3.6 Board Status LED

The converter board gives a visual indication of an error condition. There is a LED on each converter board that will flash several times during the power-up diagnostics. The LED should remain off if the diagnostics were successful. If the self-test fails, then the LED for the failing converter board will flash a sequence code to indicate the type of error detected:

SUSPECTED FAULT ON CONVERTER BOARD	LED CODE
NO_ERRORS	0
PREAMP_ERROR	1
REGISTER_ACCESS_ERROR	2
IIIC_PROTOCOL_VIOLATION_ERROR	3
RAM_TEST_ERROR	4
ROM_TEST_ERROR	5
OVERTEMP_ERROR	6
FPGA_TIMEOUT_ERROR	7
SPURIOS_INTERRUPT_ERROR	8

Table 7-4 Converter Board LED Error Codes

1.2.4 DAS Control Board (DCB)

1.2.4.1 DCB Block Diagram

Figure 7-27 shows a block diagram of the DCB.

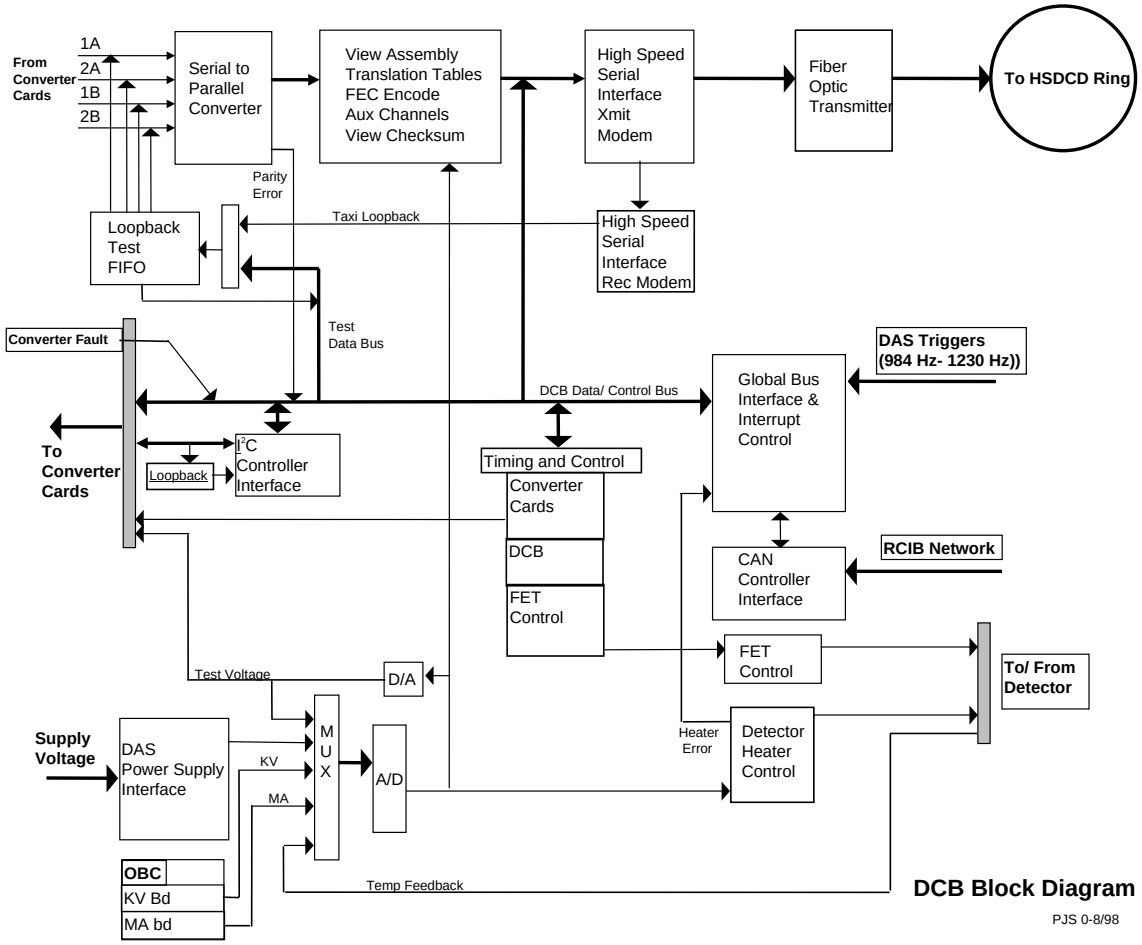


Figure 7-27 DCB Block Diagram

1.2.4.2 Theory of Operation

The DCB is the main control board for the Scaleable Data Acquisition System (SDAS). It handles all the data streams from the converter cards, and packages this data into a single high speed serial data stream. Specifically, it performs the following functions:

- Interfaces with the On-board Controller (OBC) for Rx reception and scan completion, via the CAN interface.
- Sets up and controls the converter cards, via the I^2C interface.
- Receives triggers and starts acquisitions with the converter cards.
- Performs serial-to-parallel conversion on data streams from the converter cards, does parity checking on the data, and runs it through a translation table for view data ordering.
- Adds Forward Error Correction (FEC) to the channel data and sends it across the slip-ring to the Scan Reconstruction Unit (SRU) via the high speed serial interface.
- Detects jitter and time-outs in the view trigger signal.
- Monitors the detector temperature, and controls it by turning the detector heater on and off according to software programmable temperature limits.
- Monitors the power supply voltages to make sure they are within the software programmable limits.

- Acquires the KV and mA values for each scan.
- Controls the FET switch array in the detector to change the number and thickness of scan slices.
- Monitors the SDAS system for various faults.

1.2.4.3 Inputs

- From Converter Boards:
  - Inner Row Serial Data Streams, for a 1, 2, or 4 slice system
  - Outer Row Serial Data Streams, for a 4 slice system
- From On-board Controller (OBC):
  - Input View Triggers
  - KV & mA analog signals
  - CAN Bus communication for scan prescription information
  - Fault Signal
- From Detector: Thermistor connection (for temperature monitoring)

1.2.4.4 Outputs

- To Converter Boards:
  - Shift clock
  - Trigger Signal
  - Control information via the I^2C communication bus
  - Outer Row Serial Data Streams, for a 4 slice system
  - Reset signal
  - Analog test voltage
- To On-board Controller (OBC):
  - Output View Triggers
  - CAN Bus communication for scan complete or error information
  - Fault Signal
- To Detector:
  - FET Control signals
  - Heater relay control (controls heater power supply, which drives the detector heater)
- To Slip-ring [and then on to the Scan Reconstruction Unit (SRU)]: High speed data stream containing the view data with embedded FEC CRC.

1.2.4.5 Error Codes

DCB (& CCB) BOOT OR START-UP ERRORS	ERROR CODE
Boot RAM Test Failure	12
Boot RAM copy of application code failed	13
Boot Code CRC Failure	14
Application CRC Failure	15
Boot Application CRC Failure	16
Application code size invalid	17
Boot Application code size is invalid	18

Table 7-5 DCB (& CCB) Boot/Start-up Errors

DCB (& CCB) APPLICATION ERRORS	ERROR CODE
Application Initialization Errors	
Unable to create controller heartbeat task	20
Unable to initialize the serial interface	21
Unable to init command execution and decode	22
An error was detected using the SCI Driver	23
Unable to init S/W watchdog refresh task	24
Unable to initialize idle task	25
Controller communication Init failed	26
Unable to create memory pool	27
Unable to init programmable Interrupt time	28
Serial Driver is unable to est. pend for read	29
Application Run-time Errors	
Unable to make S/W init required by applications	40
Unable to make MCU init required by applications	41
Unable to silence interrupts	42
Applications hardware failed self-test	43
Unable to create interrupt handlers	44
Unable to initialize hardware	45
Unable to create inter-task communication objects	46
Unable to create application tasks	47
Unable to initialize due to configuration data	48
Unable to initialize due to characterization data	49
Unable to initialize the error logger	50
Unable to initialize the tracer	51
Unable to create error logger task	52
Unable to create tracer task	53
Unable to create Platform task	54

Table 7-6 DCB (& CCB) Application Errors

1.2.4.6 Functional Description

Clock Overview

This section describes all the clocks that the DCB uses to perform its functions.

External Input Clocks

E_TRIG: (External Trigger.) This is the trigger input clock that occurs 984 times for every revolution of the gantry. A positive going edge tells the DCB to begin sampling another “view” of data from the converter cards.

Locally Generated Clocks

2X_SHCK: (Double Frequency Shift Clock.) This is the main 26.8 MHz synchronous clock that is used to move and manipulate the converter stream data until it gets into the left side of the dual port RAM. It is distributed via a clock buffer chip to the X1, X2, and X4 FPGAs.

50: (50MHz Clock.) This clock goes to the X3 FPGA, and is used for FEC generation on the data that comes out of the right side of the dual port RAM. It is divided by four to get the 12.5 MHz high speed serial clock.

TAXI_CLK: (TAXI Clock.) This is a 12.5 MHZ clock driven from X3 that is used to run the high speed serial communication chips.

32M_CLK: (32MHz Clock.) This clock is divided by 2 in the X4 FPGA to get the 16MHz clock used to run the 68332 processor and the CAN interface.

16M_CLK: (16MHz Clock.) This is a 16MHz clock driven by X4 that is used as a clock for the 68332 processor. It is also used as the clock for the CAN interface chip.

I^2C_CLK: ("I-squared C" Clock.) This is an 8MHz clock driven by X4 that is used to clock the two I^2C interface chips. It is derived by dividing the 68332 CLKOUT signal by 2.

AD_CLK: (Analog to Digital Clock.) This is a 1.675 MHz clock from X2 that is used for the A/D converter chip. It is derived by dividing 2X_SHCK by 16. The AD_CLK can be turned on or off by software control.

External Output Clocks

S_TRIG+, S_TRIG-: (Synchronized Trigger.) This differential PECL signal is driven to the converter cards. It is derived from E_TRIG; it has the same frequency, but it is synchronized to the shift clock (SHCK), and it is only one SHCK wide.

SHCK+, SHCK-: (Shift Clock.) This differential PECL clock is the 13.4MHz shift clock driven to the converter cards.

Core Controller

The Core Controller (located on pages 11-13 of the schematic) is the basic computing element on the DCB. It is made up of the following elements:

Motorola 68332 microprocessor

- 1 MByte of FLASH memory
- 1 MByte of SRAM
- Intel 82527 CAN communications interface
- Diagnostic LEDs
- Appropriate reset circuitry

The Core Controller utilizes many of the features of the 68332 microprocessor, such as the RS-232 interface, interrupt controller, and flexible chip select mechanism.

Analog Control Functions

The following analog circuits on the DCB are used for miscellaneous control functions:

A/D Converter (located on page 19 of the schematic). This is a 16-bit ADC that is used to sample all of the various analog voltages on the DCB, including power supplies, ground planes, KV & MA signals, and the detector temperature. All of the analog signals are fed into an analog mux (U46), which continually cycles through its 16 inputs, switching to the next channel every 26.2 us. As each input is sampled by the DAC, its digital value is stored in a software readable register inside the X2 FPGA. It takes 2.62us x 16 = 419.2 us to complete one sampling cycle.

D/A Converter. This is a 14-bit DAC that is used to create an analog control voltage for the converter boards. This control voltage is used for diagnostic purposes on the converter cards, and it is also used to test the ADC. The output range goes from 0 volts (digital input 0x00000) to -5 volts (digital input 0x3ffff).

DCB Interfaces

I^2C INTERFACE

The I^2C interfaces (on page 21 of the schematic) are used to send configuration and diagnostic commands and receive status from each converter card. Two I^2C buses are required for fan out to 48 converter cards. One I^2C bus is used for control/status to even DAS converter cards and one I^2C bus is used for control/status to odd DAS converter cards. Each DCB I^2C Bus Controller is a bus master. Each Converter I^2C port is a bus slave.

A single open-collector Converter Fault line is provided that is pulled by a converter card CPU when it senses any kind of fault. Converter Fault asserted causes a 68332 interrupt. The 68332 polls via the I^2C bus to see which converter card experienced the fault.

CAN INTERFACE

The Controller Area Network (CAN) interface bus is a serial communications interface that operates at a 1 Mbit/sec. data rate. The DCB CAN interface is fully compatible with the Philips CAN Specification 2.0A or 2.0B formats. The CAN protocol is a CSMA/CD-A, or Carrier Sense Multiple Access by Collision Detection using Arbitration Protocol. A single CAN message, with extended identifier, may vary in length from 65 bits (no data) to 129 bits (8 bytes of data). CAN messages are coded using non-return to zero (NRZ) with bit stuffing. All nodes on the CAN bus are listeners, even when they are transmitting (the sender can generate an error frame). All nodes receive and error check every message, even if the node is not the intended destination.

The DCB has two CAN connectors (J4 and J5) that have the same signals tied together for both connectors. This is so that multiple boards can be chained together on the same CAN bus. The only difference in signals between the two connectors is the fault pass-through signal on pin 8. The DCB uses a normally-open FET relay to connect these two pins together. If a fault occurs, the relay is opened, and the host records a fault. All boards in the CAN chain pass the signal through in this manner, and it insures that all boards have CAN cables connected, are powered up, and are fault-free for the system to be operational.

The DCB uses the CAN bus to communicate with the On Board Controller (OBC). For more detailed information about the CAN bus, please see the CAN bus Specification Version 2.0B, and the Core Controller DRS document.

Converter Board Serial Data

Serial data from the converter boards enters the DCB on J6 in 8 PECL serial data streams that run along the SDAS backplane. The DCB converts PECL to TTL, checks the data for odd parity in the X1 FPGA, and interrupts the 68332 Core processor, if there is a parity error.

Check-sums are generated on a view-by-view basis for each view of data in the X2 FPGA, and entered into the data stream header.

Dual Port RAM

The Dual-Port RAM is controlled on the left side by the X2 FPGA, and is controlled on the right side by the X3 FPGA. It serves 2 purposes:

- Serves as a buffer between the synchronous SDAS circuitry that shifts data a 12.73 Mhz rate, and the slower Forward Error Correction (FEC) generator & Optical high speed serial interface,

which operates on a 12.5 Mhz high speed clock.

- Translates data on a byte-per-byte basis from the SDAS backplane with DAS/detector channel dithering into the Scan Data Record format specified in the SDAS DRS.

The 68332 Core processor has read/write access to both ports of the dual-port RAM for diagnostic purposes.

FEC Generation

Forward Error Correction is implemented on a view-by-view basis using a burst error detecting FEC algorithm for data to be sent over the slip-ring. The FEC algorithm must be able to correct up to 6 byte errors per block. Incoming view data are broken up into blocks of 136 bytes, and a 15-byte CRC is added to each block. FEC adds 11.9% overhead to the data rate over the slip-ring.

High Speed Serial Interface

The high speed serial interface is a point-to-point fiber-optic serial communications interface that operates at 125 MBits/sec. It is used to transmit the view data through the RF slip-ring, and on to the Scan Reconstruction Unit (SRU). The high speed serial transmit and receive chips have parallel interfaces to the local CPU bus for easy implementation of a high-speed serial interface. The receive chip contains its own PLL clock generator for data recovery.

High Speed Serial Data Loopback

For diagnostic and test purposes, the DCB has a high speed serial loop-back feature. The high speed receiver chip is only used for test purposes, and not during normal system operations, because the DCB does not receive any high speed serial data from other boards. The loop-back data goes through the X3 FPGA into the test FIFO. From there, it goes into the X1 FPGA, where it can be inserted in place of the Converter Board data, and on into the scan data stream. It is worth noting that the loop-back FIFO can also be written to by the 68332 CPU via the X3 FPGA.

Detector Temperature Control

In order to obtain consistent and accurate results, the X-ray detector must be kept at a constant temperature. The detector temperature is maintained by hardware circuits on the DCB, along with an external power supply that powers a heating element in the detector itself.

The DCB does temperature sensing by monitoring the resistance of a thermistor that is located inside the detector. Hardware circuits on the analog section of the DCB convert the resistance of the thermistor into a digital value that represents the detector temperature. This conversion occurs where the thermistor inputs (DETHTRT+ and DETHTRT-) get connected to the input section of AR3 pins 11 and 12. The output goes through analog mux U46, an analog buffer in AR1, and finally is converted to a digital signal at the 16 bit DAC (U32). The A/D sampling is done once every 419.2 us.

Once in digital form, it is stored in the Detector Heater Analog Aux channel register, located in the X2 FPGA. This register may be monitored by software in order to obtain the current detector temperature. Inside X2, this temperature value is then averaged with the previous 16 samples, and the output is compared with an upper limit register (Detector Heater OFF Temp Set Point Register), and a lower limit register (Detector Heater ON Temp Set Point Register). These limit registers are both software configurable. When the temperature value goes below the lower limit, the DCB enables the heater power supply, via the HTR_ON signal. When the temperature value goes above the upper limit, the DCB turns the heater power supply off. In this way, the DCB can keep the detector at a constant temperature. Since there is no way to cool the detector, the target temperature must be elevated from the ambient temperature (the target temperature is typically set to 36 degrees C).

1.2.5 Backplanes

The backplane used on S-DAS are separated into three sections. A Right, Center, and a Left Backplane are used. The three backplane boards are then connected together via a ribbon cable with a 68–pin connector on each board.

Right Backplane

The Right backplane contains connectors for Converter boards 1 through 14. The pinout of these connectors is defined in Section 2.2.1, beginning on page 515.

Center Backplane

The Center backplane contains connectors for converter boards 15 through 34. The pinout of these connectors is defined in Section 2.2.1, beginning on page 515.

Test Points are available on the Center Backplane to measure Power Supply voltages.

Left Backplane

The Left backplane contains connectors for converter boards 35 through 48. The pinout of these connectors is defined in Section 2.2.1, beginning on page 515.

1.2.6 Elastomers

The Elastomer is a conductor that consists of a single row of metal filaments embedded in a core of silicon rubber. The solid rubber core is placed between two layers of soft silicone rubber.

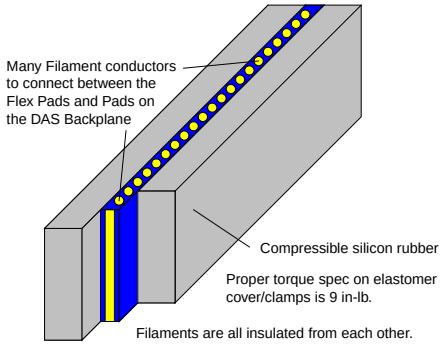
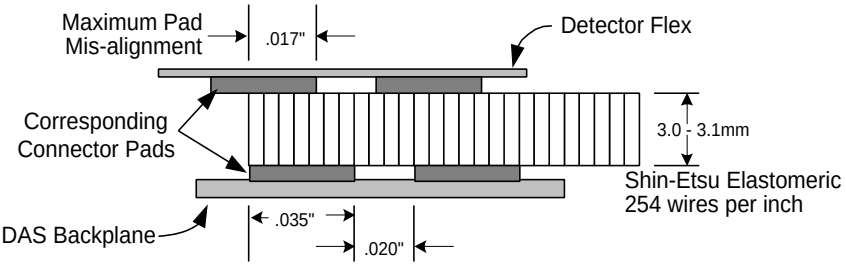


Figure 7-28 Elastomer

The brass filaments are gold plated to be especially resilient. They are treated to spring and can be repeatedly compressed.

The Elastomers are used in the LightSpeed CT System to make an electrical connection between the Detector flexes and S-DAS backplane. Since the output of the Detector is a very low current signal, the connection must be clean from debris and oil, as well as exhibit proper compression. The compression is made by correct torque of the Flex housing cover and clamp: 9 in-lbs.



- With perfect Pad to Pad alignment, there will be 9 elastomeric wire contacts between pads.
- Worst case Pad to Pad mis-alignment, there will be 4 elastomeric wire contacts between pads.

Figure 7-29 Elastomeric Pad Spacing

1.2.7 Detector and S-DAS Channel Mapping (Partial)

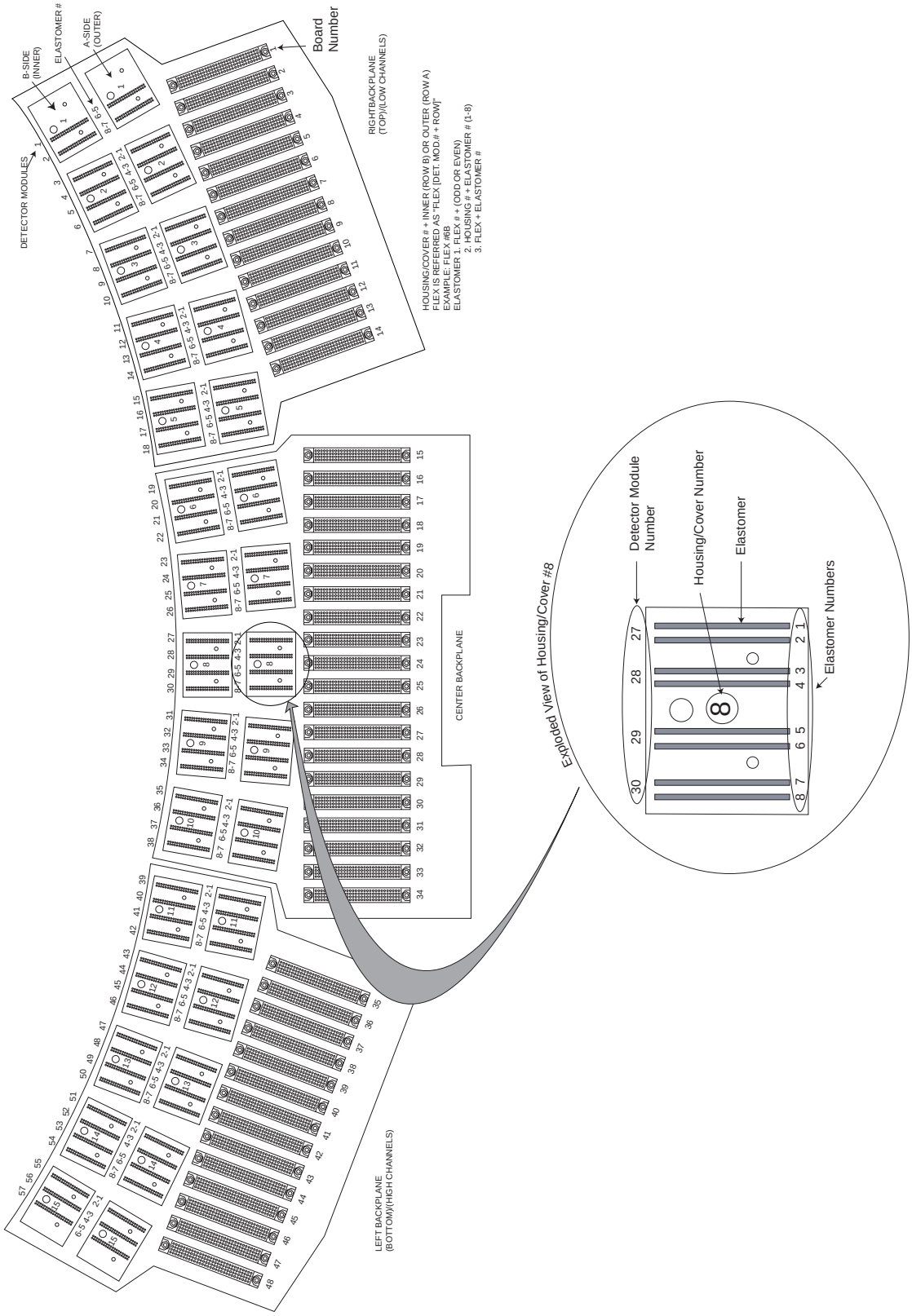


Figure 7-30 Detector/DAS Hardware Architecture Map

1.2.8 DCB Monitoring

1.2.8.1 Hardware

An A/D converter is used to measure the following. It has 16 bits of resolution. The measurements are updated at 1408Hz minimum.

- kV and mA levels from the OBC/Generator
- All SDAS power supply levels
- Test analog voltage generated by a 12bit DAC
- Detector temperature thermistor reading

1.2.8.2 Firmware

The major component of the sub-system monitoring block is an A/D converter that continuously gathers data and writes this data into the Auxiliary channels area of the data header.

Approximately every 250mS, firmware will poll the auxiliary channels that contain DAS power supply voltages and will test the voltages to the margins. If a supply is found to be outside of its margin, a warning message is to be logged into the error log.

Whenever a DAS Rx message is received, firmware will poll detector temperature and will test the temperature against the following limits:

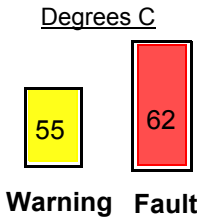
- If the detector temperature is over 36.5 degrees C, issue a warning message and allow scanning to continue.
- If the detector temperature is under 35.5 degrees C, issue a warning message and allow scanning to continue.

1.2.9 Power-On and Warm-Up/DAS Temperature Characteristics

Maximum elapsed time from power-on to full operating temperature is about 1 hour. The normal operating temperature range of the S-DAS is between 25 and 40 degrees Celsius.

Each Converter board has its own temperature sensor that is constantly monitored:

- If the temperature reaches 55 degrees C, then a **Warning Error** message will be posted to the Status Area of the ExamRx Desktop and associated Error Message in the error log.
- If the temperature reaches 62 degrees C, then the S-DAS will report an **Over-Temperature Fault** and will prevent further scanning until the DAS cools and is reset.



Conditions that lead to S-DAS over-temperature faults include:

- Room Environment/Temperature
- S-DAS cooling fans not working or Air Plenum not installed
- S-DAS filters are dirty
- Gantry fans not working properly

1.2.10 SDAS Power-Up Diagnostics

Whenever power is turned on to the DAS or a DAS Reset is performed, the DAS runs a series of Power-Up diagnostics. The sequence of tests is as follows.

DAS / DCB BOOT SEQUENCE AFTER POWER-ON OR RESET

1.) MCU Initialization
2.) RAM Test
3.) Boot Flash CRC Test
4.) Application CRC/size Test
5.) Load the code into RAM (Application code from Flash)
6.) Start the Application code

Once Application code is booted successfully in the DCB, then the DCB establishes itself with the OBC and the DAS Converter boards in the following sequence of initialization and tests:

1.) Platform Software and Hardware Driver initialization.
2.) DCB Hardware self-tests.
3.) Initialize Application Hardware and communication tasks.
4.) Initializes Converter boards, 2 boards at a time, and does this 6 times. This when the Converter board LEDs flash several short times in sequence from board 1 through 48. The Converter board initialization consists of:
    - Converter board access (Read/writes)
    - Initialization
    - Reading of EEPROM
    - Set of Temperature sensors
    - Setting of Offset Trim
    - Calibration
    - Fault line test
5.) When all the converter boards are initialized, the DCB performs the following tasks:
    - Updates configure Tracker and version verification data
    - Reads Converter board temperature tests
    - Runs a quick data path test (2 views worth of data)
6.) Ready to Interface with OBC.

In an error condition, the error is reported to the DCB if possible (depending on the type of fault), and then the DCB relays the information to the OBC, and finally to the system error log. If the DCB is at fault and cannot communicate with the OBC, then a DAS Communication Error is logged.

Section 2.0
Jumpers, Switches, Adjustments, LEDs & Connections

2.1 Detector Heater Power Supply

Refer to "Collimator/Detector Heater Power Supply," on page 740.

2.2 DAS

2.2.1 External Interface Pinouts

This section details connector pinouts for all external interfaces on the DCB.

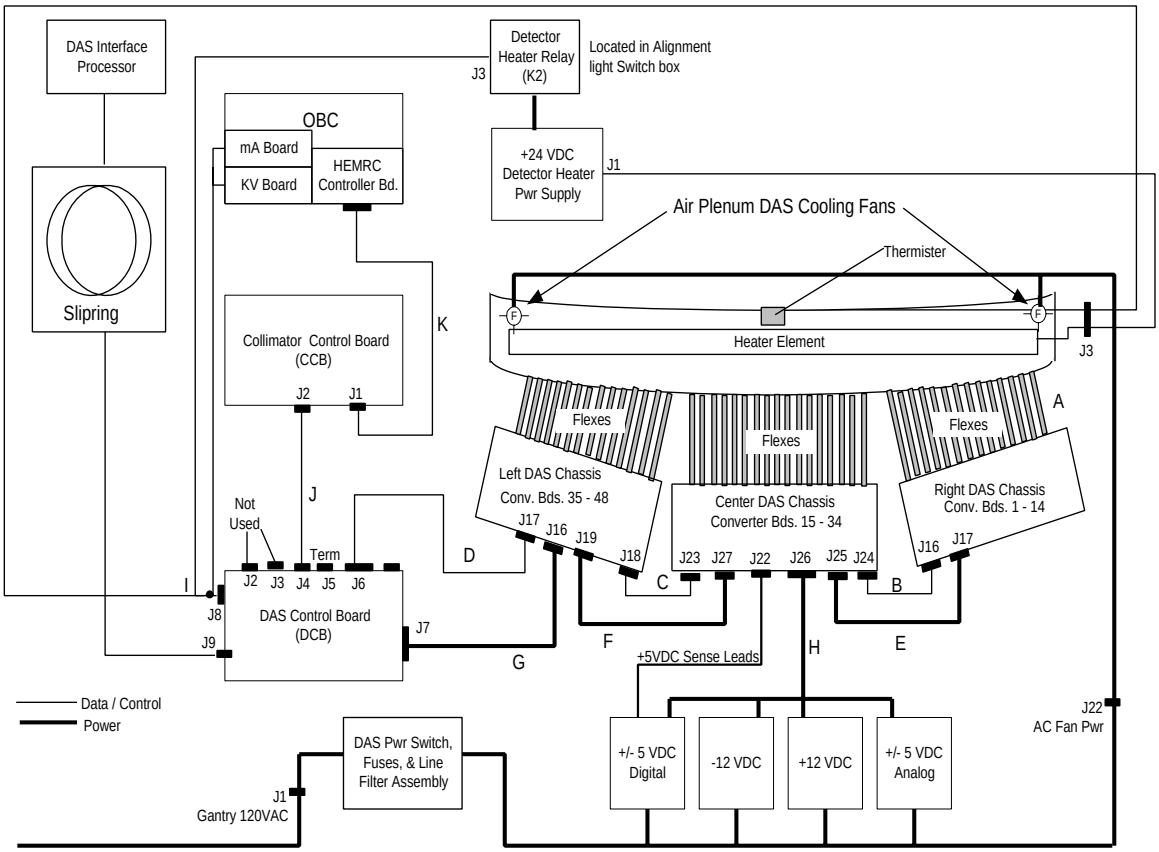


Figure 7-31 S-DAS Interface Pinout Block Diagram

Note: Letters next to Interconnect Cables represents further detailed descriptions in following pages.

2.2.1.1 Cable A (Detector Flex)

Detector Flex - The Detector Flexes are used to electrically connect the Detector Output Channels to the DAS Backplane. There are 96 Flexes used. Each Flex contains 32 Data signal output runs, 5 FET control runs, and Power and Ground runs.

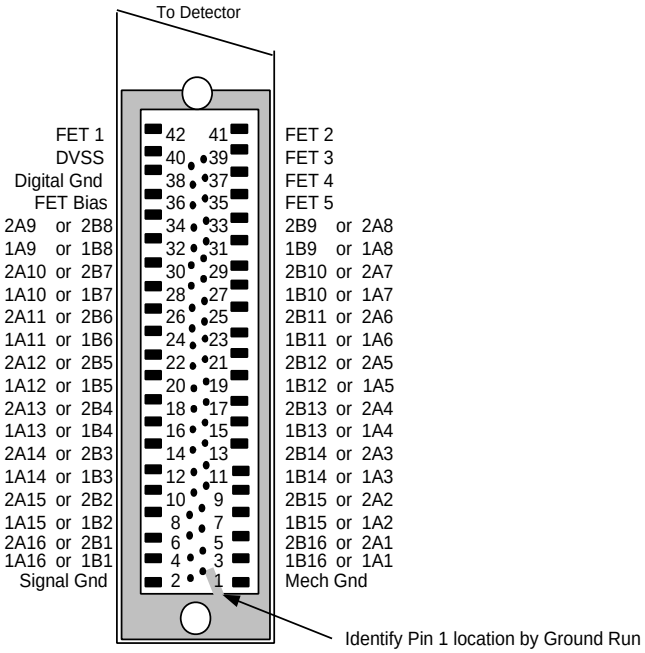


Figure 7-32 Cable A Detector Flex Pinout

2.2.1.2 Cable B, C, & D (DAS Data Cables)

DAS Data Cables between DCB, Left DAS Chassis, Center DAS Chassis, and Right DAS Chassis

DCB Connector-Pin #	I/O A	Signal Name D	Left DAS Connector-Pin #		I/O C	Center DAS Connector-Pin #		I/O B	Right DAS Connector-Pin #
J6 - 1	-	LGND	J17 - 1	J18 - 1	-	J23 - 1	J24 - 1	-	J16 - 1
J6 - 2	I	RDT_O2A+	J17 - 2	J18 - 2	I	J23 - 2	J24 - 2	I	J16 - 2
J6 - 3	I	RDT_O2A-	J17 - 3	J18 - 3	I	J23 - 3	J24 - 3	I	J16 - 3
J6 - 4	I	RDT_E2A+	J17 - 4	J18 - 4	I	J23 - 4	J24 - 4	I	J16 - 4
J6 - 5	I	RDT_E2A-	J17 - 5	J18 - 5	I	J23 - 5	J24 - 5	I	J16 - 5
J6 - 6	I	RDT_O1A+	J23 - 6	J18 - 6	I	J23 - 6	J24 - 6	I	J16 - 6
J6 - 7	I	RDT_O1A-	J23 - 7	J18 - 7	I	J23 - 7	J24 - 7	I	J16 - 7
J6 - 8	I	RDT_E1A+	J23 - 8	J18 - 8	I	J23 - 8	J24 - 8	I	J16 - 8
J6 - 9	I	RDT_E1A-	J23 - 9	J18 - 9	I	J23 - 9	J24 - 9	I	J16 - 9
J6 - 10	I	RDT_O1B+	J23 - 10	J18 - 10	I	J23 - 10	J24 - 10	I	J16 - 10
J6 - 11	I	RDT_O1B-	J23 - 11	J18 - 11	I	J23 - 11	J24 - 11	I	J16 - 11
J6 - 12	I	RDT_E1B+	J23 - 12	J18 - 12	I	J23 - 12	J24 - 12	I	J16 - 12
J6 - 13	I	RDT_E1B-	J23 - 13	J18 - 13	I	J23 - 13	J24 - 13	I	J16 - 13
J6 - 14	I	RDT_O2B+	J23 - 14	J18 - 14	I	J23 - 14	J24 - 14	I	J16 - 14
J6 - 15	I	RDT_O2B-	J23 - 15	J18 - 15	I	J23 - 15	J24 - 15	I	J16 - 15

Table 7-7 DAS Data Cables

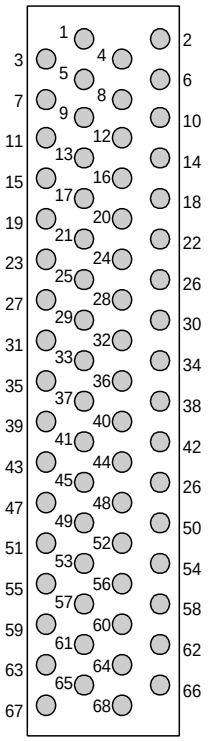
DCB Connector-Pin #	I/O A	Signal Name D	Left DAS Connector-Pin #		I/O C	Center DAS Connector-Pin #		I/O B	Right DAS Connector-Pin #
J6 - 16	I	RDT_E2B+	J23 - 16	J18 - 16	I	J23 - 16	J24 - 16	I	J16 - 16
J6 - 17	I	RDT_E2B-	J23 - 17	J18 - 17	I	J23 - 17	J24 - 17	I	J16 - 17
J6 - 18	-	LGND	J23 - 18	J18 - 18	-	J23 - 18	J24 - 18	-	J16 - 18
J6 - 19	I/O	I2C_SDA1	J23 - 19	J18 - 19	I/O	J23 - 19	J24 - 19	I/O	J16 - 19
J6 - 20	I/O	I2C_SCL1	J23 - 20	J18 - 20	I/O	J23 - 20	J24 - 20	I/O	J16 - 20
J6 - 21	I/O	I2C_SDA2	J23 - 21	J18 - 21	I/O	J23 - 21	J24 - 21	I/O	J16 - 21
J6 - 22	I/O	I2C_SCL2	J23 - 22	J18 - 22	I/O	J23 - 22	J24 - 22	I/O	J16 - 22
J6 - 23	-	LGND	J23 - 23	J18 - 23	-	J23 - 23	J24 - 23	-	J16 - 23
J6 - 24	I	CVTR_VCC	J23 - 24	J18 - 24	I	J23 - 24	J24 - 24	I	J16 - 24
J6 - 25	-	LGND	J23 - 25	J18 - 25	-	J23 - 25	J24 - 25	-	J16 - 25
J6 - 26	O	SHCK+	J23 - 26	J18 - 26	O	J23 - 26	J24 - 26	O	J16 - 26
J6 - 27	O	SHCK+	J23 - 27	J18 - 27	O	J23 - 27	J24 - 27	O	J16 - 27
J6 - 28	O	SHCK-	J23 - 28	J18 - 28	O	J23 - 28	J24 - 28	O	J16 - 28
J6 - 29	O	SHCK-	J23 - 29	J18 - 29	O	J23 - 29	J24 - 29	O	J16 - 29
J6 - 30	-	LGND	J23 - 30	J18 - 30	-	J23 - 30	J24 - 30	-	J16 - 30
J6 - 31	I	S_TRIG+	J23 - 31	J18 - 31	I	J23 - 31	J24 - 31	I	J16 - 31
J6 - 32	I	S_TRIG+	J23 - 32	J18 - 32	I	J23 - 32	J24 - 32	I	J16 - 32
J6 - 33	I	S_TRIG-	J23 - 33	J18 - 33	I	J23 - 33	J24 - 33	I	J16 - 33
J6 - 34	I	S_TRIG-	J23 - 34	J18 - 34	I	J23 - 34	J24 - 34	I	J16 - 34
J6 - 35	-	LGND	J23 - 35	J18 - 35	-	J23 - 35	J24 - 35	-	J16 - 35
J6 - 36	O	CV_FLT*	J23 - 36	J18 - 36	O	J23 - 36	J24 - 36	O	J16 - 36
J6 - 37	O	CV_RST	J23 - 37	J18 - 37	O	J23 - 37	J24 - 37	O	J16 - 37
J6 - 38	O	CV_X_PRG*	J23 - 38	J18 - 38	O	J23 - 38	J24 - 38	O	J16 - 38
J6 - 39	-	LGND	J23 - 39	J18 - 39	-	J23 - 39	J24 - 39	-	J16 - 39
J6 - 40	-	AGND	J23 - 40	J18 - 40	-	J23 - 40	J24 - 40	-	J16 - 40
J6 - 41	-	AGND	J23 - 41	J18 - 41	-	J23 - 41	J24 - 41	-	J16 - 41
J6 - 42	O	CV_WR_PRTCT	J23 - 42	J18 - 42	O	J23 - 42	J24 - 42	O	J16 - 42
J6 - 43	-	AGND	J23 - 43	J18 - 43	-	J23 - 43	J24 - 43	-	J16 - 43
J6 - 44	-	AGND	J23 - 44	J18 - 44	-	J23 - 44	J24 - 44	-	J16 - 44
J6 - 45	O	IDFET1	J23 - 45	J18 - 45	O	J23 - 45	J24 - 45	O	J16 - 45
J6 - 46	O	IDFET2	J23 - 46	J18 - 46	O	J23 - 46	J24 - 46	O	J16 - 46
J6 - 47	O	IDFET3	J23 - 47	J18 - 47	O	J23 - 47	J24 - 47	O	J16 - 47
J6 - 48	O	IDFET4	J23 - 48	J18 - 48	O	J23 - 48	J24 - 48	O	J16 - 48
J6 - 49	O	IDFET5	J23 - 49	J18 - 49	O	J23 - 49	J24 - 49	O	J16 - 49
J6 - 50	-	AGND	J23 - 50	J18 - 50	-	J23 - 50	J24 - 50	-	J16 - 50
J6 - 51	O	ODFET1	J23 - 51	J18 - 51	O	J23 - 51	J24 - 51	O	J16 - 51
J6 - 52	O	ODFET2	J23 - 52	J18 - 52	O	J23 - 52	J24 - 52	O	J16 - 52
J6 - 53	O	ODFET3	J23 - 53	J18 - 53	O	J23 - 53	J24 - 53	O	J16 - 53

Table 7-7 DAS Data Cables (Continued)

DCB Connector-Pin #	I/O A	Signal Name D	Left DAS Connector-Pin #		I/O C	Center DAS Connector-Pin #		I/O B	Right DAS Connector-Pin #
J6 - 54	O	ODFET4	J23 - 54	J18 - 54	O	J23 - 54	J24 - 54	O	J16 - 54
J6 - 55	O	ODFET5	J23 - 55	J18 - 55	O	J23 - 55	J24 - 55	O	J16 - 55
J6 - 56	-	AGND	J23 - 56	J18 - 56	-	J23 - 56	J24 - 56	-	J16 - 56
J6 - 57	O	ZFET1	J23 - 57	J18 - 57	O	J23 - 57	J24 - 57	O	J16 - 57
J6 - 58	O	ZFET2	J23 - 58	J18 - 58	O	J23 - 58	J24 - 58	O	J16 - 58
J6 - 59	O	ZFET3	J23 - 59	J18 - 59	O	J23 - 59	J24 - 59	O	J16 - 59
J6 - 60	O	ZFET4	J23 - 60	J18 - 60	O	J23 - 60	J24 - 60	O	J16 - 60
J6 - 61	O	ZFET5	J23 - 61	J18 - 61	O	J23 - 61	J24 - 61	O	J16 - 61
J6 - 62	-	AGND	J23 - 62	J18 - 62	-	J23 - 62	J24 - 62	-	J16 - 62
J6 - 63	-	AGND	J23 - 63	J18 - 63	-	J23 - 63	J24 - 63	-	J16 - 63
J6 - 64	-	AGND	J23 - 64	J18 - 64	-	J23 - 64	J24 - 64	-	J16 - 64
J6 - 65	O	TEST_V+	J23 - 65	J18 - 65	O	J23 - 65	J24 - 65	O	J16 - 65
J6 - 66	O	TEST_V-	J23 - 66	J18 - 66	O	J23 - 66	J24 - 66	O	J16 - 66
J6 - 67	-	AGND	J23 - 67	J18 - 67	-	J23 - 67	J24 - 67	-	J16 - 67
J6 - 68	-	AGND	J23 - 68	J18 - 68	-	J23 - 68	J24 - 68	-	J16 - 68

Table 7-7 DAS Data Cables (Continued)

Figure 7-33 shows the Left DAS Backplane J17 Connector, as viewed from the solder side.



Data Cable Connector on Solder side of DAS Backplanes

Figure 7-33 Data Cable Connector

2.2.1.3 Cable E (Inter-DAS Power Cable)

DAS Power Cable between Center (J25) and Right DAS Chassis' (J23)

CENTER CHASSIS CONNECTOR - PIN #	COLOR	DESCRIPTION	RIGHT CHASSIS CONNECTOR - PIN #
J25 - 1	Red	+5VDC Digital	J17 - 1
J25 - 2	Green	Digital Ground	J17 - 2
J25 - 3	Orange	+5VDC Analog	J17 - 3
J25 - 4	Brown	5V Analog Ground	J17 - 4
J25 - 5	Yellow	-5VDC Analog	J17 - 5
J25 - 6	Blue	+12VDC Analog	J17 - 6
J25 - 7	Black	12V Analog Ground	J17 - 7
J25 - 8	White	-12VDC Analog	J17 - 8

Table 7-8 Cable E - DAS Power Cable

2.2.1.4 Cable F (Inter-DAS Power Cable)

DAS Power Cable between Center (J27) and Left DAS Chassis' (J19)

CENTER CHASSIS CONNECTOR - PIN #	COLOR	DESCRIPTION	LEFT DAS CHASSIS CONNECTOR - PIN #
J27 - 1	Red	+5VDC Digital	J19 - 1
J27 - 2	Green	Digital Ground	J19 - 2
J27 - 3	Orange	+5VDC Analog	J19 - 3
J27 - 4	Brown	5V Analog Ground	J19 - 4
J27 - 5	Yellow	-5VDC Analog	J19 - 5
J27 - 6	Blue	+12VDC Analog	J19 - 6
J27 - 7	Black	12V Analog Ground	J19 - 7
J27 - 8	White	-12VDC Analog	J19 - 8

Table 7-9 Cable F- DAS Power Cable

2.2.1.5 Cable G (Inter-DAS Power Cable)

DAS Power Cable between DCB (J7) and Left DAS Chassis' (J16)

DCB CONNECTOR - PIN #	COLOR	DESCRIPTION	LEFT DAS CHASSIS CONNECTOR - PIN #
J7 - 1	Red	+5VDC Digital	J16 - 1
J7 - 2	Green	Digital Ground	J16 - 2
J7 - 3	Orange	+5VDC Analog	J16 - 3
J7 - 4	Brown	5V Analog Ground	J16 - 4
J7 - 5	Yellow	-5VDC Analog	J16 - 5
J7 - 6	Blue	+12VDC Analog	J16 - 6
J7 - 7	Black	12V Analog Ground	J16 - 7
J7 - 8	White	-12VDC Analog	J16 - 8

Table 7-10 Cable G - DAS Power Cable

2.2.1.6 Cable H (DAS Power Harness)

DAS Power Harness from DAS Power Supplies to Center DAS Chassis (J26 & J22)

CENTER CHASSIS CONNECTOR - PIN #	COLOR	DESCRIPTION	DAS POWER SUPPLIES CONNECTOR - PIN #
J26 - 1	Red	+5VDC Digital	Large 5VDC Supply (+OUT)
J26 - 2	Green	Digital Ground	Large 5VDC Supply (- COM)
J26 - 3	Orange	+5VDC Analog	Small 5VDC Supply (+5VDC)
J26 - 4	Brown Brown	5V Analog Ground	Small 5VDC Supply (+5V Rtn) Small 5VDC Supply (-5V Rtn)
J26 - 5	Yellow	-5VDC Analog	Small 5VDC Supply (-5VDC)
J26 - 6	Blue	+12VDC Analog	Middle 12VDC Supply (+OUT)
J26 - 7	Black Black	12V Analog Ground	12VDC Supply (+12V Rtn) 12VDC Supply (-12V Rtn)
J26 - 8	White	-12VDC Analog	Lower 12VDC Supply (-OUT)
		+ 5VDC Digital Power Supply Sense Leads	
J22 - 1	Black	+ 5VDC Digital Power Supply Sense Leads	5VDC Supply
J22 - 2	White	+ 5VDC Digital Power Supply Sense Leads	5VDC Supply

Table 7-11 Cable H - DAS Power Harness

2.2.1.7 Cable I (Analog Interface Cable)

Analog Interface Cable DCB (J8) to OBC and Detector - The Analog Interface Cable is used for monitoring the KV & MA analog control voltages, Detector temperature, and controlling the Detector heater power supply.

DCB CONNECTOR - PIN #	SIGNAL NAME	SIGNAL DIRECTION	DESCRIPTION	CONNECTOR - PIN #
J8 - 1	DTHTR_RLY	OUT	Detector Heater `Relay	J3 - 14 (Red Wire going to Relay)
J8 - 2	DETHTRT+	IN	Detector Heater Thermistor (pos)	J3 - 1 / Near Right DAS Chassis
J8 - 3	KV_MEA+	IN	KV Signal Input (pos)	A4 - J3 - C8 / OBC Backplane
J8 - 4	MA_MEA+	IN	MA Signal Input (pos)	A3 - J3 - C19 / OBC Backplane
J8 - 5	DTHTR_RTN	OUT	Detector Heater Relay Return	J3 - 7 (Black wire to Relay))
J8 - 6	DETHTRT-	IN	Detector Heater Thermistor (neg)	J3 - 2 / Near Right DAS Chassis
J8 - 7	KV_MEA-	IN	KV Signal Input (neg)	A4 - J3 - A8 / OBC Backplane
J8 - 8	MA_MEA-	IN	MA Signal Input (neg)	A3 - J3 - A19 / OBC Backplane
J8 - 9	-	-	No Connect	9

Table 7-12 Cable I - Analog Interface Cable

2.2.1.8 Cable J (RCIB Cable)

Rotating Controller Interface Bus (RCIB) Cable

HEMRC CONNECTOR - PIN #	SIGNAL NAME	CCB CONNECTOR - PIN #	DESCRIPTION	DCB CONNECTOR - PIN #
A2 - J3 - C4	IGND	J1 - 1	Isolated GND	J4 - 1
A2 - J3 - A5	CANH	J1 - 2	CAN data line (positive)	J4 - 2
A2 - J3 - A9	FLT_P	J1 - 3	Fault signal (positive)	J4 - 3
A2 - J3 - C14	RESET_P	J1 - 4	Reset signal (positive)	J4 - 4
A2 - J3 - C15	ExpCMD_P	J1 - 5	Exposure command signal (positive)	J4 - 5
	None	J1 - 6	Connects to J5 pin 6	J4 - 6
A2 - J3 - C16	TRIG_P	J1 - 7	External view trigger signal (positive)	J4 - 7
A2 - J3 - A8	PSFB	J1 - 8	Fault pass-through signal	J4 - 8
A2 - J3 - A4	RAW_+12V_CAN	J1 - 9	+12 volt CAN power	J4 - 9
A2 - J3 - C5	CANL	J1 - 10	CAN data line (negative)	J4 - 10
A2 - J3 - C9	FLT_N	J1 - 11	Fault signal (negative)	J4 - 11
A2 - J3 - A14	RESET_N	J1 - 12	Reset signal (negative)	J4 - 12
A2 - J3 - A15	ExpCMD_N	J1 - 13	Exposure command signal (negative)	J4 - 13
	None	J1 - 14	Connects to J5 pin 14	J4 - 14
A2 - J3 - A16	Trig_N	J1 - 15	External view trigger signal (negative)	J4 - 15

Table 7-13 Cable J - RCIB Cable

Note: The DAS Triggers that come from the SCOM across the slip-ring to the RCOM are then sent to the HEMRC board via wires on the OBC backplane.

RCOM BOARD CONNECTOR - PIN #	DESCRIPTION	HEMRC CONNECTOR - PIN #
A6 - J3 - A11	Trigger + Signal from RCOM to HEMRC	A2 - J3 - A11
A6 - J3 - C11	Trigger - Signal from RCOM to HEMRC	A2 - J3 - C11

Table 7-14 RCOM Board / HEMRC Connection

2.2.2 DAS Backplane Voltage Test Points

TEST POINT	DESCRIPTION
TP1	+12 VDC Analog wrt AGND
TP2	-12 VDC Analog wrt AGND
TP3	+5 VDC Analog wrt AGND
TP4	-5 VDC Analog wrt AGND
TP5	+5 VDC Digital wrt LGND
TP6	AGND (Analog Ground)
TP7	LGND (Logic Ground)

Table 7-15 Backplane Voltage Test Points

2.2.3 DAS Control Board (DCB)

2.2.3.1 Board Layout

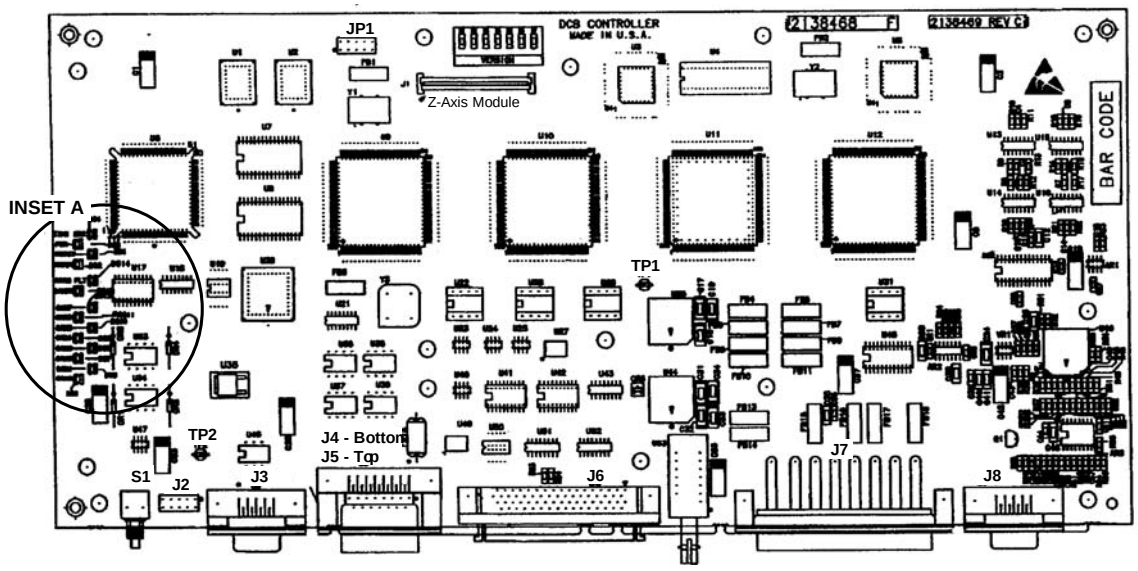


Figure 7-34 DAS Control Board Layout

ITEM	DESCRIPTION	ITEM	DESCRIPTION
S1	DCB Board Reset switch	J6	DAS Data from Converter Chassis'
JP1	Development Jumpers, No jumpers for normal operation	J7	DC Power Connector
JP2	Development Jumpers, No jumpers for normal operation	J8	KV / mA and Detector Heater
J3	Development (Not Used)	J9	Fibre Optic, High Speed Serial DAS Data Out
J4	RCIB	TP1	+5 VDC Digital
J5	RCIB Termination	TP2	Digital Ground

Table 7-16 DAS Control Board - Switch, Connector and Test Point Descriptions

Pushbutton Reset

The pushbutton reset, S1, initiates a hard reset to all the board logic. This initializes all the hardware to a known state, and causes the Core 68332 processor to reboot. The X1 - X4 FPGAs, however, are only reconfigured from serial EPROM at board power-up.

Test Points

The DCB has the following test points:

- *TP1*: +5V Digital Power
- *TP2*: Digital Ground

Jumpers

The DCB has 5 jumpers at block JP1. The factory configuration for each jumper is OUT.

- *JP1 1-2*: IN = Boots the loader; OUT = Boots the application.

  When this jumper is IN, the RS-232 serial port on J3 is enabled at 19.2K baud, allowing interactive debugging with a dumb terminal or PC.
- *JP1 3-4*: IN =Test Mode for X4 (tri-states all outputs); OUT=Normal
- *JP1 5-6*: IN =Test Mode for X1 (tri-states all outputs); OUT=Normal
- *JP1 7-8*: IN =Test Mode for X2 (tri-states all outputs); OUT=Normal
- *JP1 9-10*: IN =Test Mode for X3 (tri-states all outputs); OUT=Normal

2.2.3.2 LEDs

The figure below shows the configuration of the LEDs on the DCB. For location of the LED array on the DCB, refer to Figure 7-34 (marked “INSET A”).

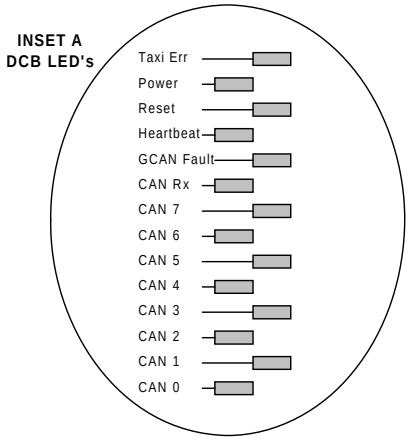


Figure 7-35 DCB LEDs (Inset “A” from Figure 7-34)

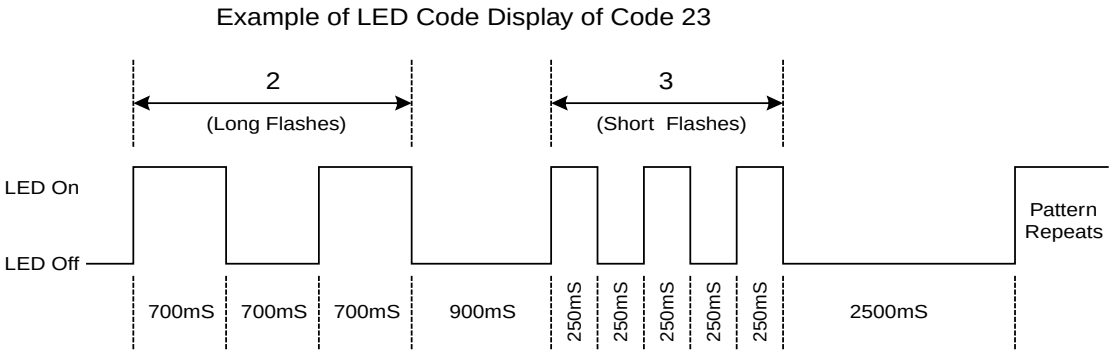


Figure 7-36 Pulse Sequence Example

LED	DESCRIPTION	NORMAL STATUS
Taxi Err	This Green LED will be on in the case of a Taxi link error.	Off
Power	This Green LED should remain ON at all times, if proper +5VDC is applied to the Controller board.	On
Reset	This LED comes on when the board is reset and will turn Off after a successful reset.	Off
Heartbeat	This LED will Flash a Error code if the micro-Controller Unit (MCU) fails boot-up. All other CAN LEDs will be turned ON. Refer to Boot-Up Error Code Table and Example of Pulse sequence display.	Flashing at 1 sec. interval
GCAN Fault	Represents the current or “Real” state of the fault line. If ON, the Fault Line is asserted. LED color is Yellow.	Off
CAN Rx	This LED flashes during data receive on the CAN bus.	Off
CAN 7	This LED will flash a error code sequence if a fault is detected while the DCB is running applications. Refer to Application Fault Error Code Table and Example of Pulse sequence display.	Off
CAN 6	LED ON: DCB is connected to OBC LED OFF: DCB is not connected to OBC	On
CAN 5	LED ON: F/W thinks Fault line is asserted. Check GCAN LED for “Real” state of fault line. LED OFF: F/W thinks Fault line is Not asserted	Off
CAN 4	LED ON: F/W sends command to prep or monitor Fault Line. Check GCAN LED for “Real” state of fault line. LED OFF: Fault line NOT Set	On
CAN 3	LED ON: DCB in Shutdown LED OFF: Not in Shutdown	Off
CAN 2	LED ON: In collection of Scan Views LED OFF: Not in Scan View collection	Off
CAN 1	LED ON: In collection of Offsets LED OFF: Not in Offset collection	Off
CAN 0	LED ON: Trigger seen for View / Offsets LED OFF: No Triggers detected	Off

Table 7-17 DCB LED Descriptions

2.3 DAS Power Supply Adjustments

Refer to "DAS Power Supplies (2225212-2 ±5 vdc, 2225217 (2) 12 vdc)," on page 572.

2.4 S-DAS - Flex Housing and Clamping

When installing Detector Flexes to the S-DAS backplane, it is very important to exercise all ESD precautions. Use of a ground wrist strap and finger cots is required, when handling the Detector Flexes.

Remove the Detector ESD Boots from 4 Detector flexes at a time.

Clean with alcohol pads to remove any dirt, debris or oils from electrical contacts.

Install 4 flexes on the Housing and install the housing cover.

While holding the housing cover in place, install 2 clamp plates and torque the clamp plates to 9 in-lbs. This is an extremely critical torque spec. Too little, the electrical connection will not be good and produce intermittent opens, noise, or popping. Too much and the elastomer will bend, causing a poor connection.

There have been tolerance stack-up measurements to determine the appropriate amount of compression to the elastomer to provide a reliable connection.

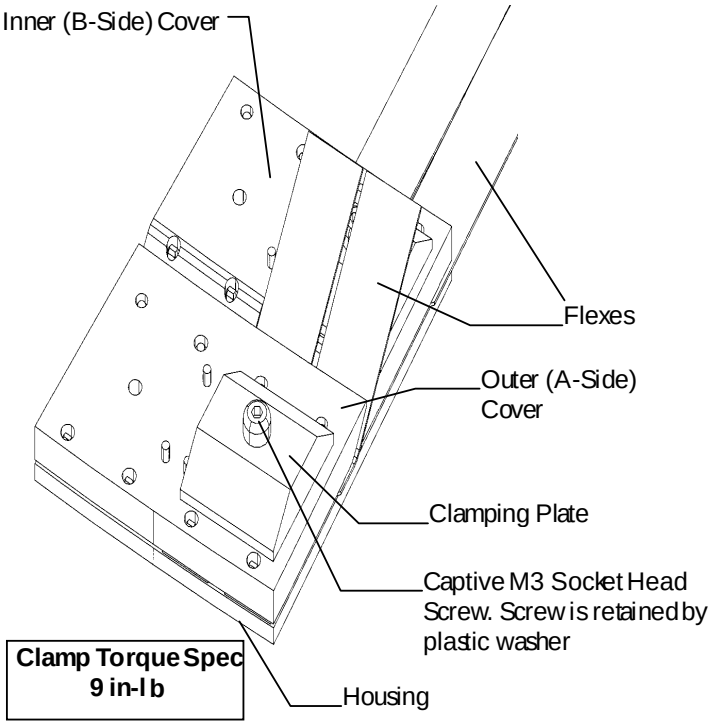


Figure 7-37 Flex Housing and Clamping

2.4.1 DAS Cleaning

OBJECTIVE OF PROCEDURE

DAS Converter boards and/or Chassis has accumulated Dirt/Dust. Dirt/Dust is typically seen more apparent in the chassis that have the cooling fan, especially the Right DAS chassis, which is closest to the floor when the Gantry is in the “Park” position. Filters are currently being investigated for proper filtration and air flow.

PROCEDURE DETAILS

1.) Accumulate Cleaning Materials.
- Compressed Air: Air must be manufactured for cleaning electronic devices and does not contain any class I or II cleaning chemicals. Propellant is 2-Tetrafluoroethane. Use of a ESD nozzle is suggested.
- Vacuum: It is suggested to use the following vacuum:
  - ESD Type Vacuum Cleaner (120VAC)
  - ESD Type Vacuum Cleaner (220/240VAC)
- Filters and accessories:
  - Vacuum Cleaner: Anti-Static Dusting Brush
  - ESD Type Vacuum Cleaner Filter, (10 per box)
- ESD Materials (Wrist strap, mat, etc.)
- ESD Board bags (Optional, obtain locally)
- High Output Ionizing Fan (Optional. Refer to Appendix F - ESD Management and Device Handling for instructions on use.)

2.) Take a DC Noise baseline scan using DASTools Manual test.
- This is to establish the DAS' current noise characteristics. Do not troubleshoot any noise failures until after the cleaning. The cleaning may "fix" some noise issues.
- Since this procedure requires the removal and handling of the Converter boards, it may induce problems. The baseline scans will be repeated after cleaning to verify DAS performance, however it may be important to know if the cleaning caused problems or if the DAS had characteristics spikes, humps before the cleaning. This information will help determine if troubleshooting or further DAS integration is necessary.

3.) Turn Off DAS Power Supplies

4.) Remove the Air Plenum (Fan Cover)

5.) Remove front chassis cover to gain access to boards.

6.) Clean 1 chassis at a time. Manually rotate the Gantry so that the DAS is at the 90 degree position. Clean the Right Chassis (or top chassis) first.

7.) Remove all the circuit cards from the chassis in sequence.
- Each board should be placed in an ESD bag or on an ESD mat.
- The order of the boards must be noted so that when the boards are re-installed, they are in the same location as original. This way, only FastCal will need to be performed. If the boards are not in the same location, Full Air and Phantom Calibrations will be required, including DAS Gain and collimator Cals.
- Cleaning the Chassis:
  - Using the compressed air, blow air from the inner diameter of the chassis. At the same time, use the vacuum on the outside of the chassis to "catch" the dirt/dust. This will also help avoid the dirt/dust from blowing around.
  - Blow air around the connectors, corners of chassis, and chassis holes. Visually inspect, and manually remove any debris that is not blown out.

- Use the ionizing fan on the empty chassis, to remove any built-up charge.

- Cleaning the Converter Boards:
  - Make sure you are fully grounded using your ESD strap.
  - Hold one board at time, and blow compressed air across the board, removing the dirt/dust that may have accumulated between component pins, etc.
  - After the board is cleaned, use the ionizing fan to remove any built-up charges on the board, and then re-install the board in its original location. Failure to do this may cause phantom calibrations to be re-done.
  - Repeat steps until all chassis and boards are cleaned and installed.
  - Turn the DAS on and let it warm-up. It takes 2 minutes of warm-up time for every minute the DAS was turned off, up to 2 hours. The DAS can be warming up while the Air Plenum is being cleaned.
- Cleaning the Air Plenum.
  - Blow or vacuum off the dirt/dust from the inside of the Air Plenum, as well as from the cooling fan blades, and in the future, the filter material.
  - Re-install the Air Plenum.
- Verify all covers are installed, and complete the following tests within DASTools:
  - 1 iteration of DC Means / Noise
  - 1 iteration of microphonics / pop

  All tests must pass. If not, troubleshoot and correct the failures Refer to DAS Troubleshooting Job cards for reference.
- 3.7.7 Complete a FastCal and verify Image Quality by scanning the 48cm phantom using the Service Protocol: "Image Series 48cm" and image specifications.

SCAN TYPE	PHANTOM	KV	MA	SFOV	THICKNESS	SCAN TIME	START/END LOCATIONS	# OF SCANS
Axial	48 cm	120	340	Large	5 mm (4i)	1.0 Sec.	I7.5/S7.5	4

Table 7-18 Service Protocol

EXAM/SERIES/ IMAGE	AVXC	AVXO	AVXO - AVXC	AVG. STD. DEV.	COMMENTS
1, 5, 9, 13					
2, 6, 10, 14					
3, 7, 11, 15					
4, 6, 12, 16					
Specs	---	---	±8.5	<40.0	

Table 7-19 Image Series Data

Box Size:45 x 45 pixels

Center Coordinates: 256, 256

Outside Coordinates: 256, 60452, 256256, 45260, 256

2.4.2 CT S-DAS Cleaning and De-Ionizing Procedure

OBJECTIVE OF THE PROCEDURE

The following procedure should be followed when DAS Converter boards and/or chassis need cleaning, or Converter boards are replaced for microphonics or noise resulting in image artifacts (rings, bands, streaks and smudges).

TOOLS REQUIRED

1.) Static Wrist Strap and cord
2.) Lint free Towels.
3.) Amax Contact, and Circuit Cleaner
4.) DAS/DET Interface Kit

Contains rubber gloves, static nozzle for use with compressed air and static bags needed by this procedure.

5.) Aero Duster
6.) Screw driver (flat) size # 6
7.) High Output Ionizing Fan (Refer to Appendix F - ESD Management and Device Handling for instructions on use.)

WARNING **ROTATING GANTRY CAN CAUSE SEVERE INJURY OR DEATH. MAKE SURE GANTRY IS PROPERLY DE-ENERGIZED AND LOCKED WHILE PERFORMING THIS SERVICE. FOLLOW THE GANTRY SAFETY INSTRUCTIONS IN CHAPTER 1 OF THE SYSTEM SERVICE MANUAL.**

NOTICE **Mishandling can easily damage converter cards. Handle only on the sides and only with proper ESD protection. Do not touch the connector. Cards should always be placed in a Static Bag when not in the DAS.**

CAUTION **Store Amax Cleaner at Site with MSDS document. Do not store in the company car. Use spray as directed in this procedure. Safety glasses and finger cots must be worn when using the spray.**

PROCEDURE

Take DC Noise baseline scan using DASTools Manual test (use default settings) to establish the current noise characteristics of DAS. Do not troubleshoot any noise failures until after the cleaning.

1.) Use Scan Analysis and plot the means and standard deviations for all rows to find channels that violate the noise specification. Refer to Direction 2211222-100 (Chapter 2, section 3) for the acceptable noise values. The Channel Map tool can be used to determine which channel(s) is (are) noisy and the card location.
2.) Lock out system power (See System Service Manual, Chapter 1).
3.) Open Gantry and shut off 550V, axial drive, and DAS power.
4.) All protective ESD materials should be in place (i.e. wrist straps and grounded mats for laying out converter cards; ionizing fan should be set up at the far end of the patient table).

5.) Rotate and lock the gantry so that the DAS Chassis that you are working with is vertical, so that run off from the Spray cleaner does not get into the elastomer housings. See Figure 7-38.

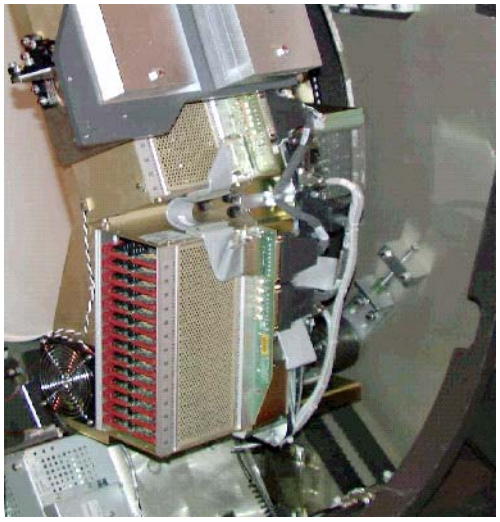


Figure 7-38 Proper Positioning of DAS Chassis for Cleaning

6.) Use the #6 screwdriver to remove the cover of the DAS chassis that has the suspected bad card(s).

7.) Remove the suspected noisy Converter card(s) and place it (them) in static free bags. Also remove the neighboring cards to the “bad” card and place them in static free bags. Mark down the slot positions of all removed cards so they can be put back in the same slots after cleaning.

8.) At this point, examine the DAS for dust. If there is dust in the DAS, perform the inspection and cleaning procedure as prescribed in the Job Card for DAS Cleaning, which is in the Advanced Service Manual. If there are still noisy channels after completing the DAS Cleaning procedure, repeat this cleaning procedure starting from step 1. If there was not any dust inside the DAS, continue with this procedure.

9.) Install the static free nozzle on the Aero Duster can and spray off the backplane connector from which the cards were removed. Use the static free nozzle every time the compressed air is used in this procedure.

10.) Position “lint free” towels between the chassis and the flex housings. This will prevent any excess cleaner from entering any parts not needing cleaning. See Figure 7-39.

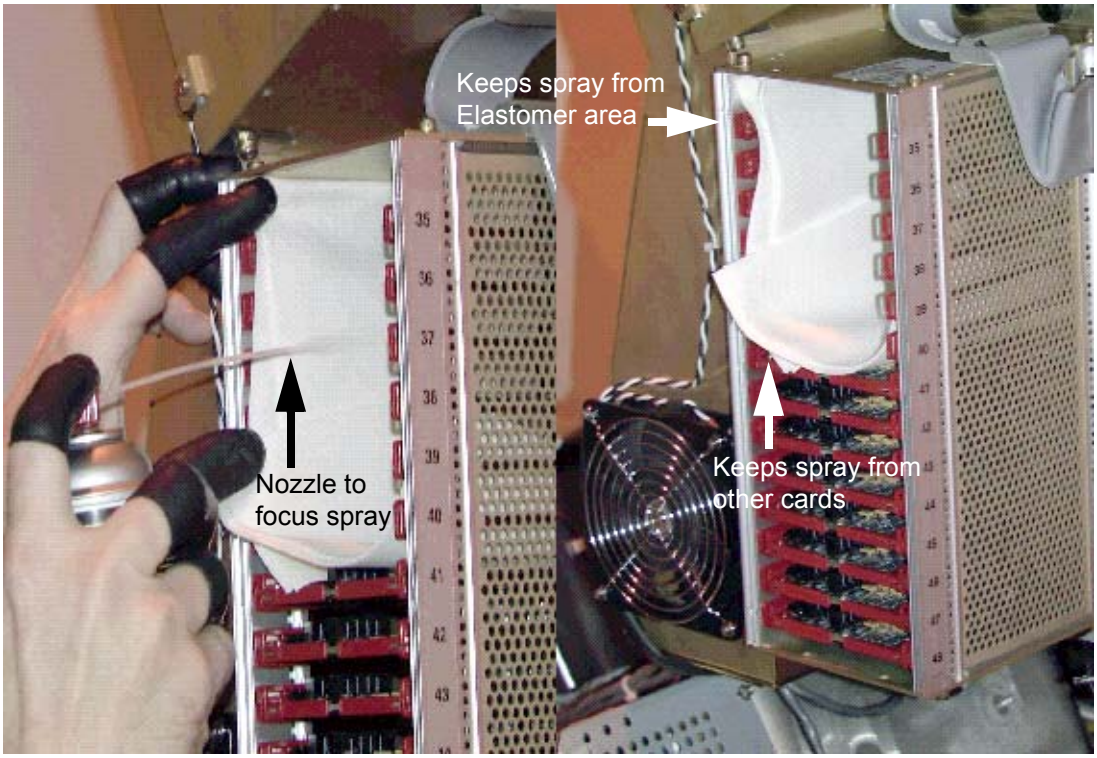


Figure 7-39 Proper placement of "lint-free" towels

11.) Use the Amax Contact Cleaner spray with the plastic tube to focus the spray to clean the backplane connectors of the suspected "bad" card location. Apply only enough to wet the entire backplane connector(s). Amax Contact Cleaner dries extremely fast. Avoid spraying directly on the detector or elastomers.

12.) Let the backplane dry for 2 minutes. Do not spray air in the chassis to dry the cleaner.

13.) Remove the Converter cards (see Figure 7-40) one at a time from their static bags and spray the connector (see Figure 7-41) with it facing down, so any spray will drip off the card and not across the converter card. Spray the outside of the connector shroud on all sides and also spray inside the pin housing. (Give it a good soaking). Allow the card to air dry. Do not use the compressed air to dry it.

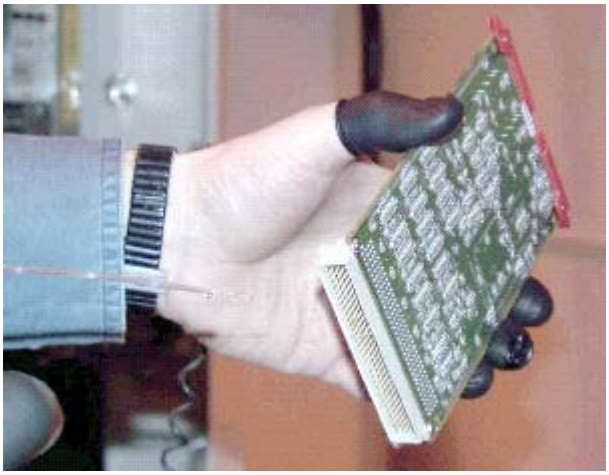


Figure 7-40 Proper method for handling converter cards

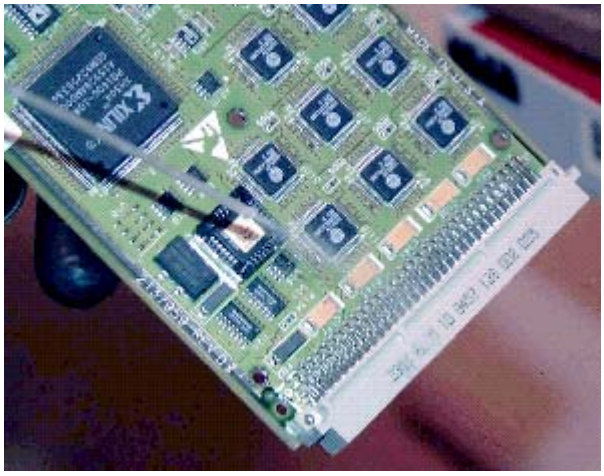


Figure 7-41 Spraying "off" the connectors

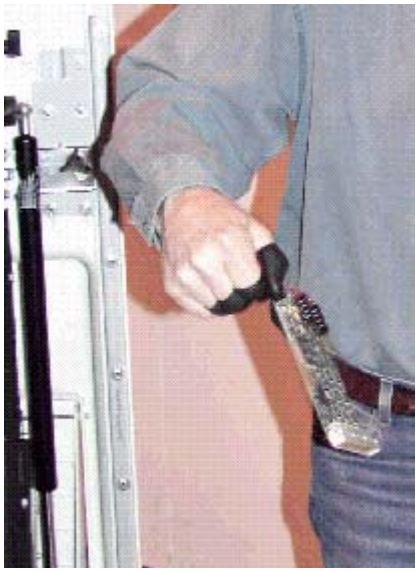


Figure 7-42 Allow the cleaner to run off the converter card completely

14.) Use the ionizing fan on the empty chassis and on the clean converter cards before reinsertion into the chassis.

15.) Reinstall cards in the same slots from which they were taken.

Turn the DAS ON and let it warm up. It takes two (2) minutes of warm-up time for every minute the DAS was turned OFF, up to two (2) hours.

Verify all covers are installed, turn on DAS power and complete the following tests within DASTools.

- 1 iteration of DC Means/Noise
- 1 iteration of microphonics/pop

All tests must pass. If not, troubleshoot and correct the failures.

Section 3.0
Replacement Procedures

3.1 Detector

Refer to Direction 2335850-100, “LightSpeed Family Detector Change Procedure” – shipped with the replacement detector – for detailed detector replacement procedures.

3.2 S-DAS

3.2.1 S-DAS Converter Board(s)

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested.**

3.2.1.1 Board Removal

1.) Open gantry (Mylar window, side & top covers).
2.) Turn off Axial Drive switch and 550 VDC Switch.
3.) Turn off DAS Power Supply switch.
4.) Rotate Gantry so that the appropriate Converter chassis is at the 3:00 Position (service side of the Gantry).
5.) Put on wrist strap and use ESD precautions.
6.) Remove Chassis cover.
    a.) If the converter board to be removed is in the center chassis and is behind the saggital alignment light (specifically, boards in slots 23 - 27), then the saggital alignment light fixture needs to be removed first.
        1.) Disconnect Power cable at J1.
        2.) Remove 3 mounting bolts and remove alignment light assembly from gantry.
    b.) Left and Right chassis have 6 captive screws.
    c.) Center chassis has 8 captive screws.
7.) Slide Converter board out of chassis.
    a.) Lift both red board retaining/ejection tabs and board will disengage from backplane connection.
    b.) Continue sliding board straight out and place into anti-static bag.

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested.**

3.2.1.2 Board Installation

1.) Remove New Converter Board from anti-static bag.
2.) Align Converter board edges to card guides in Chassis. It will be necessary to push in on the card guide tabs so the board slides into the guides.
3.) Slide the board into the chassis until Red board retaining tabs align with the card guides.
4.) Fold the Red tabs over and they will push and secure the board fully into the backplane

connector.

5.) Turn DAS Power switch On and verify no failures during power-up self-tests via LED status or System error log.

6.) Reinstall Converter board chassis cover and secure all screws tight.

7.) If applications software is up, perform a DAS Reset from the Reset Menu.

8.) Depending on the fault, let the board warm-up 5 minutes to verify it fixed the problem, but at least 1 hour before DASTools, FastCal, or Image Quality scans. A cold board may fail offset drift or popping until it is in normal operating temperature ranges.

9.) Reinstall Saggital alignment light fixture, if removed.

10.) Turn on Axial and 550VDC switches.

11.) Verify proper functionality

a.) Run at least 10 passes of Scan Data Path Diagnostic from Converter Boards.

b.) Run 1 pass of DASTools.

c.) Run FastCal, if less than 5 cards replaced.

d.) Run full FastCal and Phantom Cal, if more than 5 cards replaced or if I/Q fails due to replaced boards.

Note: Upon running FastCal the first time, Daily IQ check may fail, and can generally be ignored, provided the images look good. See "Daily IQ Check," on page 72.

e.) Take 10 I/Q scans of the 48cm phantom.

f.) Verify fault or reason to replace the board now passes.

3.2.2 DAS Control Board (DCB)

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested**

3.2.2.1 Board Removal

1.) Open gantry (Mylar window, side & top covers).

2.) Turn off Axial Drive switch and 550 VDC Switch.

3.) Turn off DAS Power Supply switch.

4.) Rotate Gantry so that the DCB is at the 3:00 Position (DCB on the service side of the Gantry).

5.) Disconnect Cables going to DCB.

a.) Connector J4; RCIB Cable.

b.) Connector J5; RCIB Terminator. Save this terminator as it needs to be installed on the replacement DCB.

c.) Connector J6; Data cable between Converter Board chassis and DCB.

d.) Connector J7; DC Power Cable.

e.) Connector J8; KV/mA & Detector Heater Analog signal cable.

f.) DAS Data Out Fiber Optic Cable.

6.) Remove 2 screws holding DCB board in DCB chassis.

7.) Slide DCB out of chassis and place into anti-static bag.

3.2.2.2 Board Installation

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested.**

1.) Remove New DAS Control Board from anti-static bag.
2.) Verify proper Jumper configuration:
   a.) JP1; No Jumpers for normal operation.
   b.) JP2; No Jumpers for normal operation.
3.) Align board to card guides in DCB Chassis. Slide the board fully into the chassis and secure using the two (2) screws. Torque screws to 2.9 N-m (25.7 lbs-in).
4.) Mount the DCB housing assembly, and torque screws to 4 N-m (35.4 lbs-in).
5.) Connect the following cables:
   a.) DAS Data Out Fibre Optic Cable.
   b.) Connector J8; KV/mA & Detector Heater Analog signal cable.
   c.) Connector J7; DC Power Cable.
   d.) Connector J6; Data cable between Converter Board chassis and DCB.
   e.) Connector J5; RCIB Cable.
   f.) Connector J4; RCIB Terminator.
6.) Turn DAS Power switch On and verify DCB Power LED is illuminated.
7.) Turn on Axial and 550VDC switches.
8.) If applications software is up, perform a DAS Reset from the Reset Menu.
9.) Verify proper functionality:
   a.) Run at least10 passes of Scan Data Path Diagnostic.
   b.) Take 10 I/Q scans of the 48cm phantom.
   c.) Verify fault or reason to replace the board now passes.

3.2.3 DAS Backplanes

3.2.3.1 DAS Chassis (Left, Center or Right) Removal

NOTICE **Ensure that you are properly grounded by using the appropriate ESD wrist strap and cord connected to a good ground point in the Gantry.**

1.) Open Right Side Gantry Cover.
2.) Turn off Axial Drive and 550VDC Switches.
3.) Lift top cover.
4.) Remove scan window.
5.) Remove Gantry Front Cover.
6.) Turn off DAS Power Switch and Gantry 120VAC Switch.
7.) Rotate Gantry until DAS is within serviceable reach.
8.) Engage rotational lock (see Figure 1-18, on page 46, in Chapter 1 - General System Safety & Service).
9.) Remove DAS Air Plenum:
   a.) Disconnect Fan AC power at Connector J22
   b.) Remove 6 Captive screws
      * 2 on left side

* 2 on right side, and
* 2 in the center

c.) Carefully slide air plenum out towards the front without catching wires or Detector flexes.

10.) Set Air Plenum aside, out of the way.

11.) Using Detector Handling precautions, verify use of ESD strap, grounding and Finger Cots, Disconnect Detector flexes from appropriate backplane.

a.) Remove the appropriate Flex housing Outer (A-Side) covers, by removing the housing Cover clamps. There are 2 clamps per cover. Each clamp is held on by a 3mm captive hex cap screw. Use a 2.5mm Hex screwdriver bit to remove each Clamp and Cover.

* Left Chassis: covers 11 - 15
* Center Chassis: covers 6 - 10
* Right Chassis: covers 1 - 5

b.) Repeat for all Covers on the A Side.

c.) Carefully remove each flex from the appropriate backplane, and bend each A-Side Flex straight out towards the front so that it is perpendicular to the Detector window. This is to gain more access to the B-Side.

d.) Place a Anti-static Detector Flex Boot on each flex.

e.) Remove all Inner (B-Side) Clamps, covers, and flexes using the same procedure as the A-Side.

f.) Set the Covers aside and keep them separated from the Inner (B-Side) covers. There are different covers between the A-side and B-Side.

12.) Disconnect appropriate Power Cables

- Left Chassis:
  * J19, Power cable between Center and Left Chassis
  * J16, Power cable between Left Chassis and DCB
- Center Chassis:
  * J25, Power cable between Center and Right Chassis
  * J27, Power cable between Center and Left Chassis
  * J26, Power Cable between Center Chassis and Power Supplies
  * J22, Power Sense Cable
- Right Chassis: Cable J17, Power cable between Center and Right Chassis

13.) Disconnect appropriate Data Cables

- Left Chassis:
  * J18, Data cable between Center and Left Chassis
  * J17, Data cable between Left Chassis and DCB
- Center Chassis:
  * J21, Data cable between Center and Left Chassis
  * J23, Data cable between Center and Right Chassis
- Right Chassis: Cable J16, Data cable between Center and Right Chassis

14.) Rotate Gantry so that the appropriate DAS Chassis is at the 3:00 O'Clock position and Pin Gantry to prevent it front rotating.

15.) For removal of the CENTER DAS CHASSIS ONLY: Remove the Saggital Alignment Light.

a.) Disconnect Power cable at J1

b.) Remove 3 mounting bolts and remove alignment light assembly from gantry.

16.) Remove 4 large 10mm Cap screws holding the chassis to the DAS mounting blocks while holding on to the chassis. When the last cap screw is removed, remove the chassis from the Gantry and place on an ESD pad. The converter boards still in the chassis need to be protected from

ESD, and they also need to be transferred to the new, replacement chassis (if applicable).

3.2.3.2 DAS Chassis (Left, Center or Right) Installation

NOTICE **Ensure that you are properly grounded by using the appropriate ESD wrist strap and cord connected to a good ground point in the Gantry.**

1.) Carefully place the DAS Chassis in position. Use special care:
   - Do not smash, damage Detector flexes
   - Keep Detector Flex Boots in place
   - Ensure that ALL Detector flexes are in front of backplane

2.) Secure by using 4 large 10mm Cap screws with Loctite 272 applied to each of the screw's threads. Torque each Chassis mounting screw to 30 ft.-lbs.

3.) Connect appropriate Power Cables.
   - Left Chassis:
     * J19, Power cable between Center and Left Chassis
     * J16, Power cable between Left Chassis and DCB
   - Center Chassis:
     * J25, Power cable between Center and Right Chassis
     * J27, Power cable between Center and Left Chassis
     * J26, Power Cable between Center Chassis and Power Supplies
     * J22, Power Sense Cable Connect Data Cables
   - Right Chassis: J17 Power Cable between Center and Right Chassis

4.) Connect appropriate Data Cables.
   - Left Chassis:
     * J18, Data cable between Center and Left Chassis
     * J17, Data cable between Left Chassis and DCB
   - Center Chassis:
     * J21, Data cable between Center and Left Chassis
     * J23, Data cable between Center and Right Chassis
   - Right Chassis: J16 Data Cable between Center and Right Chassis

5.) If applicable, transfer the Converter boards from the replaced chassis to the new chassis.
   a.) Confirm ESD practices
   b.) Remove Chassis board cover
   c.) Remove 1 board at a time and transfer each board from the original chassis to the new chassis in the same board slot location.

6.) Install Detector flexes (B-Side)
   a.) Confirm ESD and Detector flex handling practices. Use ESD Wrist strap and Finger Cots.
   b.) Remove retainer that is covering housing and holding Elastomers in place.
   c.) Verify all Elastomers are in their slots in the housings and are free from debris.
   d.) Remove Flex Boot and visually inspect each flex before installing for debris. Clean with approved alcohol pads where required.
   e.) Install Inner row (B-Side) flexes first.
   f.) Install 4 flexes over appropriate housing slots and install cover and clamps to hold flexes in place. Torque each clamp cap screw to 9 in-lbs (no more, no less).

7.) B-Side Checkout
   a.) Keep Axial switch Off, but turn on Gantry 120VAC and 550VDC switches.

b.) Do NOT Rotate Gantry because the A-Side Detector flexes are not connected.
c.) Turn on DAS Power switch
d.) Verify Converter board power-up diagnostics passed, via NO Board LEDs remain on.
e.) From the Operator's console, perform a Hardware Reset
f.) Perform DAS / Detector Integration to verify B-Side connections
g.) When the B-Side is okay then install Outer row (A-Side) flexes.

8.) Install Detector flexes (A-Side)
a.) Turn OFF the DAS Power Switch and 550VDC Switch
b.) Remove Flex Boot and visually inspect each flex for debris before installing. Clean with approved Alcohol pads where required.
c.) Install 4 flexes over appropriate housing slots and install cover and clamps to hold flexes in place. Torque each clamp cap screw to 9 in-lbs (no more, no less).
d.) Turn DAS and Gantry Power switches ON
e.) Perform DAS / Detector Integration
9.) For installation of CENTER DAS CHASSIS ONLY: Install Saggital Alignment Light assembly.
10.) Install Air Plenum.
11.) Install Chassis Board Cover.
12.) Reassemble Gantry.
13.) Restore power.
14.) See Retest Matrix for tests after replacing a DAS Chassis.
15.) Install / Close All covers.

3.2.3.3 Retest Matrix

1.) DAS Detector Integration
a.) X-Ray Verification
b.) Microphonics
c.) Pop/Noise
2.) Air Cal
3.) Image Quality Checks
4.) Save State

3.2.4 DAS Power Supply - Right/Left Side

3.2.4.1 Required Tools

- 5mm hex keys
- 10mm socket.

3.2.4.2 Other Procedures

DAS Power Supply Adjustment Procedure.

3.2.4.3 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove the right cover.
3.) LEFT POWER SUPPLY
a.) Turn off the HVDC and 120VAC switches on the STC backplane.
b.) Rotate gantry until the power supply assembly is within reach.
c.) Turn off the Axial Drive switch on the STC backplane.

d.) Turn off A1 power and follow Lockout/Tagout procedures.

e.) Remove any cable that may interfere with the removal of the external plastic cover.

f.) Remove the external plastic cover by removing 4 screws with the 5mm hex key.

g.) Using a 10mm socket, remove 4 hex nuts that secure the part of the power supply assembly you are trying to replace.

Note: Do not lose flat washer and lock washer.

h.) Lift the power supply off the threaded rod.

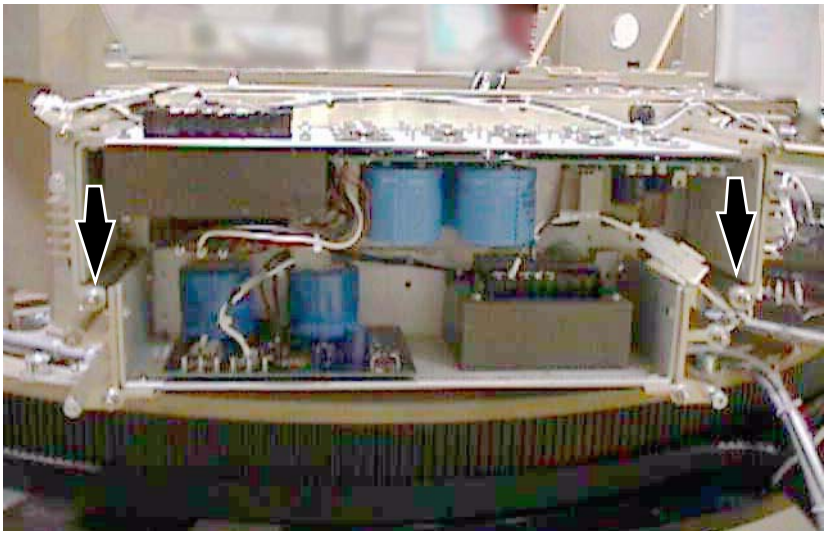


Figure 7-43 Lift power supply off of threaded rod (top view)

i.) Replace the part of the power supply assembly you are replacing.

j.) Reassemble gantry.

k.) Verify power supply voltages per adjustment procedure.

4.) RIGHT POWER SUPPLY

a.) Remove the five (5) DCB 5mm cap screws.

b.) Fold the DCB assembly over the DAS.

c.) Follow the LEFT POWER SUPPLY steps.

3.2.5 Cooling Fans

1.) Move table to lowest elevation.

2.) Turn off facility power to PDU.

DANGER USE LOCKOUT/TAGOUT PROCEDURE.

3.) Remove gantry side covers.

4.) Lift top cover.

5.) Remove scan window.

6.) Remove front cover.

7.) Rotate the Gantry until the DAS Fan is within serviceable reach.

8.) Engage rotational lock. (See Figure 1-18, on page 46, in Chapter 1 - General System Safety & Service)

9.) Disconnect Power Cord from Fan.

10.) Remove and keep the four (4) screws that fasten Fan and Grill in place.

11.) Transfer grill to new fan, if necessary, and install new Fan.

12.) Reassemble Gantry.

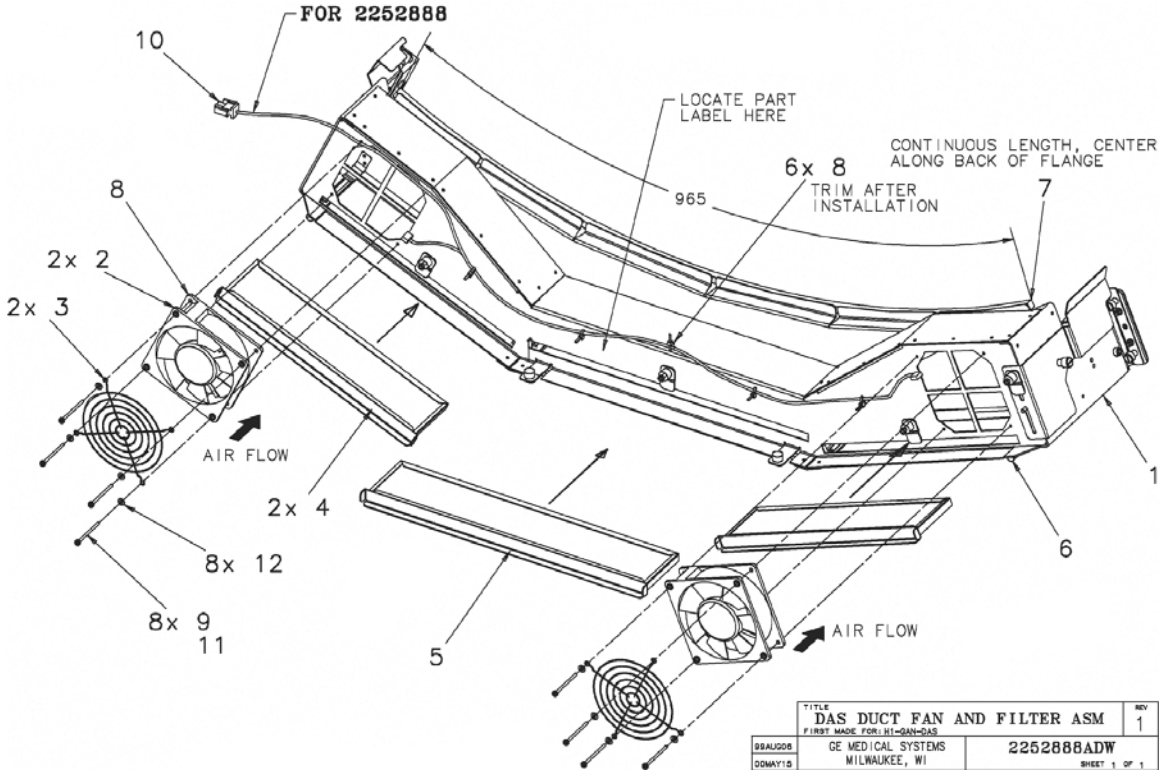


Figure 7-44 DAS Air Plenum and Cooling Fans

3.2.6 Detector Thermistor

3.2.6.1 Required Parts

QTY	PART NUMBER	PART NAME
1	2147197	Detector Thermistor Probe
2	511A59OP274	Amp Mate n Lok Male Pins
1	90300-1-E	AMP Universal Mate-N-Lok Pin Crimper Tool
1	2214897	EMC Tape (enough to cover thermistor wire along Detector)
1	458994	Amp Universal Mate-N-Lok Pin Pusher (Extractor)
3-4		Small tie-wraps

Table 7-20 Required Parts

3.2.6.2 Retest Matrix

- Two hour warm-up
- Verify detector temperature is 36 degrees Celsius
- FastCal
- IQ Check

3.2.6.3 Procedure Details

1.) Verify that you have all the parts/tools required.

2.) Turn off 120VAC Gantry Power.

3.) Disconnect Detector Cable at J3.

4.) Remove Thermistor wires/pins from J3 connector. These are the Red and Black wires. Note their location within the connector. Use Pin extract tool.

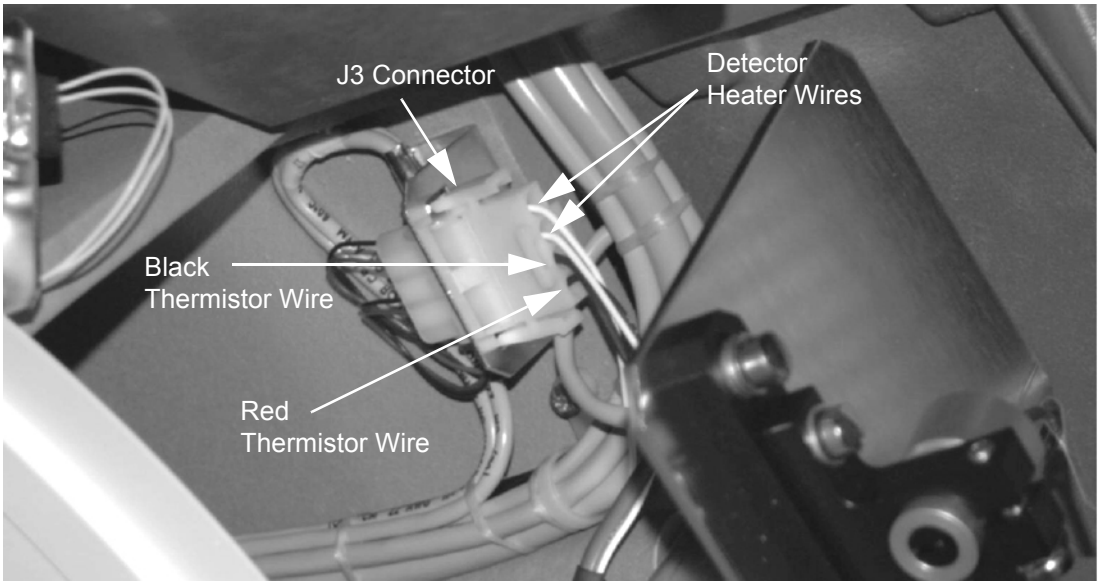


Figure 7-45 J3 connector, showing thermistor wires

5.) Verify correct old Thermistor wires, then cut the old Thermistor cable close to where the Thermistor cable and Detector Heater cables are joined in the shrink-wrap sleeve. Do NOT cut the Detector Heater wires.

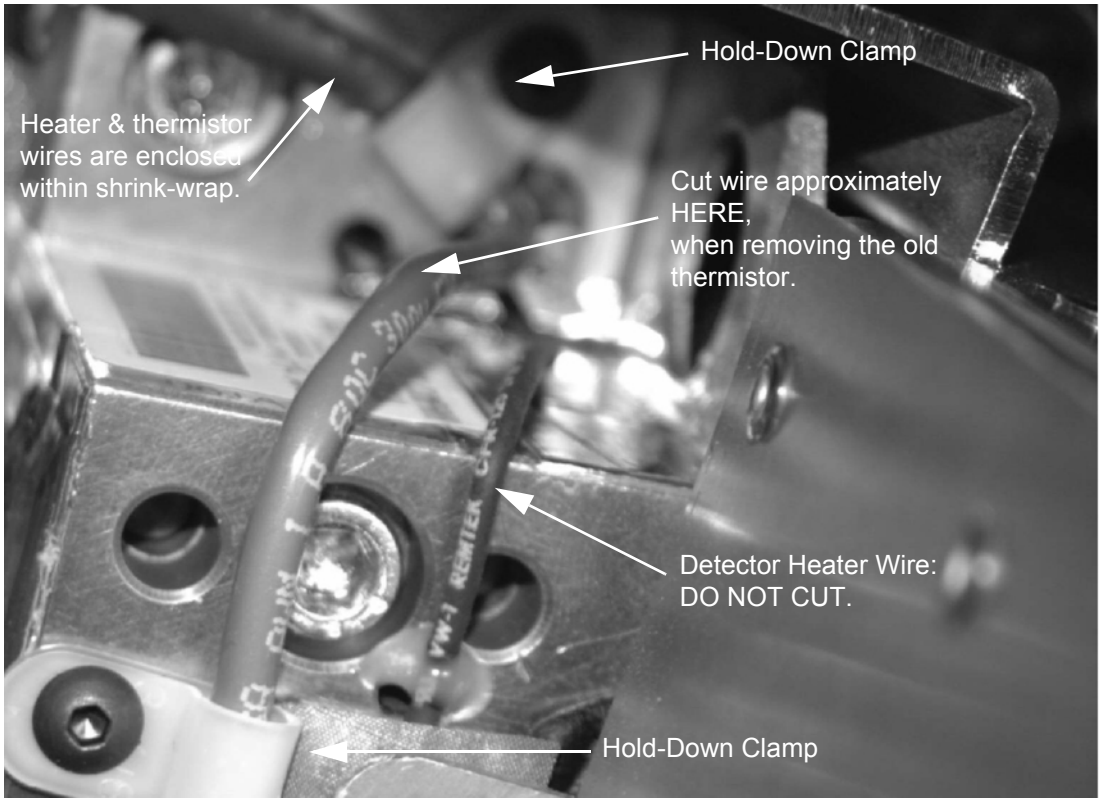


Figure 7-46 Approximate location for cutting thermistor wire

6.) Unscrew the Thermistor wire “Hold-down clamps”. There are two (2): one is near the end of the detector, the other is near the Thermistor.

7.) Carefully peel back the EMC tape covering the Thermistor wire so the wire is free.

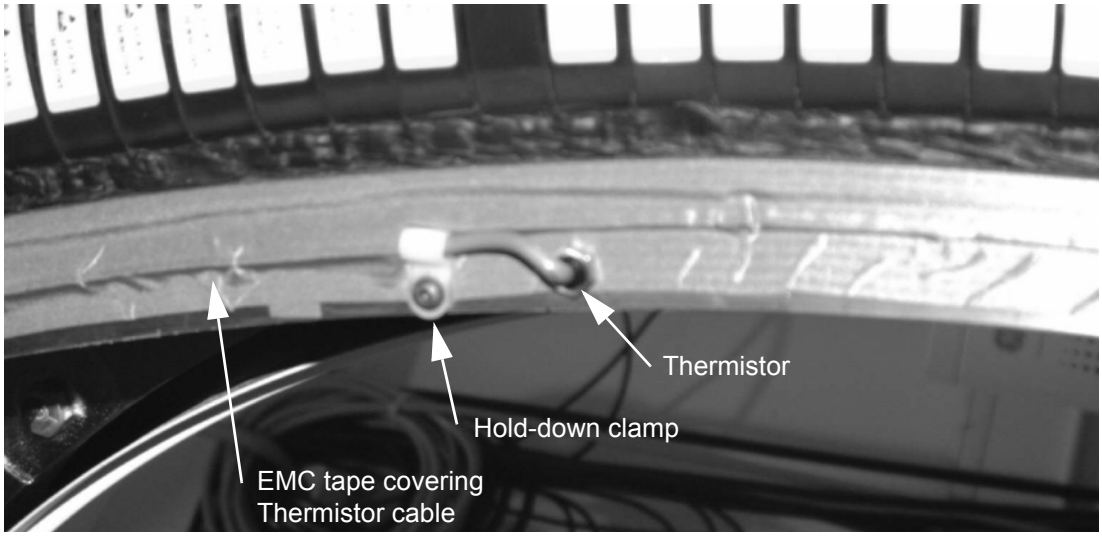


Figure 7-47 Remove old thermistor

8.) Unscrew and remove the Thermistor using a 9mm open-end wrench.

NOTICE **Make sure no dirt or debris gets into the detector through the open hole.**

9.) Make sure the new Thermistor is clean before installing (No lint, dirt, debris, etc.)

10.) Screw in the new Thermistor until snug. Use finger pressure on wrench. Do not over-tighten. The metal Thermistor housing is only a shell. The wire should be free so it does not get twisted.

11.) Route the wire along the detector side just like the old wire, against the inner radius of the Heater element.

12.) Use EMC tape or Conductive tape to cover the wire.

13.) Secure the wire with the 2 “Hold-down” wire clamps. Make sure the wire is properly positioned at the Thermistor so it doesn't interfere with the DAS Fan Air Plenum, and that the wire isn't too tight, creating a sharp bend at the detector. It should also not be so loose as to get caught or rub on anything during rotation.

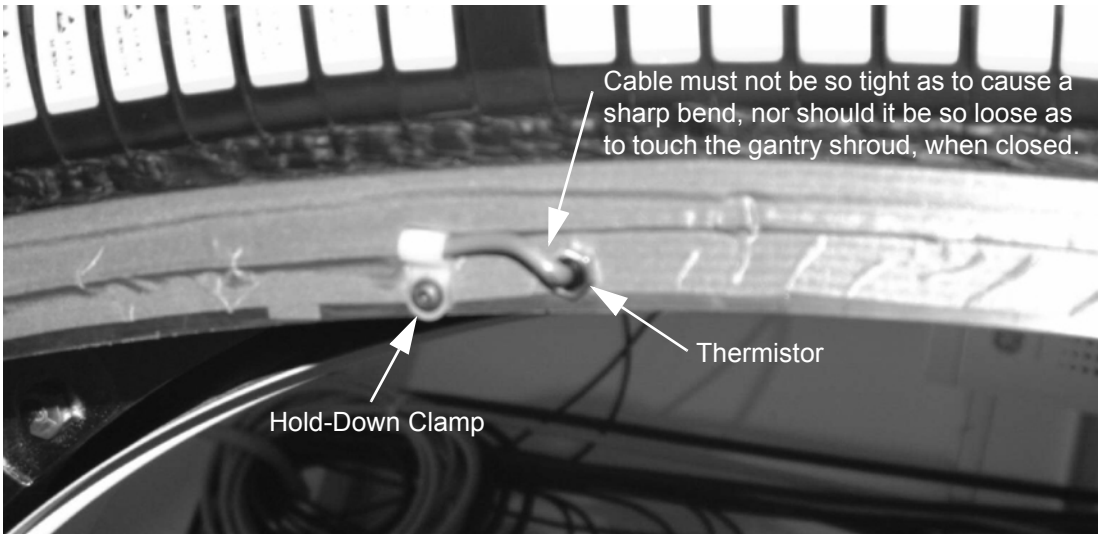


Figure 7-48 Route new thermistor cable

14.) Route the wire along side the Shrink-wrapped cable going to J3. Tie-wrap the new cable to the outside of the shrink-wrapped cable.

15.) Install the pins of the wire into the J3 connector.

16.) Connect J3 and confirm that any excess wire is secure and out of the way.

17.) Test the system. Take several scans for a couple of hours so that you are satisfied that the problem has been corrected.

18.) Wait at least two (2) hours with power on so the Detector warms up. Then FastCal.

Chapter 8
Gantry

Section 1.0
Theory

1.1 Functions of the Stationary Gantry

FRU	FUNCTION
STC Computer	Axial board control
	LSCOM board control
	Lan communications to System Host Control
Axial Board	Scan Start/stop control
	Operator Hard key monitor
	X-ray light control
	DAS trigger generation
	Gantry axial speed and position control
	Axial speed/position monitoring
LSCOM Board	Slip ring communications to/from rotating gantry

Table 8-1 Stationary Gantry FRU versus Function

DAS and HV subsystems are located in other sections of this manual.

1.1.1 Communication Subsystem Theory

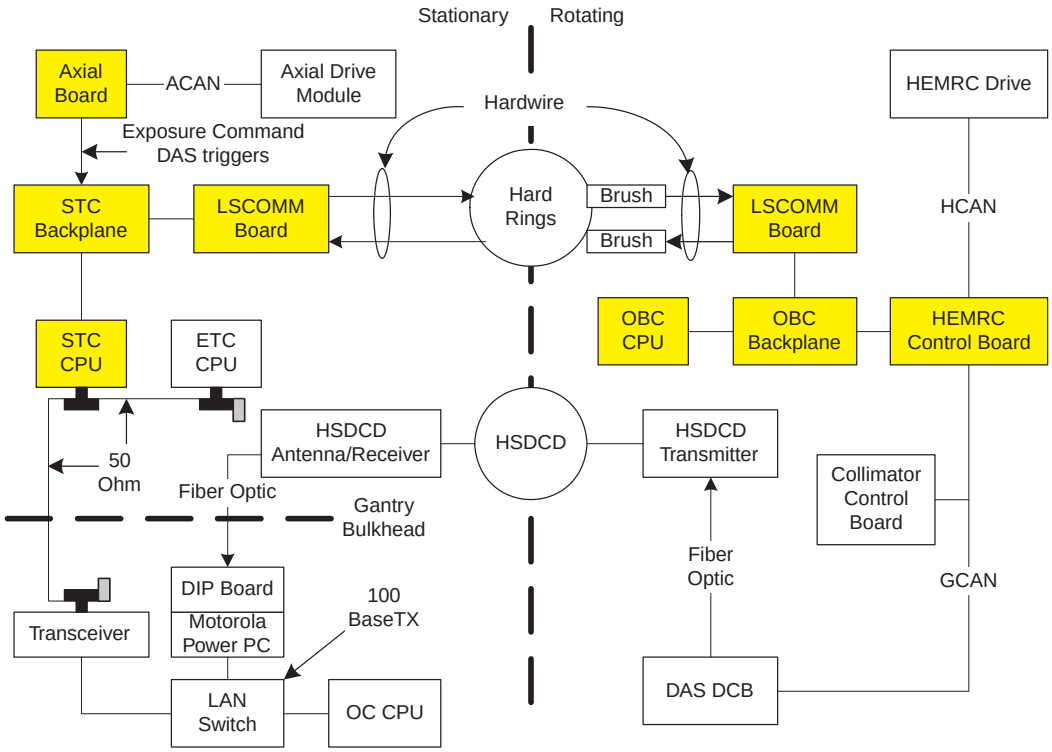


Figure 8-1 Communication Block Diagram

Communications between the OC and Table/Gantry computers are performed by a LAN connection and hard-wired slip-rings. Scan data from the DAS is transferred across the **HSDCD** (High Speed Data Capacitive Device) ring to the DIP board in the console. The DAS data transfer rate is up to 110 Mbaud. The 10base2 thin net 50 ohm LAN cable provides the communication path between the OC computer in the console, the ETC in the table, and the STC in the stationary gantry. The hard slip rings allow the bidirectional transfer of data between the STC and the rotating components, including the OBC. The control rings transfer data at 2.5 Mbaud.

The system utilizes one HSDCD ring and 11 hard wired slip rings. Five rings provide AC and DC power and ground; three provide interlock signals for the HV subsystem; and three provide the communication path between the stationary and rotating components. Only the three communication rings will be discussed here.

DANGER **EXTREME CAUTION IS NECESSARY WHEN WORKING IN THE SLIP RING AREA, AS BOTH HV DC PRIMARY AND 120 VAC ARE PRESENT AND EXPOSED ON THE RING.**

The hard slip rings communication connection acts as a sub-network between the STC and OBC, but also carries the specific DAS trigger and Exposure Command signals multiplexed within the data stream. Control and status information travels in both directions across the rotating interface along 2 high speed serial links utilizing 3 rings, one inbound and one outbound, both using an isolated ring as signal reference. This provides for excellent noise immunity. Brushes ride on the conductive ring material to provide signal connection to the stationary components, and screws inserted into the back of each ring provide the connection for the rotating components. Serial link control and signal multiplexing/de-multiplexing is provided by 2 common LSCOM boards. LEDs located on these boards indicate communication status of the data paths.

Scan Data travels from the rotating side to the stationary side and ultimately to the reconstruction sub-system through the HSDCD ring. This contact-less path consists of the HSDCD transmitter on the ro-

tating structure. The stationary pickup is a antenna and receiver coupled together. The HSDCD ring and antenna form two plates of a capacitor. The transmitter input and receiver output are fiber-optic connections. Forward error correction is utilized in this path to ensure extremely high data reliability.

1.1.2 Axial Motion & Control

The Axial II Control Board is responsible for interfacing the axial drive control firmware of the gantry Stationary Controller (STC) microprocessor. The hardware involved in the axial servo drive consists of the Axial II Control Board, the Axial Motor Drive, the Axial Motor, Axial Motor Dynamic Brake Assembly, Axial Encoder, Axial Drive Belt and Axial Home Flag. See Figure 8-2.

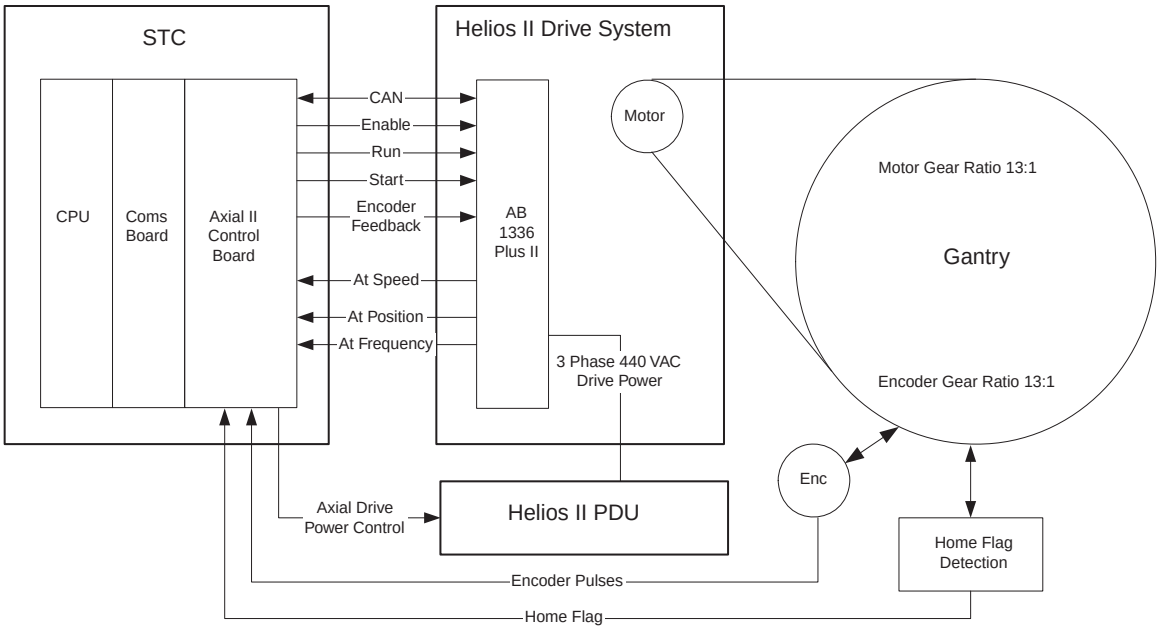


Figure 8-2 Axial Control Block Diagram

The Axial Drive Power Contactor in the PDU controls the 3 phase, 440 VAC input of the Axial Motor Drive Module. There are interlocks in the power contactor control for an Axial Enable/Disable switch located on the STC chassis backplane.

The Axial Motor Drive module is supplied with enable, speed, brake and direction information from the Axial II Control Board. The Axial Motor Drive monitors the axial speed and direction internally, as well as receiving axial encoder feedback from the Axial II board for fine speed control. The combination of internal and external control allows the drive module to modulate the frequency of the AC output, allowing the gantry to rotate at a maximum speed of 0.5 seconds per revolution in the clockwise direction. Note, the drive module will not drive in a counter clockwise direction under normal control.

The Axial Motor is an AC induction type. The axial brake engages the motor shaft and is meant as a static brake to hold the gantry still once it has been positioned by the axial drive.

The motor is coupled to the rotating bearing with a belt, with a gear ratio of 13 motor rotations to 1 gantry bearing rotation. An optical “slip-flag” detector senses a metal flag that rotates through it once every bearing revolution. The slip-flag information is used for axial coincidence as a position reference and over-speed sensing.

The encoder is directly coupled to the rotating bearing next to the Axial Drive Belt. It is interfaced with a direct contact gear as weighted assembly with a 13 to 1 gear ratio, the same as the axial motor to rotating bearing. This arrangement allows for simplified transfer functions for speed control and more accurate positioning of DAS trigger generation versus motor mounted encoder packaging. The axial encoder is an incremental encoder and provides 2048 counts per encoder rotation. The information from the encoder is decoded on the Axial board and used for gantry position and

speed control as well as DAS trigger generation. The STC firmware verifies the Axial II board's encoder counts to be 106496 ± 3 counts per gantry revolution referenced to home coincidence.

The axial dynamic brake assembly is used to dissipate energy originating from the induction motor. Axial braking is accomplished by reducing the frequency applied to the motor leads to a level lower than the current operating point of the motor windings. This is termed negative slip. Negative slip generates electrical field resistance or negative torque within the windings. At the same time the motor windings generate voltage raising the motor lead voltage. This excess voltage is dissipated by the dynamic braking module via load resistors and chopper circuit control via the AXDC bus. This means that 440 VAC is always applied to the Axial Motor Drive module to both accelerate and decelerate the gantry. Loss of this voltage will result in the gantry coasting to stop - this can take more than one minute.

Scan start/stop and Autovoice control are implemented using switches on the console keyboard assembly. A hard-key processor on the keyboard assembly is hard-wired to the axial board via a UART serial link. The hard-key processor monitors the status of the "Start Scan" and "Stop Scan" switches on the keyboard assembly. Upon closure of the Start Scan Switch Contacts, the Hard-key processor sends a start scan message to the STC via the axial board, indicating that the scan should start. This communications link is also used to signal the start of Autovoice messages.

DANGER **DISABLE THE AXIAL DRIVE MECHANISM BEFORE SERVICING THE GANTRY INTERIOR.**

- **THE AXIAL DRIVE ENABLE STATUS LED, DS4, ON THE STC CHASSIS BACKPLANE INDICATES STATUS OF THE AXIAL POWER CONTROL CIRCUIT ONLY, NOT THE STATE OF THE AXIAL POWER CONTACTOR.**
- **A FAILURE IN THE POWER CONTACTOR COULD ENABLE AXIAL MOTOR DRIVE AND CAUSE UN-COMMANDED MOTION.**
- **WHENEVER SERVICING THE ROTATING ASSEMBLY, LOCK THE GANTRY USING THE LOCKING MECHANISM.**

1.1.2.1 Axial Motor Drive (AMD Assembly)

The AMD Assembly consists of an Interface Board, AC Drive, Dynamic Brake Assembly, harnesses and 2 power sources. Figure 8-3 shows a block diagram of the AMD assembly.

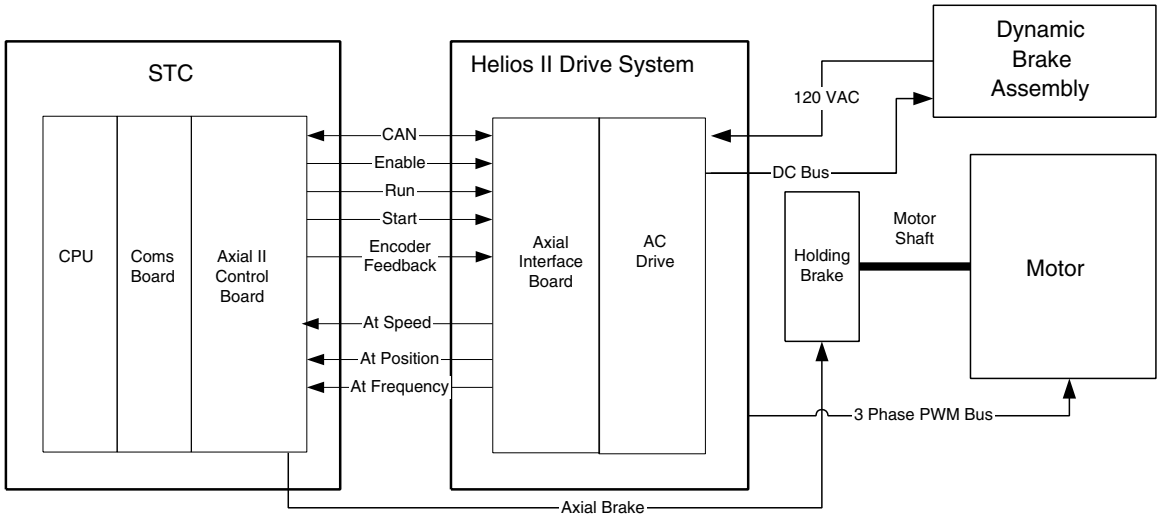


Figure 8-3 AMD Hardware Block Diagram

1.1.2.2 General Axial Drive Function

The Axial Motor Drive (AMD) provides three phase power to the Axial AC motor. In addition to the Axial II Control Board, the axial motor requires an external Axial Dynamic Brake Module. The AMD is a 2 part integrated device, Axial Interface board (AIF) and AC Drive. The axial firmware controls the acceleration, run, and deceleration cycles of the axial motor. The axial control firmware resides in the STC CPU and sends drive instructions to the Axial II Control Board (ACB).

The ACB communicates with the AC Drive through the AIF, located on the AMD assembly. The AMD interprets the instructions and configures itself to execute the commands. The AMD has its own self contained firmware. The drive converts 3 phase 440 VAC input power to three phase Axial HEM (High Efficiency Motor Drive) power. This motor drive power is applied directly to the Axial Motor for acceleration, run and braking functions.

Refer to Figure 8-3. Control signals travel from the STC Axial II Control Board to the AMD through the Axial Interface harness. The AIF routes the signals to the AC Drive.

1.1.3 Axial II Control Board – Theory of Operation

The Axial Control board (ACB), located in the STC chassis, uses the VME bus to communicate with the STC CPU. The ACB uses a CAN (Controller Area Network) serial interface, called the ACAN (Axial CAN), and discrete signals to communicate with the AMD. Figure 8-4, shows the discrete control signals. The ACAN interface and discrete control signals enter the AIF for control of the AC Drive.

The AMD supplies isolated 12V power (1.2A capability) to the ACAN and Fault circuitry.

Fault detectors and fault status feedback from the ACAN monitor hardware operation. The AMD notifies the ACB when it detects a fault, or a monitored value falls out of tolerance.

1.1.3.1 VME Interface

The VME interface contains the logic to perform address and data latching, address decoding, and VME handshaking, according to timing specified in PAL documentation, 2147462PDL. All signals pass through the standard VME connector, J1.

Of the seven interrupts defined for the VME bus, the ACB uses level 1, level 2, level 4 and level 5. Other boards on the STC also use the level 1 interrupt, which is wire OR-ed on the backplane.

- **IRQ1**: Interrupt level 1 indicates an over-speed condition. This can be reset by firmware and function retried.
- **IRQ2**: The ACB uses Interrupt level 2 during ACAN communications.
- **IRQ4**: Interrupt level 4 is a normal operating indication the ACB uses for state or positive edge transitions.
  - Axial Power COntactor >State Change
  - Exposure Command> Positive edge detect
  - option Box (Cardiac R Pulse) > Positive edge detect
  - Zero Trigger (Scan End) > Positive Edge Detect
  - Home Flag> Positive edge detect
  - Axial Sample timer (25 msec timer for speed control)> Positive edge
  - Table Sync (Used to synchronize scout and Helical Scans with cradle motion)> Positive edge detect.
  - Smart View foot switch> State transition
  - Gantry contact (Gantry tape switches)> Positive edge detect
  - Axial Motor Drive (Faults; AT_SPEED, AT_FREQ, AT_POS)> State transition.
  - Extra Inputs (Undefined Spares)> State transition
  - I2C interrupts (ACB mounted temp sense, communications) > STATE TRANSITIONS
- **IRQ5**:The ACB uses interrupt level 5 for console pushbutton, serial communications.

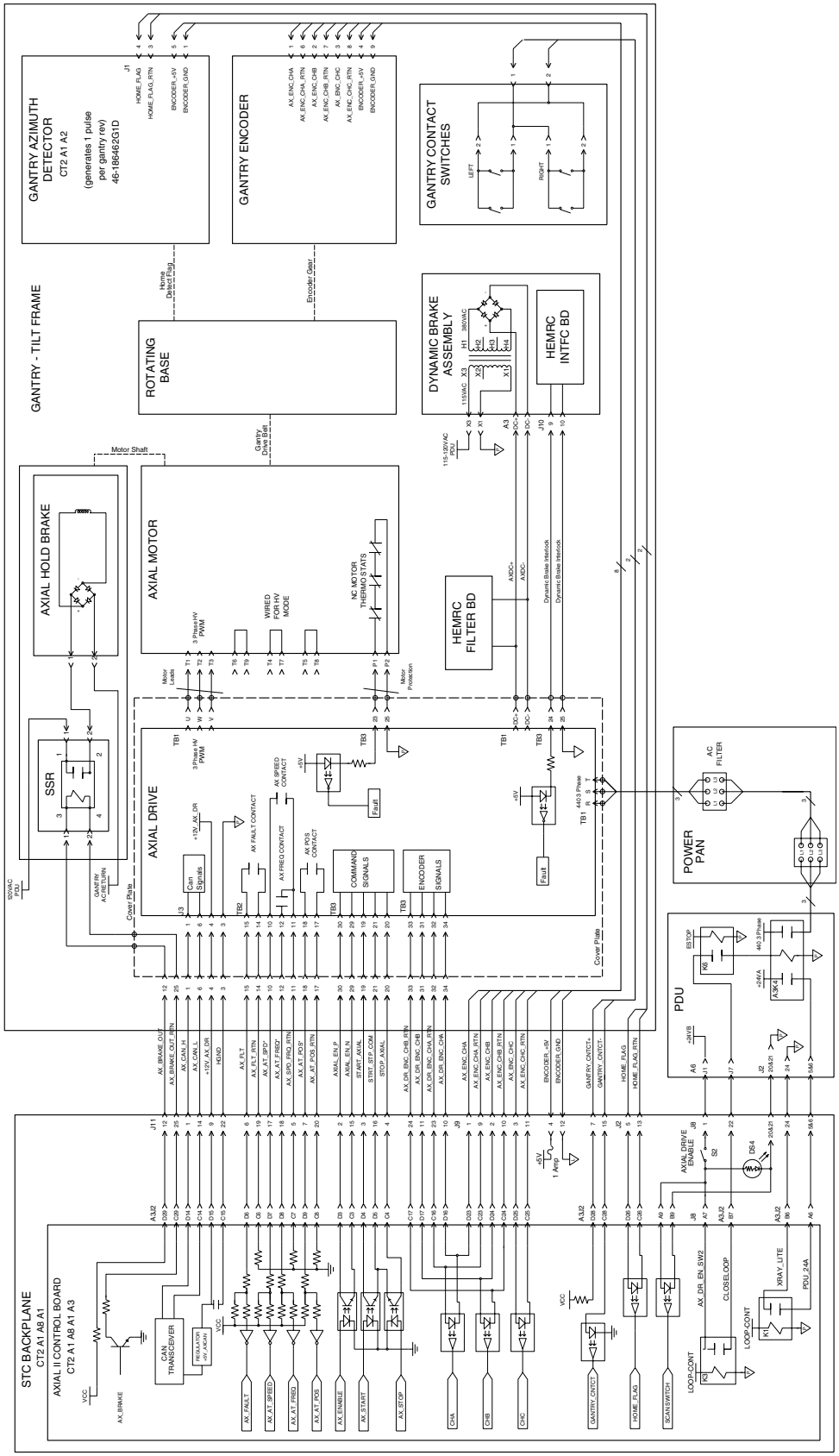


Figure 8-4 Hardwire Control Signals, Functional Interconnect

1.1.3.2 Command I/O

In normal operation, the STC CPU sends state commands through the command registers located at address 0xFFAC00 to 0xFFAFFF. This includes Diagnostic testing and status reporting.

1.1.3.3 Reset Pushbutton

The ACB contains a manual board reset pushbutton, S1. Pushing the on-board reset has the same effect as receiving a SYSRST from the VME.

1.1.3.4 Clocks

Y1, Y2, Y3, and Y4 on the ACB generate 16MHz, 12MHz, 40Mhz, and 3.6864Mhz clocks respectively. Y1 is used for AX_CAN communications. Y4 is used for console pushbutton communications from the SCIM.

1.1.4 Axial Controller Interface Bus (ACIB) Theory

The ACIB is the umbilical cord that links the Axial Motor Drive to the Axial II Control Board. This link consists of the signals listed below. Each signal is a differential pair for noise immunity.

- Isolated 12VDC is generated by the HEMRC Control Board that powers the Controller Area Network (CAN) Drivers.
- Axial Enable is available to the AMD to determine when gantry rotation begins and ends.
- CAN Serial Line is used for the transmission of control signals. It must be terminated by a 120 ohm resistor at the beginning and end of the cable. This particular CAN line is referenced as the Axial CAN (ACAN) bus.
- Fault Line is the primary means to inform the Axial II Control Board of a fault. The fault line is asserted by the AMD under the following conditions:
  - The Controller is reset
  - A Fault is detected by the controller

Reset is asserted by the STC when it becomes desirable to reset the AMD. The ACB resets the AMD via a command register or during an STC reset.

1.1.4.1 Axial CAN (AX_CAN)

The ACB uses the 82527 CAN protocol controller (U45) and CAN bus interface circuitry to communicate with the AMD Assembly. This is a bidirectional serial link. The 82527 interrupts the Altera controller (FPGA) with the AX_DRIVE_COMM* signal to indicate a status change of the 82527. The 82527 communicates with the Altera (FPGA) directly via AXADDR and DATA buses on the ACB. The 82527 uses the 16MHz clock for timing. The board AXRESET* signal resets the 82527.

U26 and U24 optically isolate the AX_CAN bus from the ACB board circuitry. U28, the CAN transceiver chip, resides on the isolated side of the CAN interface. The optically isolated side of the AX_CAN receives power from an isolated 12 volt, 125 mA supply located on the AMD. VR1 regulates this 12 volt supply down to 5 volts (+5V_AXCAN). This isolated 5 volt supply provides power to the isolated side of the AX_CAN interface. The AX_CAN output signals are AX_CAN_H and AX_CAN_L. R339 provides the required CAN bus termination for the Axial II Control Board end of the AX_CAN bus.

DS12 illuminates whenever U26 receives data over the AX_CAN bus.

1.1.4.2 ACB to AMD Interface Overview

The communications between the ACB and AMD consist of:

- Bidirectional CAN serial communications bus: a 125 Kbaud bidirectional serial link, used to convey commands and status information.
- AX_Fault signal from the AMD to ACB.
- AX_AT-SPD* signal from the AMD to the ACB.
- AX_AT_FREQ* signal from the AMD to the ACB.
- AX_AT_POS* signal from the AMD to the ACB.
- AX_EN_P, AX_EN_N signal from the ACB to the AMD
- AX_ENC_CHA/CHB signals from the ACB to the AMD
- Three-wire start-stop signal

The opto-isolated Enable, Start, and Stop signals from the ACB to the AMD provide a contact closure as an input to the AMD. The Enable contacts close electrically to enable the AMD, the Start contacts close electrically to start the AMD, and the Stop contacts close electrically to enable the AMD to run and open electrically to stop the AMD. The Enable, Start, and Stop opto-isolators carry 10mA with less than a 3V drop when closed, and withstand 5V when the contacts open.

The fault signal from the AMD to the ACB consists of the AX_FLT and AX_FLT_RTN signal wires. The circuit uses drives with a normally-open fault contact. If either the fault signal wires open electrically, the ACB generates a fault condition. If the AX_SPD_FRQ_RTN signal wire opens during operation, the system can report either AX_AT_SPD or AX_AT_FREQ errors.

The AX_AT_SPD*, AX_AT_FREQ* AND AX_AT_POS* are active low or NO FAULT conditions during normal axial operations. These signals should be high with the gantry rotation idle. The AX_FLT is a normally low signal. If this signal goes high, then the AX_FAULT_CONTACTS in the AMD have opened and you have a fault.

If the motor is at or above Frequency for the phase it is currently in, then AT SPEED will be satisfied and closes. AT SPEED will then open when the phase changes transition, and waits for the motor to be at or above Frequency again for this next phase, then will close if the motor reaches Frequency. This will continue throughout the entire rotation cycle, Accel, Run, and Brake. It is key to know that the AMD module will try to drive the motor to the correct speed, and if it cannot attain the speed requested, the current will max out at a specific level and not drive any higher, the result will be that the motor could not make it to the correct frequency in the allotted time for that phase, and the AT SPEED fault will be seen.

1.1.4.3 AMD Stop and Start

The discrete start and stop signals to the AMD are opto-coupled logic signals. The STOP_AXIAL signal must equal a logic high for the AMD to start acceleration, continue acceleration or run. The logic high STOP_AXIAL signal creates a low impedance between the STOP_AXIAL and STRT_STP_COM output signals, which permits the AMD to accelerate or run.

When the START_AXIAL signal goes to a logic high (causing a low impedance between the START_AXIAL and STRT_STP_COM outputs) and the STOP_AXIAL signal equals a logic high, the AMD begins to accelerate (if it hasn't already done so). Once acceleration begins, the AMD continues to advance along its acceleration profile, or continues to run, regardless of the logic condition of the START_AXIAL signal. The AMD begins to decelerate (if it is running) whenever the STOP_AXIAL signal goes to a logic low.

1.1.4.4 AXDC Bus Voltage Monitoring

This function is performed within the AMD module. Errors will be reported to the Axial II Control Board.

1.1.4.5 CAN Error Detection

CAN implements five error detection mechanisms: three at the message level, and two at the bit level.

Note: CAN will retry up to 128 times before logging an error.

The following mechanisms are at the message level:

- **Cyclic Redundancy Checks (CRC) -** Every transmitted message contains a 15 bit Cyclic Redundancy Check (CRC) code. The CRC is computed by the transmitter and is based on the message content. All receivers that accept the message perform a similar calculation and flag any errors.
- **Frame Checks -** There are certain predefined bit values that must be transmitted at certain points within any CAN Message Frame. If a receiver detects an invalid bit in one of these positions, a Form Error (sometimes also known as For at Error) will be flagged.
- **Acknowledgement Error Checks -** If a transmitter determines that a message has not been acknowledged, then an ACK Error is flagged.

The following mechanisms are at the bit level:

- **Bit Monitoring -** Any transmitter automatically monitors and compares the actual bit level on the bus with the level that it transmitted. If the two are not the same, then a bit error is flagged.
- **Bit Stuffing -** CAN uses a technique known as bit stuffing as a check on communication integrity. After five consecutive identical bit levels have been transmitted, the transmitter will automatically inject (stuff) a bit of the opposite polarity into the bit stream. Receivers of the message will automatically delete (de-stuff) such bits before processing the message in any way. Because of the bit stuffing rule, if any receiving node detects six consecutive bits of the same level, a stuff error is flagged.

1.1.5 Axial Motor Drive – Theory of Operation

1.1.5.1 Axial Motor Drive (AMD)

The Axial Motor Drive is a customized version of a commercially available Allen-Bradley Model 1336 Plus II variable frequency AC motor drive. It contains its own microprocessor, power supplies and a three-phase full bridge inverter. The AMD communicates with the Axial II Control Board through a CAN (Controller Area Network) serial bus.

1.1.5.2 Jumper Settings for the Axial Motor Drive

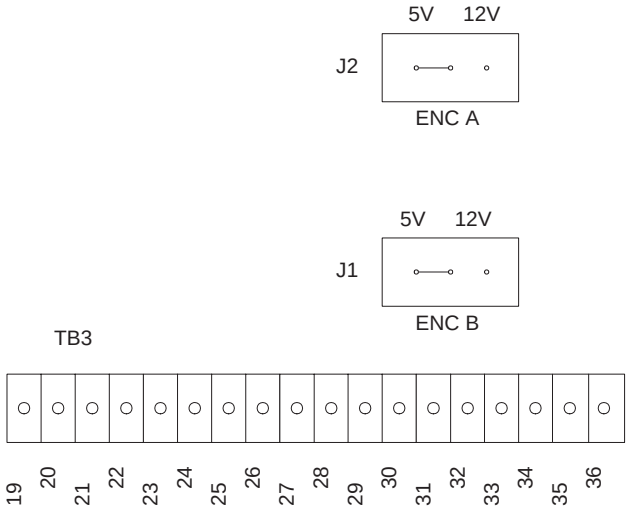


Figure 8-5 Axial Motor Drive Encoder Board Jumpers

The AMD Encoder board jumpers J1 and J2 should be set for 5V.

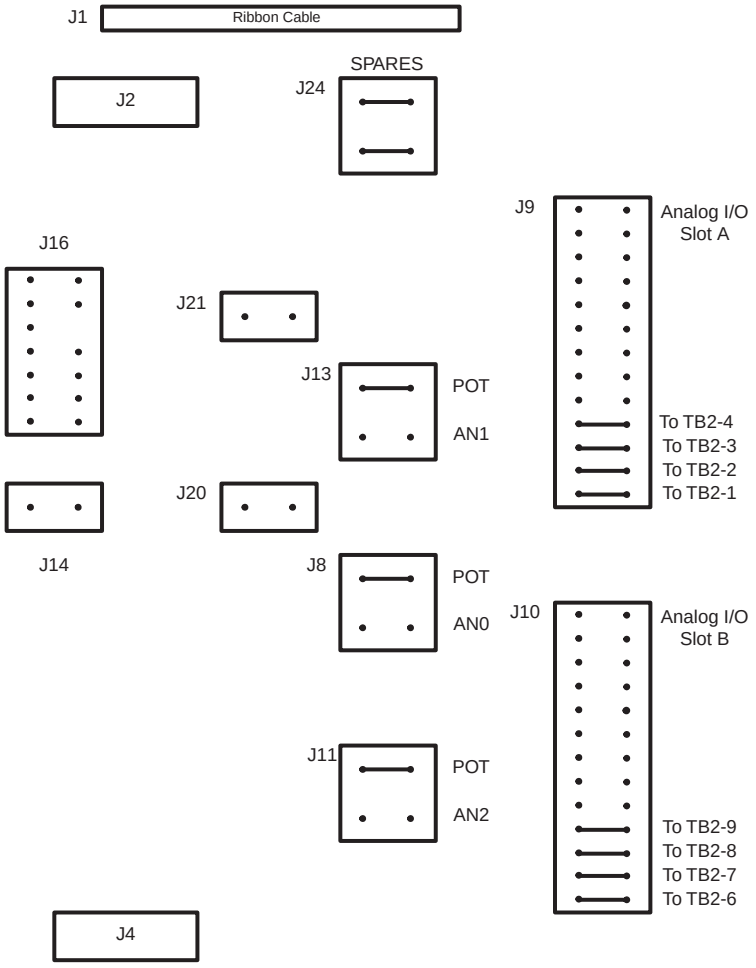


Figure 8-6 Axial Motor Drive Control Board Jumpers

The AMD Control board jumpers are all factory default settings. See Figure 8-6 for specifics.

1.1.6 Axial Control Error Messages

The Axial II Control Board receives certain detected error conditions, generally related to communication or functional interfaces to the AMD. Many of these messages contain variable fields. The general description has been provided for clarity.

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F01	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F02	Auxiliary Fault. The interlock between the Chopper Control circuit on the axial I/F Board and the Drive is open. Possible Chopper Control fault or connections to the I/F board. Also check the fuse on the chopper resistor pan.
F03	Power Loss Fault. The Drive internal DC bus remained low for >500mS. Possible low voltage condition on 480 VAC in gantry or power interruption. Also may indicate excessive run or braking power required due to sluggish Motor.
F04	Undervoltage Fault. The Drive internal DC bus voltage dropped below 325V. Possible low voltage condition on 480 VAC in gantry or power interruption. Also, may indicate excessive run or braking power required due to sluggish Motor.
F05	Overvoltage Fault. The Drive internal DC bus voltage has exceeded 810V. Possible failure of axial I/F Board Chopper Control or excessive motor regeneration from AXMotor during braking.
F06	Motor Stall Fault. The Drive output current has exceeded 12.6A for > 4 seconds. Possible Motor frozen bearing or shorted Motor winding. Defective Motor and/or cabling.
F07	Overload Fault. The Drive output current has exceeded 9.7A for an extended time. Possible Motor sticky bearing or shorted Motor winding. Also, possible defective Motor and/or cabling.
F08	Overtemp Fault. The Drive heatsink temperature has exceeded 90C (195F). Check for blocked or dirty heat sink fins. Also check if the gantry ambient temperature has exceeded 40C (104F).
F09	Open Pot Fault. Potentiometer speed control is not used in this system. This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry operation.
F10	Serial Fault. This fault code indicates a possible corrupted configur-ation parameter, defective Drive or Control Board. Retry Operation.
F11	Op Error Fault. This fault code indicates a possible corrupted config-uration parameter, defective Drive or Control Board. Retry Operation.
F12	Overcurrent Fault. Check for a short circuit at the drive output or excessive load conditions at the motor.
F13	Ground Fault. Check the motor and external wiring to the drive output terminals for a grounded condition.
F14	Option Error. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F15	Motor Thermistor. System detected and open or short in the Motor Thermistor. Retry Check connections to thermistor and motor heat.
F16	Bipolar directional fault detected by the axial drive.
F17	C167 Watchdog. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F18	Hardware Trap. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F19	Precharge Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F20	The load loss detect is set to enabled and the drive output torque current was below the load loss level for a time period greater then the load loss time.

Table 8-2 Axial Control Error Messages

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F21	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F22	DSP Reset Fault. Power up has occurred with an open Stop_AX2 or closed Start_AX2* signal. Check Control Board and wiring between Drive and STC.
F23	Loop Overrun Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F24	Motor Mode Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F25	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F26	Power Mode Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F27	DSP Comm Fault. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F28	DSP Timeout Fault. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F29	Hertz Error Fault. This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F30	Hertz Select Fault. This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F31	DSP Queue Fault. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F32	EEprom Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F33	Max Retries Fault. The Drive unsuccessfully tried to reset a fault. See message(s) above for original problem.
F34	Prm Access Flt. Verify that the [Run Boost] parameter is less than or equal to the [Start Boost] parameter.
F35	Negative Slope Fault. This fault code indicates a Volts / Hertz programming error. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F36	Diag C Lim Fault. Check programming of [Cur Lim Trip En] parameter. Check for excess load, improper DC boost setting, DC brake volts set too high or other causes of excess current.
F37	P Jump Error Fault
F38	Phase U Fault\n\ A phase to ground short has been detected in the U phase. Check the wiring\n\ between the drive and Motor. Check Motor for grounded primary winding.
F39	Phase V Fault. A phase to ground short has been detected in the V phase. Check the wiring between the drive and Motor. Check Motor for grounded primary winding.
F40	Phase W Fault. A phase to ground short has been detected in the W phase. Check the wiring between the drive and Motor. Check Motor for grounded primary winding.
F41	UV Short Fault. A phase to phase short has been detected between the U & V phases. Check the wiring between the drive and Motor. Check Motor for shorted primary.
F42	UW Short Fault. A phase to phase short has been detected between the U & W phases. Check the wiring between the drive and Motor. Check Motor for shorted primary.
F43	VW Short Fault. A phase to phase short has been detected between the V & W phases. Check the wiring between the drive and Motor. Check Motor for shorted primary.

Table 8-2 Axial Control Error Messages (Continued)

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F44	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F45	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F46	Power Test Fault. This fault code indicates a possible hardware failure in the Drive. Check all connections to the Power/Driver Board. Retry operation. If problems persist, replace the Drive.
F47	Transistor Saturation Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F48	Reprogram Fault. Reset the STC or cycle power to the drive.
F49	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F50	Poles Calc Fault
F51	Background 10ms Over. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F52	Foreground 10ms Over. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F53	EE Init Read. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F54	EE Init Value. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F55	Temp Sense Open. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F56	Precharge Open. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F57	Ground Warning. Check the Motor and external wiring to the drive output terminals for a grounded condition.
F58	Blown Fuse Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F59	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F60	Encoder Loss. This indicates that the axial drive can not sense the axial encoder. Possible causes are:Encoder, cabling, unplugged Axial II Control Board or improper axial drive encoder jumper setting.
F61	Mult Prog Input. Multiple functions selected may indicate a defective Drive. Retry More than one function has been programed reset hardware.
F62	III Prog Input. Multiple functions selected may indicate a defective Drive. Retry Config file or Drive Eprom may be corrupt reset hardware.
F63	Shear Pin Fault. Output Amps exceeds program limits Check Axial hardware and belt. Retry Look for slippage in Axial drive hardware or Axial Drive Belt.
F64	Power Overload. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F65	Adapter Frequency Error. This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F66	EEprom Checksum Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F67	Sync Loss Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.

Table 8-2 Axial Control Error Messages (Continued)

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F68	ROM or RAM Loss Fault. Internal power-up tests did not execute properly. Check Language Module. Retry operation. If problems persist, replace the Drive.
F69	Open Output Fault. An undercurrent condition has been detected in one or more of the Drive output wires. Check the wiring between the drive and the Motor. Check the Motor for an open primary winding.
F70	Phase Unbalance Fault. An imbalance between Drive output phase currents has been detected. Check the wiring between the drive and the Motor.

Table 8-2 Axial Control Error Messages (Continued)

1.1.7 Axial Dynamic Brake Assembly

This assembly provides logic and control power for the AMD when the Axial Power Contactor is open. During gantry deceleration, excess AMD AXDC bus power is dissipated through chopper load resistors.

The Axial Dynamic Brake Assembly is a modified HEMRC circuit. All components are identical, but configured differently. The following theory describes the Axial Applications only.

The following reference information comes from the HEMRC Interface Board Test Specification, 2145832TST. Refer to the 2145832TST document for any updated information, or for more complete discussion of the Interface Board functions.

Chopper Control

DANGER **THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE AXDC – RAIL AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.**

The Interface board Chopper circuit helps dissipate excess energy in the Axial Motor Drive's internal AXDC bus. The Chopper circuit is always active in this application. As the motor decelerates, it acts as a generator, which converts some of the kinetic energy to current. The Axial Motor Drive channels this current into its internal AXDC bus, which causes the voltage on the bus to rise. If the bus voltage exceeds 810V, the drive will disable itself and abort the braking process. When the braking process aborts, the gantry coasts to a stop. The chopper circuit limits the bus voltage to approximately 750V to prevent the gantry from coasting.

The Axial Motor Drive's AXDC voltage powers the circuit at J7 of the HEMRC board. Two 7500 ohm 40W chassis mounted dropping resistors, connected at J4 & J5, limit the power supply current to <50 mA. CR4 regulates the nominal 15V to power the Chopper Control circuit. LED DS3 illuminates to indicate the presence of circuit power.

Since the chopper is always enabled, the open collector of AR1-1 floats, which in turn enables the operation of comparator circuit of AR1-2. The voltage sensed at J7-1 is scaled and compared to a fixed 5V reference provided by VR1. When the bus voltage exceeds 750V, AR1-2 goes high, driving Q3 and turning on IGBT Q1. An external 100 ohm, 1000W shunt resistor is connected through a fuse (AXDC+ and J7-5) to the collector of Q1. When Q1 turns on, this shunt resistor is applied to the AXDC bus and discharges the excess energy. When the voltage falls below 700V, AR1-2 goes low and driver transistor Q2 turns off Q1, which disconnects the shunt resistor.

The AR1-13 circuit detects the on state of Q1. Normally, Q1 stays on for a few milliseconds at a time. If it stays on too long, Q1 can damage the shunt resistor. Therefore, when the collector of Q1 goes low for more than ~1ms, AR1-13 floats high to release the RC timer of R26 & C10. If this condition lasts for more than ~130ms, AR1-14 goes high, which generates a fault condition.

Pins 4 & 5 of J8 are normally jumpered together so the normal low state of AR1-14 turns “on” the normally open solid-state relay U2, and closes its output “contact”. The output of U2 passes through J10-9 & 10 to the Axial Motor Drive. When this circuit opens, the drive detects an error condition and aborts all operation. It also notifies the system of an auxiliary drive fault.

The detected fault also turns on Q4, to generate a pulse from T1 at J8-1 & 3, which fires the gate of an external SCR. The SCR is connected between an 8 ohm tap on the shunt resistor and the AXDC-. When the SCR fires, the surge current blows the chopper’s input fuse and isolates the fault from the AXDC bus supply.

1.1.7.1 Filter Board

The filter board adds differential mode and common mode capacitance to the Axial Motor Drive internal AXDC bus, to reduce the electrical noise created by the switching IGBTs. This board is required for EMI/EMC compatibility.

1.1.7.2 Chopper Resistor Assembly

The chopper resistor assembly provides a high power dissipation load to the AMD bus, if required during axial braking. The chopper resistor configuration resembles the shunt regulator. The Interface Board contains the actual chopper switching element (an IGBT).

When the axial induction motor brakes, it can momentarily generate a current. When this happens, the AMD converts some of the rotational energy to electrical energy and returns it to the internal AXDC bus causing a rise in the bus voltage. If the AXDC bus voltage exceeds ~750V, the chopper IGBT turns on and discharges the excess energy through resistors A4R1 & A4R2. The IGBT turns off when the voltage drops below ~700V. This process continues as long as necessary to keep the bus voltage below ~750V. Normally this action occurs for less than 5 seconds during the brake cycle. At all other times the IGBT remains off and essentially “disconnects” the resistors from the bus. The intermittent duty cycles permits the use of resistors with a much lower power rating than a continuous duty cycle would require.

Because the circuit uses the intermittent duty rated resistors A4R1 & A4R2, it contains fuse A4F1 to isolate the resistors from the bus in the event of a control failure. If a fault occurs, A4SCR1 fires and crowbars the bus. The anode of A4SCR1 connects to a tap on resistor A4R1, nominally set to 8 ohms from the fused end. When the SCR fires, the high current load it creates causes fuse A4F1 to open and disconnect the resistor assembly from the bus, to isolate the fault.

1.1.7.3 Step-Up Transformer

500VA isolation transformer, T1, is configured as a nominal 115:380 V step-up transformer. T1 provides the 24 hour power to the AMD that is needed to maintain communication with the ACB. Diodes inside the AMD rectify the ~380VAC to create a nominal 500 VDC bus (no load, with 120 VAC input). DC to DC converters inside the drive develop power for its internal logic from this bus. T1 should normally never provide power for axial braking.

1.1.7.4 Bridge Rectifier

Bridge Rectifier CR1 connects in series between the T1 step-up transformer and the AMD AXDC bus as the logic and control power source for the drive. The drive internal bus voltage always equals the greater of either the braking voltage or the T1 voltage.

1.1.7.5 Dropping Resistors

Chassis mounted dropping resistors R4 & R5 limit the chopper circuit power supply current derived from the AMD AXDC bus to <50 mA. The Chopper Control supply is referenced to the AXDC bus return, NOT to ground. NEVER reference this voltage to ground.

DANGER

THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE AMD AXDC BUS AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

VARIOUS COMPONENTS, INCLUDING THE CHOPPER RESISTOR ASSEMBLY AND HEMRC INTERFACE BOARD, ARE REFERENCED TO THE AXIAL MOTOR DRIVE AXDC BUS AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

THE HEMRC INTERFACE BOARD CONTAINS NO TEST POINTS. ALL ACTIVE CIRCUITRY IS HIGH IMPEDANCE AND TIED TO HAZARDOUS VOLTAGES. DO NOT PROBE.

A4R1 & A4R2 TAP ADJUSTMENTS

Verify/Align the connection tabs and hardware of the chopper resistors A4R1 and A4R2 so they clear any sheet metal by at least 0.5in.

Adjust the tap band on chopper resistor A4R1 to 8 ohms ± 0.5 ohms, with respect to the end connected to fuse A4F1.

The tap band on chopper resistor A4R2 is not used, but you still must secure the band in place to prevent dielectric failure to the adjacent sheet metal. To minimize confusion, adjust the tap band to 8 ohms ± 0.5 ohms, with respect to the end connected to A2J7-5.

1.1.8 X-Ray Light Control

The axial board provides a set of relay contacts, K1, to control a relay in the PDU. The PDU relay closes a set of contacts that drive the site X–ray ON Light. The relay contacts are closed (x–ray light turned on) whenever the Axial II Control Board commands X–rays to the OBC. The axial board must drive a 24V 100mA LED mounted in the rear of the Gantry. This light, separate from the Gantry display, will indicate the presence of the axial board's x–ray command and will coincide with the PDU x–ray ON light signal. The light is controlled by firmware rather than hardware so that it can be coordinated with actual x–ray state and not just the x–ray exposure command. STC firmware receives notification via the communication slip rings from the OBC when x–rays turn on and off.

1.1.9 DAS Triggers

The Axial II Control Board generates DAS triggers for all data collection modes. Refer to Table 8-3). The DAS trigger signal uses inputs from gantry encoder, table, and x–ray command circuitry to coordinate the DAS trigger signal with gantry and table motion. The DAS trigger function produces both offset triggers for DAS offset characterization and view triggers for actual scan data acquisition.

The trigger circuitry supports 4 scan modes: static, scout, axial, and helical. The modes and offset or view triggers output are selected by firmware. Firmware sets up the hardware by pre–programming the modes and parameters before the triggers are actually generated.

Scout and helical modes require a sync pulse from the table to coordinate the start of triggers. Scout scans use a fixed clock input reference to generate the triggers. Static mode also uses a fixed clock reference. Helical and axial use the gantry encoder signal as a reference to generate triggers.

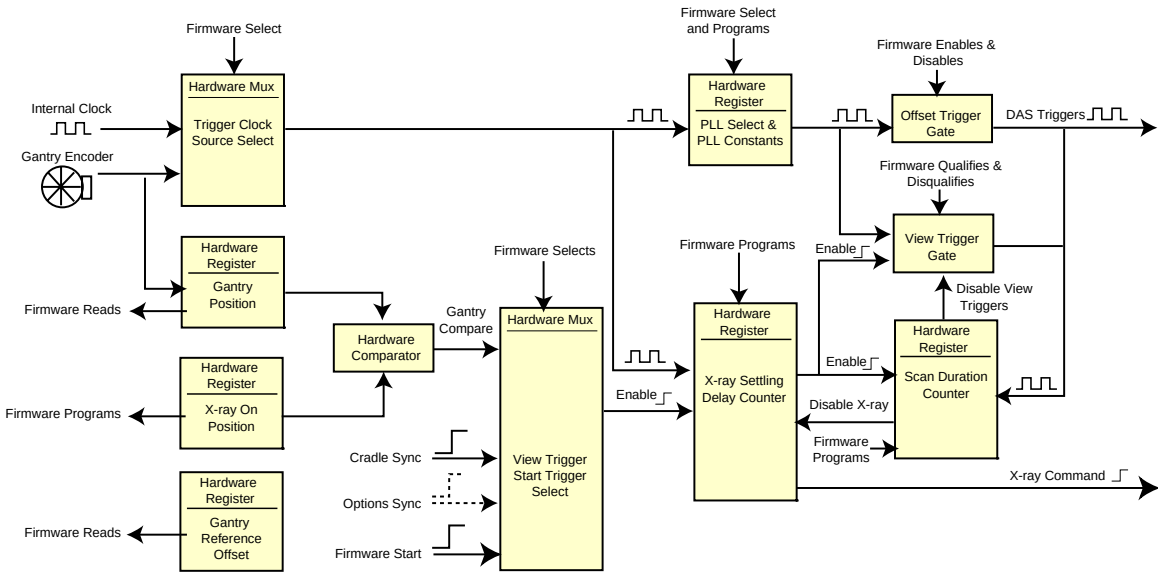


Figure 8-7 Triggers Block Diagram

The DAS trigger counter controls the duration of the scan by counting the number of DAS triggers generated by the ACB. When the programmed number of triggers is received, the zero triggers signal is asserted, causing exposure command to deactivate, trigger generation to deactivate and firmware to be interrupted by a maskable interrupt on VME IRQ4.

To allow for variable length scans, such as required by the CT Smartview option, four counters make up the DAS trigger counter circuit: pre-trigger, minimum triggers, maximum triggers and cycle triggers. Note that if the respective counter is programmed to zero, then the output is active. When the pre-trigger counter expires, the other counters begin counting. This allows for a fixed number of triggers to be generated outside of the control of the other counters. The minimum counter inhibits the zero trigger signal until at least a minimum number of triggers in addition to pre-triggers has been generated. The maximum counter asserts zero trig when the maximum number of triggers in addition to pre-triggers has been generated. The cycle counter, in conjunction with a bit programmable via the VME, can be used to force the system to collect an integer number of triggers in addition to pretriggers. The cycle counter allows for the acquisition of a variable number of “sectors” during scanning.

Speed control is achieved by using the Axial encoder input in two places: the STC and the AMD via the ACB. The AMD uses the encoder feedback to close its control loop and regulate speed. The STC uses the encoder feedback and compares it to the AT SPEED feedback from the AMD. The AMD status is polled every 25 msec. A speed fault will occur if 5 consecutive samples are out of tolerance. The speed regulation is ± 3% of commanded velocity.

SCAN SPEED (SEC)	VIEWS PER GANTRY ROTATION	SLIPRING BANDWIDTH (MBAUD)
Scout	Variable	Variable
0.5 sec	704 views	118 Mbaud
0.6	840	117
0.7	980	117
0.8	984	103
0.9	981	91
1.0	984	83

Table 8-3 Scan Speeds, # of Views and Slipring Bandwidth

SCAN SPEED (SEC)	VIEWS PER GANTRY ROTATION	SLIPRING BANDWIDTH (MBAUD)
1.5	1968	83
2.0	1968	83
3.0	2952	83
4.0	3936	83

Table 8-3 Scan Speeds, # of Views and Slipring Bandwidth (Continued)

1.2 Axial Control *(Major Function)*

1.2.1 Axial Power Contactor Interlock (Minor Function)

The Axial Power Contactor minor function controls the 440 VAC input to the Axial Motor Drive. The Axial Power Contactor is an AC rated contactor that connects or disconnects the 3-phase 440 VAC. This function also provides status monitoring and reporting of the power contactor. There is an interlock in the power contactor control for the Axial Enable/Disable switch on the STC chassis backplane.

DANGER **DISABLE THE AXIAL DRIVE MECHANISM BEFORE SERVICING THE GANTRY INTERIOR. THE AXIAL LOOP CONTACTOR STATUS LED ON THE STC CHASSIS BACKPLANE INDICATES THE STATUS OF THE AXIAL POWER CONTROL CIRCUIT ONLY, NOT THE STATE OF THE AXIAL POWER CONTACTOR. A FAILURE IN THE POWER CONTACTOR COULD LEAVE 440 VAC CONNECTED TO THE AXIAL MOTOR DRIVE AT ALL TIMES.**

1.2.1.1 Axial Power Contactor Circuit

The base requirements for this circuit to function are: Power to the PDU, DRIVEON enabled, and Axial drive switch enabled on the STC chassis backplane. At this point the firmware is needed to close the Axial Drive Power Contactor. This means the scan hardware needs to be downloaded successfully. The Axial II Control Board, Altera (FPGA), now contains the necessary firmware. When the FPGA receives a valid request to rotate the gantry, the LOOPCONT signal is generated. This signal energizes the K3 relay on the Axial board. The following sequence then occurs.

The 24V-B from the PDU relay board goes through the Axial drive enable switch, S2, on the STC chassis backplane. At this point 24V-B becomes AX_DR_EN_SW/SW2. When Axial board relay K3 closes, AX_DR_EN_SW/SW2 becomes CLOSELOOP as it leaves the Axial board. The CLOSELOOP signal goes to the PDU Relay bd, K6. This in turn energizes K13, on the PDU relay bd, generating the LOOPHI command. LOOPHI energizes A3K4, which closes and provides 3-phase 440 VAC power to the Axial Motor Drive.

Note: 440 VAC will be present at the Axial Motor Drive under normal conditions. Remember that this is firmware controlled. Also the Axial Drive Enable Switch on the STC backplane will disable/enable the Axial Drive Power Contactor independent of firmware control. A second hardware reset is not required.

1.2.1.2 Axial Power Contactor Read Back Circuit

When the Axial Power Contactor is energized, it closes a set of N.O. contacts that permits the application of +24V through the Axial Power Contactor relay contacts, back to the Gantry. The signal LOOP-CONT-CLOSED enters the Axial Board at J2A3 and flows into an opto-isolator. The opto-isolator converts the 24 VDC LOOP_CONT signal to 5 volt logic and is sent to the Altera (FPGA). Also the green LED LPC (DS13) illuminates.

LOOP-CONT-CLOSED_RTN is actually PGND from the PDU. This is a differential circuit.

1.2.1.3 Axial Brake Circuit

The Altera generates the AXBRAKE command based upon the scan type and firmware request. A 5 VDC signal called AX_BRAKE_OUT is routed to the SSR (Solid State Relay) mounted on the Axial motor. This signal is always present. The Altera generates the control signal AXBRAKE, which provides a return path for AX_BRAKE_OUT_RTN. This allows current to flow through the SSR, which energizes the coil of the holding brake assembly. When the SSR is energized, its contacts close and apply 120 VAC to the Axial Holding Brake assembly. The Axial Holding Brake is now released. With no power applied, the holding brake is engaged.

Note: The axial brake is released when the Axial Drive Enable Switch is in the “disable” position. This allows the gantry to be rotated by hand without fighting the friction of the brake.

1.2.1.4 Remote Axial C-Pulse Indicator Circuit

The Axial II Control Board receives the “C” pulse from the encoder at J2D25 (AX_ENC_CHC) and J2C25 (AX_ENC_CHC_RTN). This signal is opto-isolated and becomes CHC. A green LED DS2 (CHC) lights when a “C” pulse is received. CHC is processed and becomes CH_C*. This CH_C* signal provides the return path for REMOTE_C_L. REMOTE_C_H is the 5 VDC source used to illuminate the “C” pulse LED on the STC backplane. The “C” pulse LED located on the left fan assembly is also driven by this circuit.

1.2.2 Axial Servo Control Loop (Minor Function)

The hardware involved in the axial servo drive consists of the Axial II Control Board, Axial Motor Drive, Axial Motor, Axial Motor Brake, Axial Encoder, Axial Drive Belt and Axial Home Flag.

The Axial Motor is an induction motor. The axial brake engages the motor shaft and is meant as a static brake to hold the gantry still once it has been positioned by the axial drive. The brake's friction is not sufficient to hold the gantry still against the full accelerating force of the motor and amplifier. Should the brake fail while the gantry is in motion, the gantry will continue to rotate until halted by firmware. The brake cannot hold the gantry still while the tube or inverters are being changed. When servicing the rotating base, the gantry should be locked using the locking block mechanism.

The axial brake is released when the Axial Drive Enable Switch is in the “disable” position. This allows the gantry to be rotated by hand without fighting the friction of the brake.

The encoder is directly coupled to the rotating bearing. It is an incremental encoder and provides 2048 counts per rotation. The quadrature information from the encoder is decoded on the Axial board and used for gantry position and speed control as well as DAS trigger generation.

The motor is coupled to the rotating bearing with a steel reinforced Kevlar belt, with a gear ratio of 13 motor rotations to 1 gantry bearing rotation.

1.3 S/A HSDCD Slip Ring Architecture

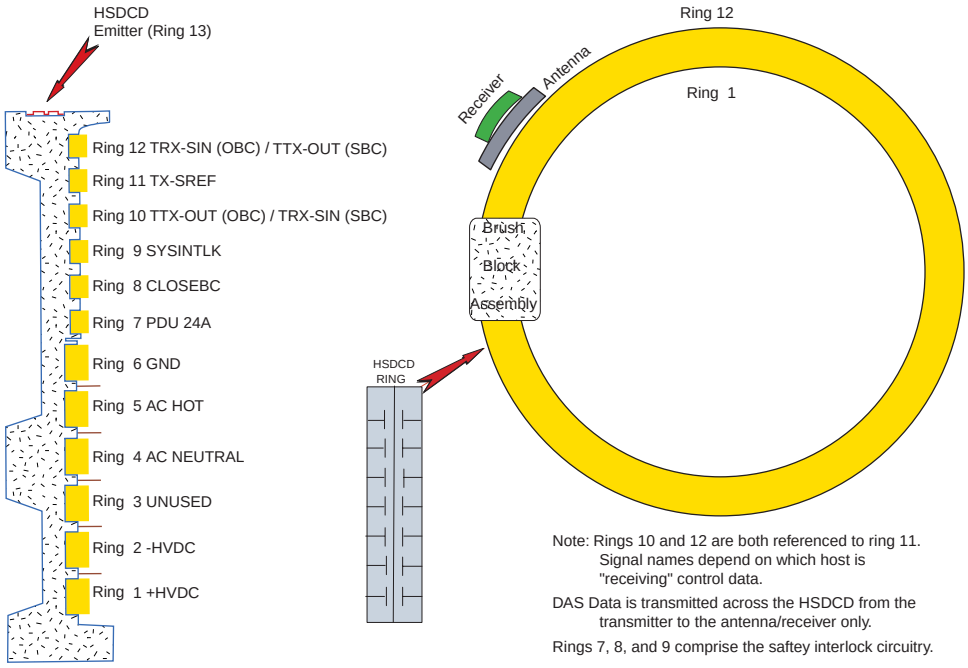


Figure 8-8 S/A HSDCD Slip Ring Architecture

1.3.1 S/A HSDCD Communications

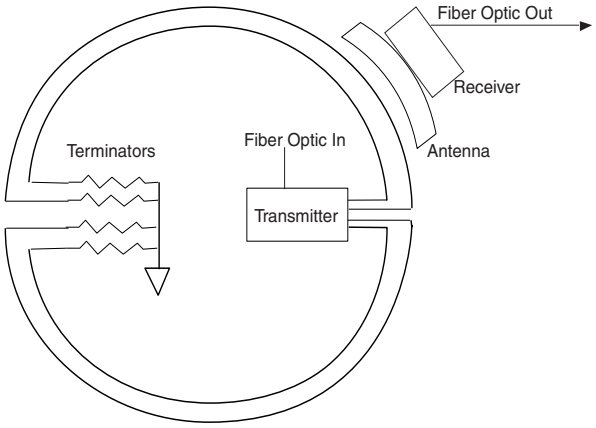


Figure 8-9 S/A HSDCD Slip Ring Communications

1.3.1.1 S/A HSDCD Modulation

DAS data received by the transmitter is converted into HSDCD differential signalling. The transmitter converts its input to differential signals on the ring itself. The antenna is capacitively coupled to the ring and passes the differential signal to the receiver. The receiver converts and amplifies the differential signal to the original transmitter data input format.

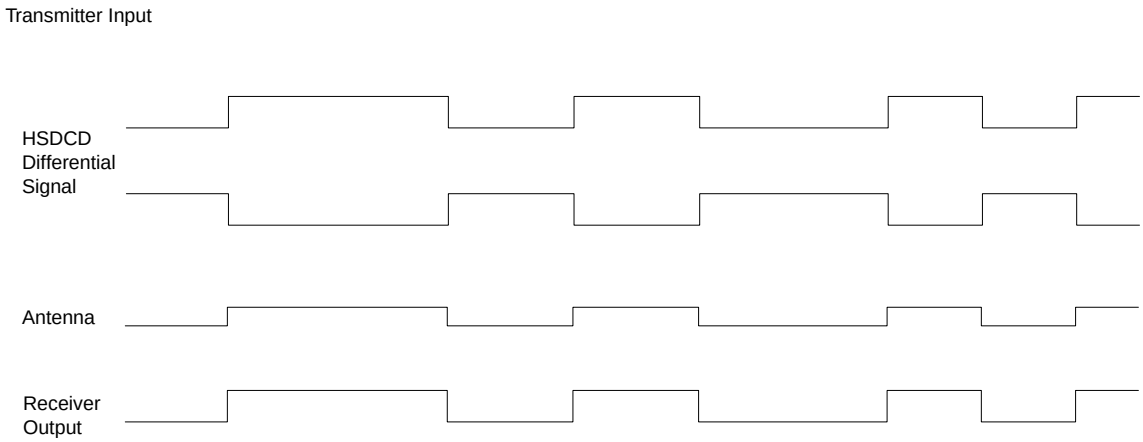


Figure 8-10 S/A HSDCD Modulation

1.3.1.2 Data Rate

Serial Taxi DAS Data is transmitted at a rate of 110 MegaBaud. Each bit cell is 9.1 nanoseconds wide. Each byte consists of 10 bits, due to Taxi encoding, so each byte cell is 91.0 nanoseconds wide. This comes out to 10 Mbytes per second, max burst rate.

1.3.1.3 S/A HSDCD Transmitter

The function of the transmitter is to take 110Mbaud taxi DAS data from its fiber-optic input port and send this signal out on transmitting antenna structure.

1.3.1.4 S/A HSDCD Ring

The HSDCD section of the slip ring is actually made up of a circuit board material that has two traces that run its entire circumference to carry the differential signal. This is called the emitter. They also has a ground plane underneath. The dimensions of the board are controlled to maintain a low trace impedance. This cross sectional shows its construction.

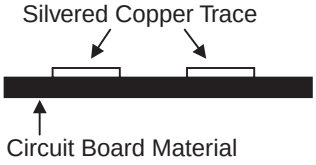


Figure 8-11 S/A HSDCD Ring

At the end of each strip, opposite the end fed by the transmitter, each trace is terminated with a 16 ohm surface mount resistor to the ground plane. So each board strip feeds one half of the ring with the HSDCD signal.

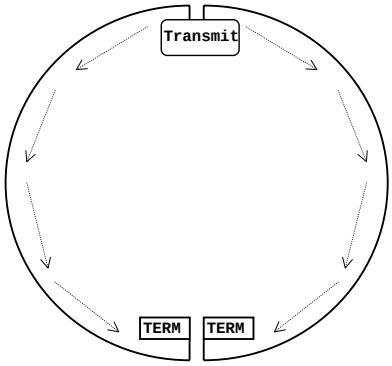


Figure 8-12 S/A HSDCD Ring Termination

1.3.1.5 S/A HSDCD Antenna

The purpose of the HSDCD antenna is to pick up the differential signal from the traces on the ring. The pickup face of the antenna, which is positioned 1.41 mm height (0.60 inches) (use alignment tool 2245483) away from the ring traces, has two traces the same width and spacing as the traces on the ring, and each one acts like one plate of a capacitor. Hence the signals are capacitive coupled from the ring to the antenna.

1.3.1.6 S/A HSDCD Receiver

The purpose of the HSDCD receiver is to amplify the transmitted data signal from the HSDCD antenna to a usable level and convert it back into fiber-optic DAS taxi data.

1.3.1.7 Communication Error Rates

Errors are caused by any noise that enters the HSDCD system within its pass band. Communication error rates are measured by how many errors occur in N number of bits. This is called the Bit Error Rate (BERR). The HSDCD system has been designed to produce 0 or 1 bad bits in 10E12 bits. Note that this is exclusive of forward error correction that enhances BERR to 0 or 1 errors in 10E15 bits. Under normal system operation, this would translate into one scan abort in five years due to DAS data channel errors. The system BERR performance can be monitored through the Dip Stats selection under the service menu. This tells you:

- When the DipStats file was created or reset to zero
- When the stats were last updated (end of last exam)
- How many data bytes were transmitted since file creation (or reset)
- How many offset bytes were transmitted since file creation (or reset)
- How many taxi violations occurred since file creation (or reset)
- How many successful forward error corrections (FEC) occurred since file creation (or reset)
- How many scan aborts (unsuccessful FEC) occurred since file creation (or reset)

BERR can be calculated by the following:

E Number of Errors = Number of Scan Aborts

NO Number of offset bits = Number of offset bytes X 10

ND Number of Data bits = Number of data bytes X10

BERR = E / (NO + ND)

1.3.2 S/A HSDCD Service Indicators

1.3.2.1 S/A HSDCD Transmitter

The transmitter has two LEDs. The green LED is on for power and the yellow is on for data. The yellow data LED is normally on in both system idle or active data collection.

1.3.2.2 S/A HSDCD Receiver

The receiver has two LEDs. The green LED is on for power and the yellow is on for data. The yellow data LED is normally on in both system idle or active data collection.

1.3.2.3 S/A HSDCD Antenna

The HSDCD antenna has no indicators.

1.4 Gantry Tilt

Gantry tilt is achieved by means of a hydraulic pump and 2 hydraulic cylinders. Control signals are received from the ETC-IF board. The Tilt Relay board can operate in 2 modes: system control or manual. Under system control the tilt relay board receives tilt enable, forward and backward control signals. These signals energize either the pump motor or tilt solenoids. Under manual control power is received from the STC power circuit, and motion is controlled manually by switch S2. Switch S1 determines System or manual control.

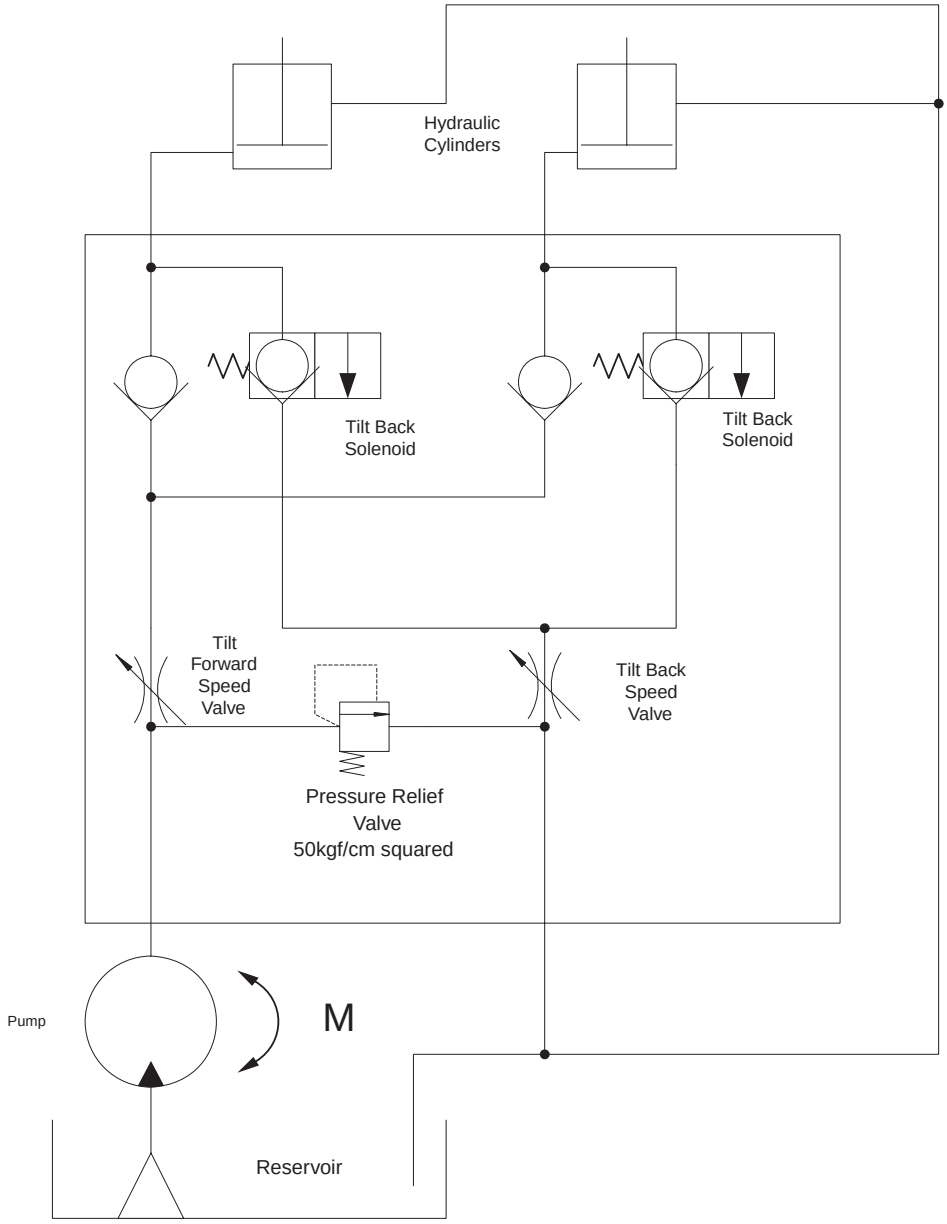
Gantry forward tilt requires the energizing of the pump motor. The pump increases the fluid pressure in the system, resulting in the extension of the cylinder pistons, and the gantry tilts forward.

Gantry backward tilt requires the energizing of the two (2) tilt backward solenoids. This relieves fluid pressure, and the weight of the gantry compresses the cylinder pistons. This is true for all gantry angles. Reference Figure 8-13.

Speed control for both forward and backward motion is set by adjusting separate restrictor valves for 1 second per degree of motion.

The hydraulic system has a pressure relief bypass valve, which is factory set to 50 kgf/cm squared. This hydraulic system is also self bleeding.

Tilt limits are set at ± 30 degrees. Angle position is monitored via feedback of the tilt potentiometer. The feedback is sent to the table electronics, where it is digitized for gantry tilt display and prescribed remote tilt position control.



Tilt Function Control Block Diagram

Figure 8-13 Gantry Hydraulic Tilt Functional Block Diagram

1.5 Gantry Service Balance

Gantry service balance is achieved by use of a service GUI tool, accessed from a variety of locations, from the common service desktop. This balance procedure is used for the Static (or X) Balance only. Dynamic (or Z) Balance is performed during manufacturing, and is not possible in the field.

WARNING **GANTRY BALANCE MUST BE CHECKED FOR ANY COMPONENTS REPLACED ON OR REMOVED FROM THE ROTATING ASSEMBLY.**

Why? > Large changes in “X” have small effects on “Z” motion.

Where? > Where any part is replaced on the Rotating Gantry Assembly.

When? > After every rotating gantry part replacement.

Measurements of Gantry motion:

- Motion > kg-m, kilograms per meter
- Amplitude > kg-m, kilograms per meter
- Phase Angle > Degrees, 0 to 360

How is Gantry Imbalance Detected?

- X motion is a 1 hertz signal per 360 degrees of gantry rotation.
- The amplitude of this signal determines the percent of imbalance.
- The phase angle determines where trim weight needs to be added to achieve desired gantry balance.

The Axial drive subsystem is the heart of Field Gantry Balance.

The Axial Encoder output is the source of data for calculations.

Firmware controls axial open loop rotation and data calculations.

Calculation results are reported using an arbitrary scale.

- Balanced > 0 to 180 counts, GREEN
- Marginally Balanced > 180 to 240 counts, YELLOW
- Not Balanced > 240 or greater count, RED

The gantry service balance procedure consists of four steps, and requires new balance trim weights, as described below:

- Balance Check > Evaluate current Gantry Balance state.
- Create Baseline > Remove “Trim Weights” and calculate Gantry Imbalance.
- Reference Weights > Add “8” Full Side weights and calculate “known” Gantry Imbalance amplitude and phase angle. Report recommended “Trim Weights” and locations to achieve gantry balance.
- Balance Verification > Same as Balance Check.
- Side Weight “Full and Half” > Mounted at 125 and 235 degree rotating gantry locations.
- Round Weights > Mounted at 84 and 276 degree rotating gantry locations.
- Wedge and Wedge Adder Weights > Mounted at 60 and 308 degree rotating gantry locations.

PROBABILITY OF IMBALANCE IN THE FIELD

FRU Replacement Examples

- Tube Change > 0.1 per 1000
- Tube and HV Tank > 3 per 1000

Risks of False Results

- Axial hardware component failures
  - Axial Encoder
  - Axial Circuit Board
  - Axial Drive Assembly
- Incorrect Reference Weight Placement
- Incorrect torque of Trim Weight Fasteners

Risk of Severe Gantry Damage

- Incorrect installation of Full Side Weights at 125 or 235 degree locations.
- Using Threaded Rods to manually rotate the gantry.
- Incorrect torque of Trim Weight Fasteners.

Section 2.0
Procedures and Adjustments

2.1 Power Supply Checks

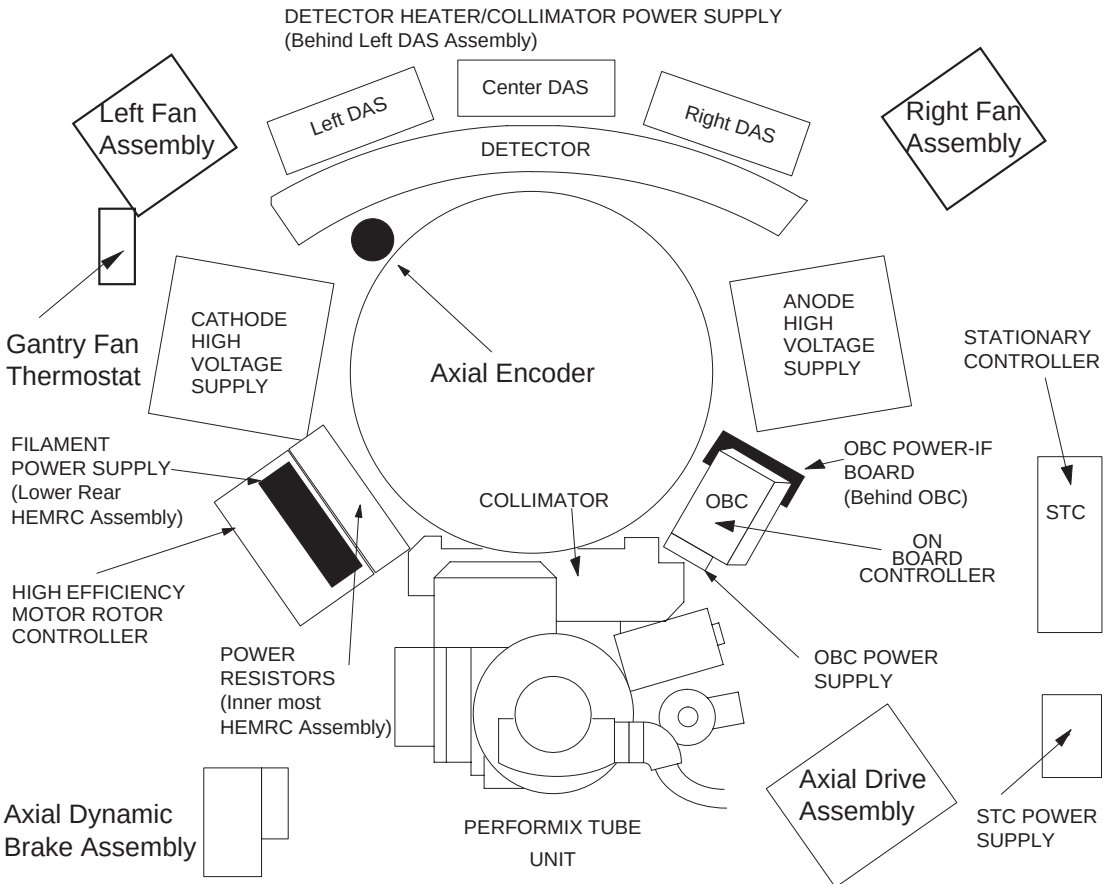


Figure 8-14 GANTRY POWER SUPPLIES WITH A PERFORMIX TUBE

2.1.1 STC Power Supplies

1.) Turn OFF the axial drive enable and HVDC enable switches on the STC chassis.
2.) Turn ON gantry 120VAC enable switch on the STC chassis.
3.) Use a DVM to verify the STC power supply voltages at the following test points on the Axial bd:

AXIAL BOARD TEST POINTS	SPECIFICATIONS	SOURCE
TP12 (VCC) WRT TP9 (GND)	+5vdc (±0.25V)	STC Power Supply
TP10 (3V3) WRT TP9 (GND)	+3.3vdc (±0.05V)	Axial Board (No Adjustment)
TP3 (12V) WRT TP3 (HGND)	+12vdc (±0.25V)	Axial Motor Drive (No Adjustment)
TP2 (5V CAN) WRT TP1 (HGND)	+5vdc (±0.25V)	Axial Board (No Adjustment)
WRT means “With Respect To”		

Table 8-4 STC Power Supply Test Points

FUSE	VALUE	DESCRIPTION
F1	1 amp	5Vdc to external Axial Encoder & Home Flag assemblies
F2	1 amp	5Vdc to external Cardiac Interface assemblies.

Table 8-5 STC Backplane Fuses

SWITCH #	LABEL	DESCRIPTION
S1	S1	Momentary PB, resets gantry drives enable circuit in PDU.
S2	S2	Toggle switch enables Axial Drive.
S3	S3	Toggle switch enables HVDC
S4	S4	Toggle switch enables Gantry 120Vac

Table 8-6 STC Switches

LED	COLOR	LABEL	DESCRIPTION
DS1	Green	C Pulse	C Pulse indicator from Axial Encoder.
DS2	Green	RST	Indicates status of the HVDC & gantry drives circuit in the PDU: On steady = HVDC & Drives Enabled Slow Flash = E-Stop activated. HVDC & Drives Disabled Fast Flash = Table Tape Switch activated. Cradle, Tilt & Elevation Disabled
DS3	Yellow	AX DR ON	Indicates the Axial Drive Contactor in the PDU is energized.
DS4	Green	ENBL	Indicates the Axial Drive Contactor in the PDU is enabled.
DS5	Yellow	HVDC ON	Indicates the HVDC Contactor in the PDU is energized.
DS6	Green	ENBL	Indicates the HVDC Contactor in the PDU is enabled.
DS7	Yellow	120VAC ON	Indicates the Gantry 120Vac Contactor in the PDU is energized.
DS8	Green	ENBL	Indicates the Gantry 120Vac Contactor in the PDU is enabled.
DS9	Green	ENC PWR	Indicates fuse, F1, which feeds the Axial Encoder is OK.
DS10	Green	HHC PWR	Indicates fuse, F2, which feeds the Cardiac Interface is OK.
DS11	Green	ETC PWR	Indicates 5Vdc from the ETC, which feeds Hand-Held Control is OK.

Table 8-7 STC LEDs

TP #	COLOR	LABEL	DESCRIPTION
TP1	Yel	TRX-SIN	Communication signals inbound to STC from Slip Ring 10.
TP2	Blk	TX-SREF	(Isolated) Communication signals reference from/to Slip Ring 11.
TP3	Yel	TTX-SOUT	Communication signals outbound from STC to Slip Ring 12

Table 8-8 STC Test Points

2.1.2 OBC Power Supplies

Turn OFF the Axial Enable and HVDC switches on the STC backplane.

NON-ADJUSTABLE SUPPLIES	ADJUSTABLE SUPPLIES
OBC +24	ETC,OBC, +5, ±15
Table (Display, Emergency Stop) +24	Table (Cradle Drive, Relays) +24
Filament Supply +30	Data Communication +12
Tilt/Elevation +170	DAS +5, ±5
	Collimator/Detector Heater +24

Table 8-9 OBC and Table Power Supplies

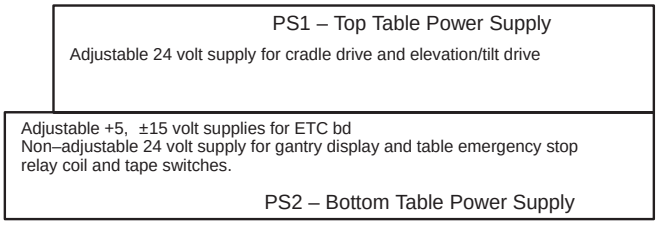


Figure 8-15 Table Power Supplies (Left View)

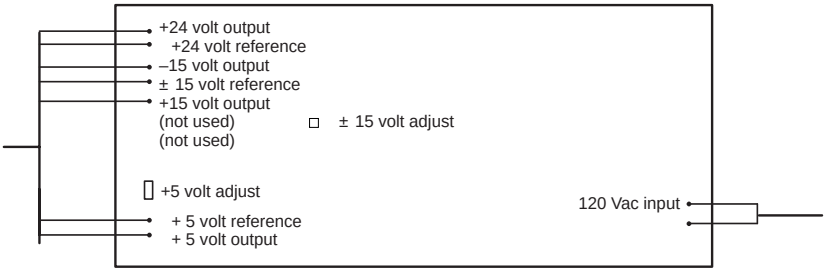


Figure 8-16 OBC and Bottom Table Power Supplies (Top View)

TEST POINT	SPECIFICATION
Gentry I/O bd **TP 3** Ref **TP 4**	5 vdc ± 0.25 vdc
Gentry I/O bd **TP 6 (+15**) **TP 7 (-15**) Ref **TP 5**	±15 vdc ± 0.25 vdc
Gentry I/O **TP 11** Ref **TP 17**	24 vdc ± 2.0 vdc

Table 8-10 OBC Power Supply Test Points and Specifications

SW #	LABEL	DESCRIPTION
S1	Lights Laser	Laser alignment light control ON/AUTO.

Table 8-11 OBC Backplane Switches

LED #	COLOR	LABEL	DESCRIPTION
DS1	Yellow	DS1	Indicates laser alignment light power supply is ON.

Table 8-12 OBC Backplane LEDs

RELAY #	LABEL	DESCRIPTION
K78	K78	Filament selection relay. De-energized => Large Focal Spot Selected. Energized => Small Focal Spot Selected.

Table 8-13 OBC Backplane Relays

TP #	COLOR	LABEL	DESCRIPTION
TP1	Yellow	TRX-SIN	Communication signals inbound to OBC from Slip Ring 12.
TP2	Black	TX-SREF	(Isolated) Communication signals reference from/to Slip Ring 11.
TP3	Yellow	TTX-SOUT	Communication signals outbound from OBC to Slip Ring 10.

Table 8-14 OBC Backplane Test Points

2.1.3 OBC Power Interface Board

Turn OFF the axial drive enable and HVDC enable switches on the STC chassis.

- The primary function of the OBC PWR I/F is to provide a single, 120 Vac power distribution point on the rotating gantry for the X-Ray Generation Subsystem.
- The second function of the board is to provide a convenient location for fusing the various subsystem circuits. In this way the major pieces of the XRGEN subsystem have been grouped logically, while adequately protecting the harnessing from faults.
- The third function of the board is to provide “Open Fuse Detection” for the Tube fan & pump circuit. A small voltage sensing circuit monitors the level at the load end of F3. In the event fuse F3 should open, the optically coupled solid state relay, U1, will interrupt the XRT pressure switch signal to the Gentry I/O board. This will cause an immediate scan abort and prevent additional energy from being dumped into the XRT.
- For personnel protection, adhesive insulating pads are applied to the back of the OBC PWR I/F board to protect service personnel from accidentally contacting live component leads.
- The OBC PWR I/F contains devices that can be damaged by ESD. This damage may not be immediately apparent, but may show up in the future as degraded operational performance. Therefore, these components should never be handled by anyone who is not wearing a properly grounded ESD prevention wrist strap. Careful attention to ESD packaging and handling procedures are required, to insure long term reliability of this assembly.

FUSE #	RATING	DESCRIPTION
F1	8A, MDA	Protects 120 Vac to the OBC and Inverters.
F2	15A, MDA	Protects 120 Vac to the HEMRC Assembly.
F3	12A, FNM	Protects 120 Vac to the X-Ray Tube Assembly.
		Note: All fuses are specified with slow-blow characteristics.

Table 8-15 OBC Power Interface Board Fuses

LED #	COLOR	LABEL	DESCRIPTION
DS1	Green	DS1	Indicates 120 Vac is present on the board.

Table 8-16 OBC Power Interface Board LEDS

CONNECTOR	VALUE	COMMENTS
J8-1 & 2	120 Vac (Line)	Input externally protected to 30A maximum.
J8-3 & 4	0 Vac (Grounded Neutral)	

Table 8-17 OBC Power Interface 120 Vac Distribution

There are no Switches or Test Points on this board.

2.1.4 DAS Power Supplies (2225212-2 ±5 vdc, 2225217 (2) 12 vdc)

Test Points are available on the Center Backplane to measure Power Supply voltages.

TEST POINT	DESCRIPTION	SPECIFICATIONS
TP1	+12 VDC Analog wrt AGND	+12 vdc ± 0.6 vdc
TP2	-12 VDC Analog wrt AGND	-12 vdc ± 0.6 vdc
TP3	+5 VDC Analog wrt AGND	+5 vdc ± 0.25 vdc
TP4	-5 VDC Analog wrt AGND	-5 vdc ± 0.25 vdc
TP5	+5 VDC Digital wrt LGND	
TP6	AGND (Analog Ground)	
TP7	LGND (Logic Ground)	

Table 8-18 Backplane Voltage Test Points

2.2 Axial Motion Checks

2.2.1 Axial Encoder Check

Turn the Gantry by hand until it passes through the Axial Home Flag. Verify:

- Axial board CHA and CHB LEDs toggle.
- Axial board CHC LED toggles on and off once while home LED is illuminated.
- Also verify the "C Pulse" LED on the STC Backplane illuminates with the CHC LED.

2.2.2 Axial Home Flag Check

Turn the Gantry by hand until the Axial Home Flag approaches the sensor. Verify:

- Flag passes through sensor without making contact.
- Flag is centered in sensor window top to bottom.
- With flag in sensor window, verify DS5 (Home) LED on Axial board illuminates.
- Perform Axial Encoder Check, page 573.

2.2.3 Axial Brake Check

Toggle the axial drive enable switch on the STC backplane. Listen to the brake; it should energize and de-energize.

Note: The brake may not toggle if the system underwent a hardware reset since the last time you turned on gantry AC power. If the brake doesn't toggle, use the 120 Vac enable switch on the STC backplane to turn gantry 120 Vac power off, then on. Then toggle the axial drive enable switch on the STC backplane. You should now hear the brake as it energizes and de-energizes.

Make sure:

- When you turn off the axial drive enable, the switch pilot light turns off and the brake releases. (You can easily rotate the Gantry by hand.)
- When you turn on the axial drive enable switch, the switch pilot light turns on and the brake energizes.

Turn on all three switches on the STC backplane.

2.2.4 Axial Dynamic Brake Fuses

FUSE#	VALUE	DESCRIPTION
F1	20A, 700Vdc	Not Used
F2	20A, 700Vdc	Not Used
F3	3A, 250Vdc	Not Used
F4	8A, 350VAC, Slo-Blo	Not Used
F5	8A, 350VAC, Slo-Blo	Not Used
A4 F1	10A, 700Vdc	DCIN+ to Chopper Resistor Assembly

Table 8-19 Axial Dynamic Brake Fuses

2.2.5 Axial Control Functional

Perform gantry rotational testing using Axial Functional Diagnostic. Service Desktop>Diagnostics>Axial Control>Axial Functional.

1.) Perform one (1) pass each "Open Loop Rotation" at each scan speed. Verify no errors.
2.) Perform one (1) pass each "Closed Loop Rotation" at each scan speed. Verify no errors.
3.) Perform several passes of "Goto Position" choosing different angles. Verify no errors.

2.3 Resetting the C-Pulse

1.) Turn off the axial drive and the HVDC switches located on the STC backplane.

2.) Rotate the gantry until the middle of the home plate is in the center of the opto-sensor window. Verify that the DS3 LED on the axial board lights up. Notice that when the gantry is rotated, LEDs DS7 and DS6 flash. The DS3 LED should only light up when the home plate is in the opto-sensor window.

3.) Once the DS3 LED is on, rotate the gantry ± 1 degree. Verify that the DS2 LED lights up. Notice that the DS2 LED might not stay on but rather just flash. The key is to stop rotating the gantry as soon as the DS2 LED flashes. If the DS2 LED flashes or lights up, you have coincided with the c-pulse, otherwise follow the additional step.

If the DS2 LED does not flash or light up, verify that the home plate is in the center of the opto-sensor, and lift as well as rotate the encoder gear assembly until DS2 lights up.

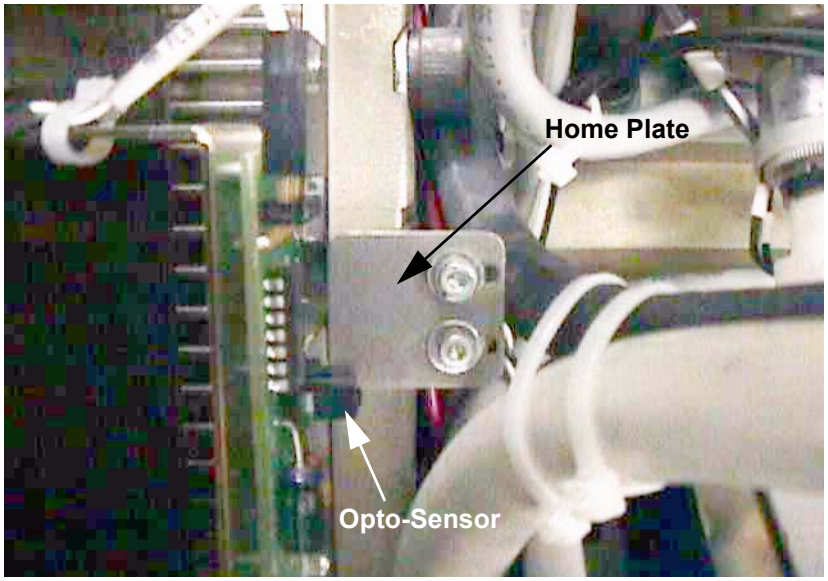


Figure 8-17 Home Plate Passing Through Opto-Sensor Window

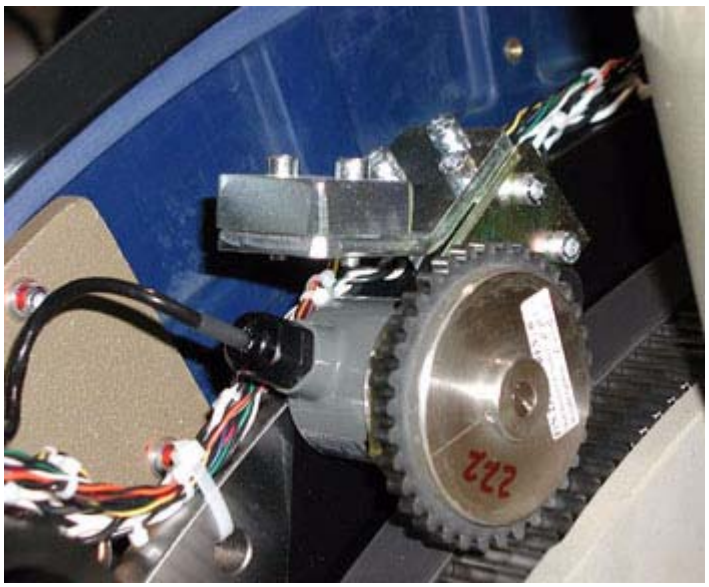


Figure 8-18 Encoder

2.4 Tilt Pot Assembly

Tilt angle accuracy is achieved by using potentiometer feedback and three reference points. Characterization is performed by reading the potentiometer voltage feedback at each of these three points. This method creates a slope characterization file that is accurate, independent of the gantry leveling procedure performed during installation. (See the Installation manual for details on gantry leveling.)

For this reason, unique precise tilt angle values are written on the tilt label for your system. Reference Figure 8-19. This method allows manufacturing to measure and record precise tilt angle values using an inclinometer. The manufacturing process first takes a relative reading creating an offset, and then absolute readings are used with offset correction. The result is actual tilt angles during normal system operation.

WARNING **DO NOT ATTEMPT TO ADJUST THE 150 TOOTH PULLEY. THIS IS FACTORY SET. DISTURBING THIS PULLEY WILL RESULT IN INVALID TILT LABEL VALUES AND INACCURATE APPLICATION TILT ANGLES. CARE SHOULD ALSO BE USED TO PREVENT DAMAGING THE LEGIBILITY OF THE TILT LABEL.**

2.4.1 Tilt Pot and Belt Adjustment

The tilt pot is a 5 turn, 5k ohm potentiometer. The adjustment of this potentiometer can be confusing. The procedure is based upon a relative tilt value as opposed to an absolute or real value. It is very important that this procedure be followed carefully.

WARNING **DO NOT USE THE GANTRY DISPLAY TO DETERMINE TILT ANGLE. YOU MUST USE THE SCRIBE MARKS ON THE 150 TOOTH PULLEY TO SET CORRECT TILT ANGLE FOR POTENTIOMETER ADJUSTMENT.**

1.) Tilt gantry to middle reference position. Refer to Figure 8-19.

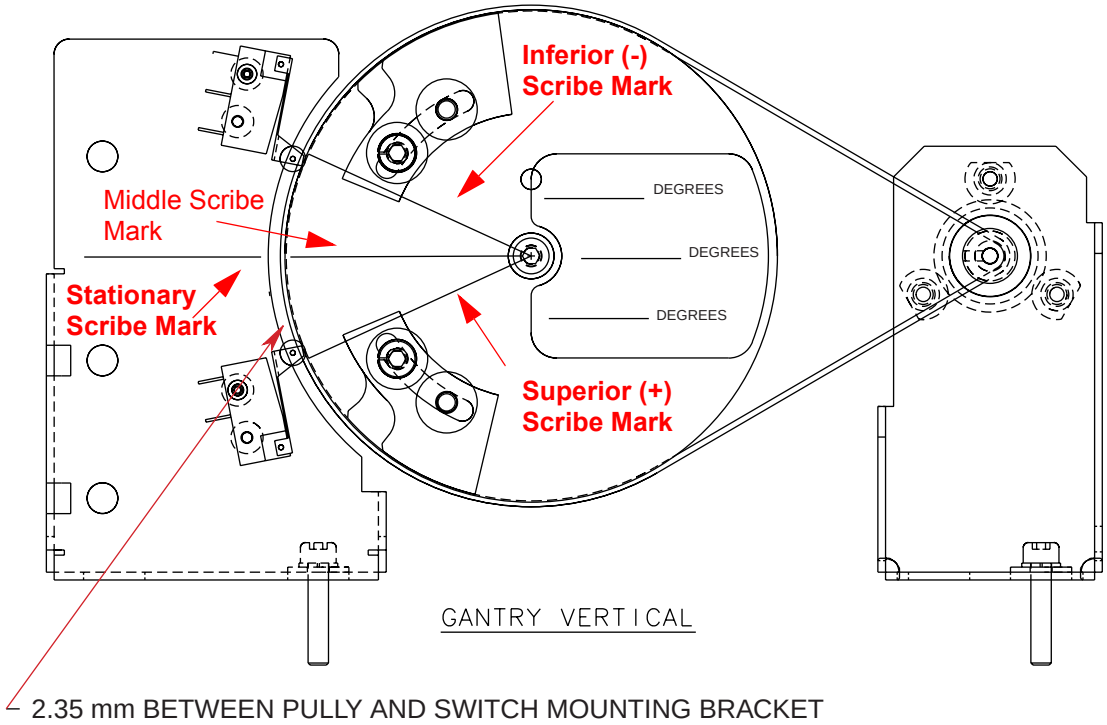


Figure 8-19 Tilt Pot Adjustment Diagram

2.) For coarse adjustment, loosen tilt pot mounting bracket and relieve tension on the timing belt.

3.) Connect DVM minus lead to **CCW** (center post) of the potentiometer and DVM plus to **S** (closest outside post) of the potentiometer.

4.) Rotate small pulley until the DVM reads 5 vdc.

5.) Restore belt tension with the tilt pot mounting bracket and secure.

6.) For final adjustment, loosen tilt pot clamps and rotate the body of the pot until the DVM reads 5.0 ± 0.1 vdc.

7.) Tighten pot clamps and verify DVM reading.

Refer to Figure 8-20 for the following steps:

8.) Loosen both screws holding the Tilt Pot Bracket.

9.) Ensure that the belt's edge is parallel to the Large Pulley.

10.) Tension the belt by applying a force of 0.56 N (.1258 lbs, 57.1 grams) to the Tilt Pot Bracket.

11.) While the belt is in tension, torque the two screws to 7.9 Nm (68.97 in.-lbs).

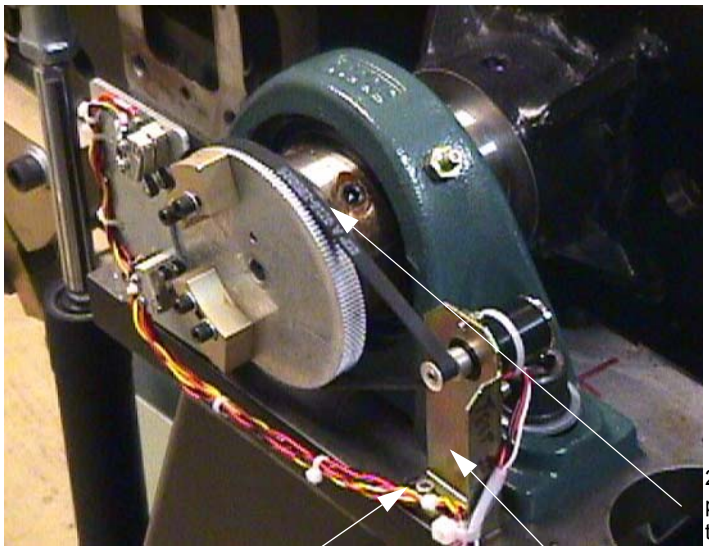


Figure 8-20 Tilt Pot Belt Tension Adjustment

Note: Although CT Engineering has indicated a “recommended” tension of 57.1 grams as optimal, the *exact* amount of force is not critical to proper system function. Measurement methods for this can be as specific as the use of a force gauge, or as general as a light tug, using one finger.

Tool suggestions:

1.) Locally acquired Force Gauge that measures in the 1 to 8 ounce range.

Example: Economy Linear Tension & Compression Gauge 8 oz X 220 G Cap, 0.25 oz X 5 G Grad, 14" Lg $69.11 Each (Part #2115T11), available from McMaster-Carr Supply Company.

2.) One finger with light force applied to the bracket.

2.4.2 Tilt Limit/Interference Adjustments

Tilt limit and interference is sensed using micro-switches to provide feedback in a faulted state. These switches are not activated during normal operation. Firmware control stops tilt motion prior to these switches being activated. A faulted state will prevent further tilt motion in that direction. Tilt is functional in the opposite direction to clear the faulted state.

Tilt interference limits are minus (-) 22.00 degrees and plus (+) 19.00 degrees.

Tilt limits are ± 30.00 degrees.

The interference matrix is dependent upon table elevation and cradle position.

ADJUSTMENT PROCEDURE

1.) Launch Tilt Characterization: SERVICE DESKTOP > SYSTEM INTEGRATION > CHARACTERIZATION > TILT CHARACTERIZATION

WARNING **DO NOT ACCEPT AND SAVE ANY VALUES DURING THIS PROCEDURE. YOU WILL CORRUPT YOUR TILT CHARACTERIZATION. THIS PROGRAM DISABLES FIRMWARE CONTROL AND ALLOWS THE USER TO TILT THE GANTRY UNDER HARDWARE CONTROL TO ACTUATE THE SWITCHES FOR ADJUSTMENT AND VERIFICATION PURPOSES.**

2.) Elevate the table slightly above middle height. Press and hold the limits pushbutton. Verify that S22 and I22 alternate on the gantry display tilt window. Adjust elevation height as necessary.

3.) Release limit pushbutton and tilt gantry back to minus (-) 22.50 degrees. This will be seen on the gantry display cradle window.

4.) Remove Back Limit Cam and adjust Back Interference Cam to actuate the Back Tilt Interference Switch. (Use a DVM set to DC volts to monitor the switch activation). Refer to Figure 8-21.

5.) Tilt gantry forward and then back again. Verify the tilt stops between minus (-) 22.50 and minus (-) 22.60 degrees as shown on the gantry display cradle window.

6.) Tilt gantry forward to plus (+) 19.50 degrees as shown on the gantry display cradle window.

7.) Remove the Forward Limit Cam and adjust the Forward Interference Cam position to just actuate the Forward Tilt Interference Switch. (Use a DVM set to DC volts to monitor the switch activation). Reference Figure 8-21.

8.) Tilt gantry back and then forward again. Verify the tilt stops between plus (+) 19.50 and plus (+) 19.60 degrees as shown on the gantry display cradle window.

9.) Elevate the table to maximum height. Press and hold the limits pushbutton. Verify that S30 and I30 alternate on the gantry display tilt window.

10.) Tilt gantry forward to plus (+) 30.25 degrees as shown on the gantry display cradle window.

11.) Install the Forward Limit Cam and adjust position to just actuate the Forward Tilt Limit Switch. (Use a DVM set to DC volts to monitor the switch activation). Refer to Figure 8-21.

12.) Tilt gantry back and then forward. Verify the tilt stops between plus (+) 30.25 and plus (+) 30.35 degrees as shown on the gantry display cradle window.

13.) Tilt gantry back to minus (-) 30.25 degrees.

14.) Install Back Limit Cam and adjust to actuate Back Tilt Limit switch. (Use a DVM set to DC volts to monitor the switch activation). Refer to Figure 8-21.

15.) Tilt gantry forward and then back again. Verify the tilt stops between minus (-) 30.25 and minus (-) 30.35 degrees as shown on the gantry display cradle window.

16.) Tilt the Gantry through both Forward and Backward tilt range. Verify the gantry stops at both angles as specified above.

17.) Proceed through the Tilt Characterization screens and exit **WITHOUT SAVING**. It is not necessary to tilt the gantry as instructed. Ignore all reported values.

18.) Exercise the tilt function under firmware control, and verify that the Interference and Limit Switches are not activated during normal operation. Use the DVM as above for each switch. Notice the gantry display will show tilt with 1 decimal point in the tilt window.

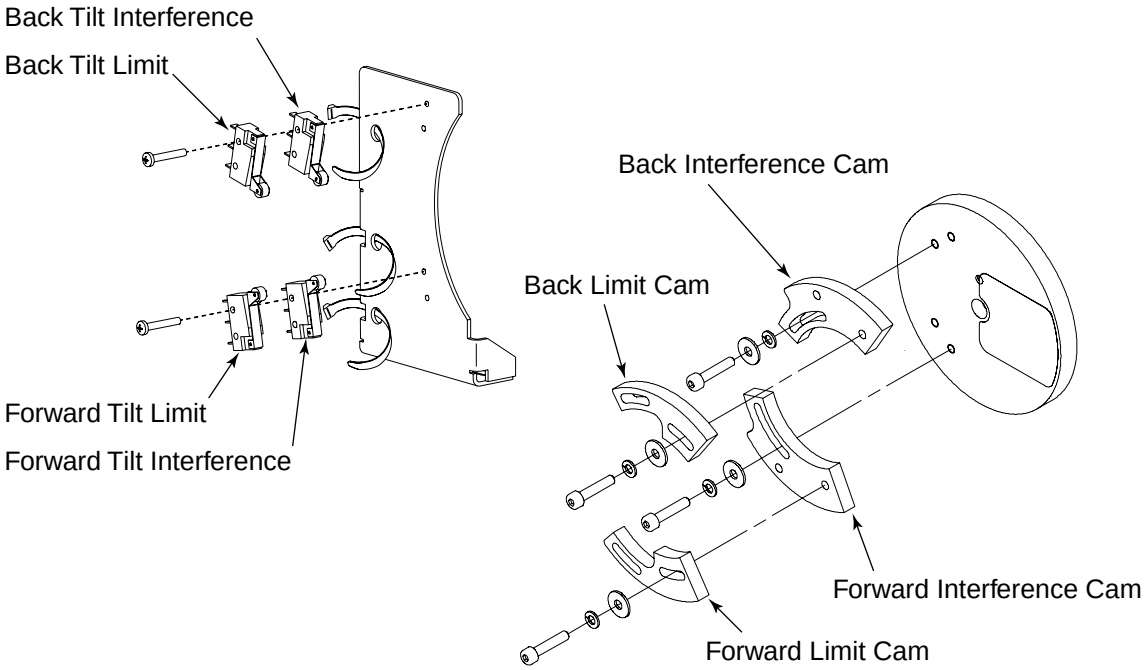


Figure 8-21 Tilt Limit/Interference Cam Adjustment

2.5 Hydraulic Tilt Motor Assembly

This assembly has two basic elements, fluid level and speed control.

2.5.1 Tilt Speed Adjustment Procedure

1.) Remove rear gantry base covers.

2.) Using a stop watch or suitable time piece adjust for one (1) degree per second motion.

WARNING **Adjustments are very sensitive. Improper speed adjustments will result in overspeed error generation.**

Note: Tilt speed will vary based upon hydraulic fluid temperature. Adjustments should be made at normal scan room temperature settings.

3.) From zero (0) degrees tilt, press and hold the tilt forward button, until gantry display reads S25. Observe tilt speed using time piece.

4.) Press and hold backward tilt button, until gantry display reads I25. Observe tilt speed using time piece.

5.) Adjust forward speed control valve for one (1) degree per second motion. See Figure 8-22.

6.) Adjust backward speed control valve for one (1) degree per second motion. See Figure 8-22.

7.) Repeat steps 3 through 6 until tilt speed for both directions is correct.

8.) Now tilt the gantry forward to S30. Observe the S25 to S30 speed. Do this several times. If a noticeable difference is observed, then check the hydraulic fluid levels.

Note: This is a self bleeding system. Trapped air can cause slowed or limited tilt range. Exercising the full range of motion several times should purge any trapped air from the hydraulic system.

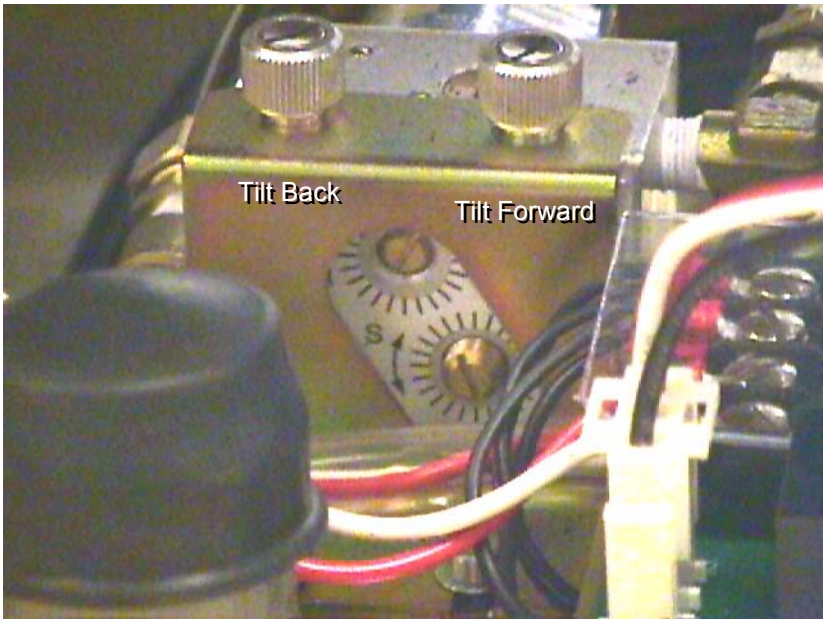


Figure 8-22 Tilt Speed Adjustment Screws

2.5.2 Hydraulic Fluid Check and Fill Procedure

REQUIRED TOOLS

- 5 mm Hex key
- Hydraulic fluid (P/N 2227239)
- Teflon Tape

WARNING **ALWAYS CHECK AND FILL THE HYDRAULIC TILT ASSEMBLY WITH THE GANTRY TILTED FULL BACKWARDS. FAILURE TO DO THIS WILL RESULT IN HYDRAULIC FLUID SPILLS VIA THE OVERFLOW TUBE WHEN THE SYSTEM IS PRESURIZED.**

1.) Remove the rear gantry base covers.

2.) Tilt the gantry forward and backward the full range of motion several times. It is important that the pump be warm to the touch.

3.) When the pump is warm to the touch, tilt the gantry back 30 degrees.

4.) Remove the forward 6 mm cap screw (without the vent tubing).

5.) Use the 5 mm hex key as a dip stick.

Clean the hex key with alcohol to remove any grease or other contaminants.

6.) The fluid level should be just below the fill port (about 15 mm on your dip stick). Reference Figure 8-23.

Figure 8-23 Tilt Fluid Level Measuring Device

7.) To fill the unit a flexible hose on suitable squeeze bottle is recommended.

8.) Use paper towels to catch any overflow.

9.) Clean the threads of the cap and wrap 2 full turns with new teflon tape.

10.) Reassemble gantry.

Note: This Hydraulic system is not permanently sealed. It is normal to see RED coloring around the teflon tape of the threaded joints. The difference between a “seep” and a “leak” is a puddle.

2.6 Mechanical Characterization - Gantry Tilt

Select TILT and CHARACTERIZE in sequence, then follow the Tilt Characterization instructions displayed on the monitor screen. (See Figure 8-24.)

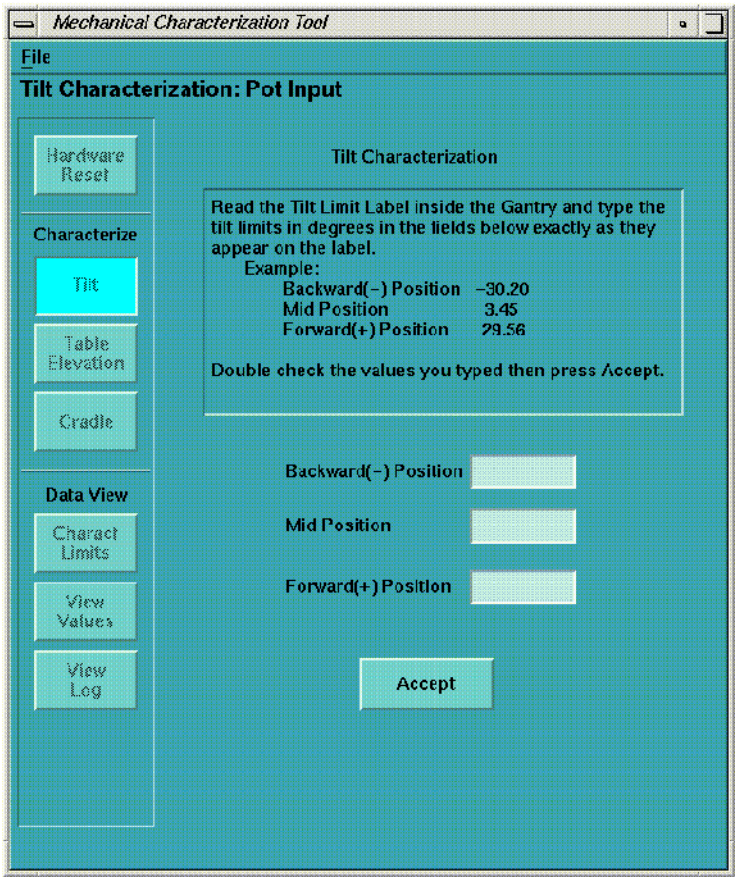


Figure 8-24 Gantry Tilt Characterization

2.7 Alignment Lights Visual Checks

DANGER **VERIFY THAT ALL PERSONNEL ARE CLEAR OF THE SYSTEM, AND THE GANTRY ROTATES FREELY TO 180 DEGREES.**

1.) Press the alignment light button on the gantry-mounted table controls, to position the gantry.
2.) Press the alignment light button on the gantry-mounted table controls again to turn the lights OFF.
3.) Turn OFF the axial drive enable and HVDC enable switches, on the STC backplane.
4.) Use the switch on the OBC backplane to manually turn on the alignment lights, (table side, upper left corner, labeled “Lights Laser”). Note, DS1 next to “Lights Laser” switch will illuminate.

WARNING **WHEN YOU OPERATE THE ALIGNMENT LIGHTS, NEVER STARE AT THE LASER BEAMS, BECAUSE THIS CAN CAUSE PERMANENT EYE DAMAGE.**

LASER LIGHT

2.7.1 Internal Axial Lights

Place a sheet of plain white paper over the output port of each light and verify that the two lines of laser light coincide with each other.

Do not try to adjust the internal axial lasers on the CT system to shine “down” on the collimator.

2.7.2 External Axial to Internal Axial Distance

Raise the table to its highest elevation. Extend the cradle until both the internal and external laser lights shine on the cradle. Place a metric rule on the right edge of the cradle, and measure the distance from the internal axial laser line to the external axial line generated by each laser. Verify this distance equals 240.0 mm ±1.0mm. Place the rule on the left edge of the cradle and measure again.

Extend the cradle until both internal and external laser lines shine on it. Lower the table to the interference limit. Verify the 240.0 mm ±1.0mm distance between the internal and external lights, on both edges of the cradle, as above.

2.7.3 Coronal Lights

Place a sheet of plain white paper at the left side of the patient opening, in front of the coronal laser light. Verify that the two coronal lines coincide with each other. Check the right side in the same way.

Place the paper in the center of the Gantry opening, and use a level to verify that the coronal lines are horizontal.

2.7.4 Alignment Light Visibility

H.H.S. requirements state that lights used to define the tomographic plane must be visible under ambient light conditions, up to 500 lux. To verify:

1.) Turn the scan room lights on to their brightest normal level. Do not add localized spot lights to increase the brightness level.

2.) Raise the table to its highest position, advance the cradle into the gantry, and turn on the alignment lights.

3.) Center the back of your hand over the cradle, and hold it in the alignment light. Make sure you can see the external axial alignment lights on your hand. You only have to see the axial lights, not the sagittal or coronal lights.

4.) Repeat the procedure with the internal axial lights.

If you cannot see the external or internal axial lights under the conditions described above, obtain a DIGAPHOT model #3300 or 3303 light meter; measure the ambient light intensity at the cradle surface at the external and internal alignment light locations.

Note: Foot-candles x 10.76 = lux.

If the light reading(s) exceeds 500 lux, reduce the room lighting to the 500 lux level, and repeat steps 3 and 4. If the light meter readings equal 500 lux or less, replace the laser light(s) and/ or their power supplies.

2.8 Alignment Light Adjustment Procedure

2.8.1 Required Tools

- Long Phillips #2 screwdriver
- 1 large washer 0.5 ID, 1.5 OD
- Masking Tape
- Torpedo Level
- Large 48 cm Phantom
- 5 mm Hex key

2.8.2 Procedure Details

1.) Remove gantry side, top front and back covers.
2.) Remove cradle pad and associated accessories.
3.) Place Large Phantom on end of cradle so it extends 2 inches beyond the cradle end.
4.) Verify phantom is level front to back and side to side.
5.) Assemble washer and screwdriver and secure to phantom as shown in Figure 8-25.

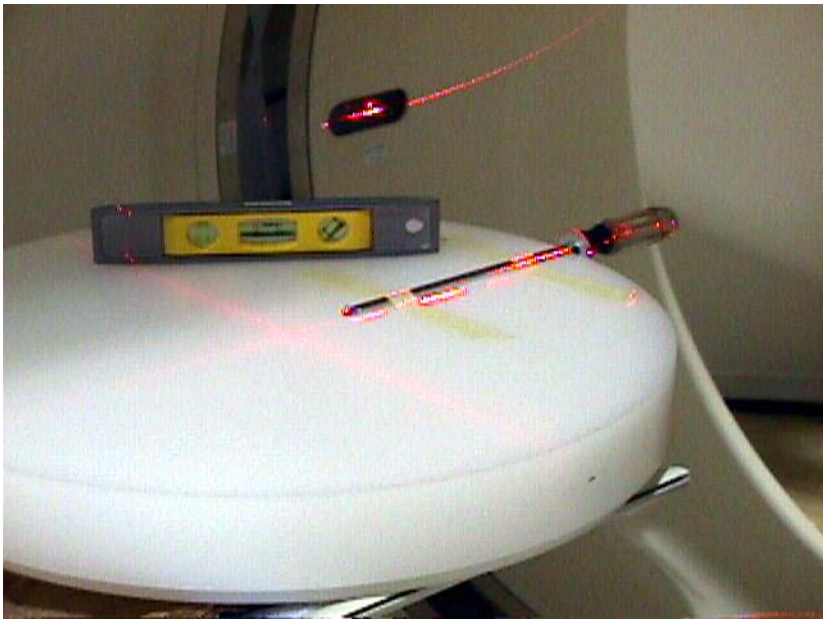


Figure 8-25 Internal and External Laser Alignment Jig Setup

DANGER **VERIFY THAT ALL PERSONNEL ARE CLEAR OF THE SYSTEM, AND THE GANTRY ROTATES FREELY TO 180 DEGREES.**

6.) Turn on laser lights using gantry control panel.
7.) Adjust jig position such that:
- Internal lasers shine on the washer's edge center
- Sagittal and Coronal lasers shine on the center of the screwdriver shaft

Note: Chose either the left or right side of the jig as a reference for this procedure.

8.) Select New Patient, Baby, 20.1 Service Generic Scan, Create New Series, Scout.

SCOUT	SCAN TYPE	START LOC.	END LOC.	KV	MA	SCOUT PLANE
1	Scout	S 50	I 50	120	80	90
2	Scout	S 50	I 50	120	80	0

Table 8-20 Laser Align Generic Service Scan Scout Protocol

9.) Confirm and Scan.
10.) Image Works, Browser Select Exam, Series, Image.

11.) Select Format one over one (lower left)

Note: Both scout should now be displayed. Adjust the window and level setting so you can see the outline of the screwdriver handle. Click in a viewport to activate it, and select Grid.

The washer and screwdriver shaft need to be centered under the zero (0) grid lines. Both washer and screwdriver should also be parallel to the associated grid lines. See Figure 8-26.

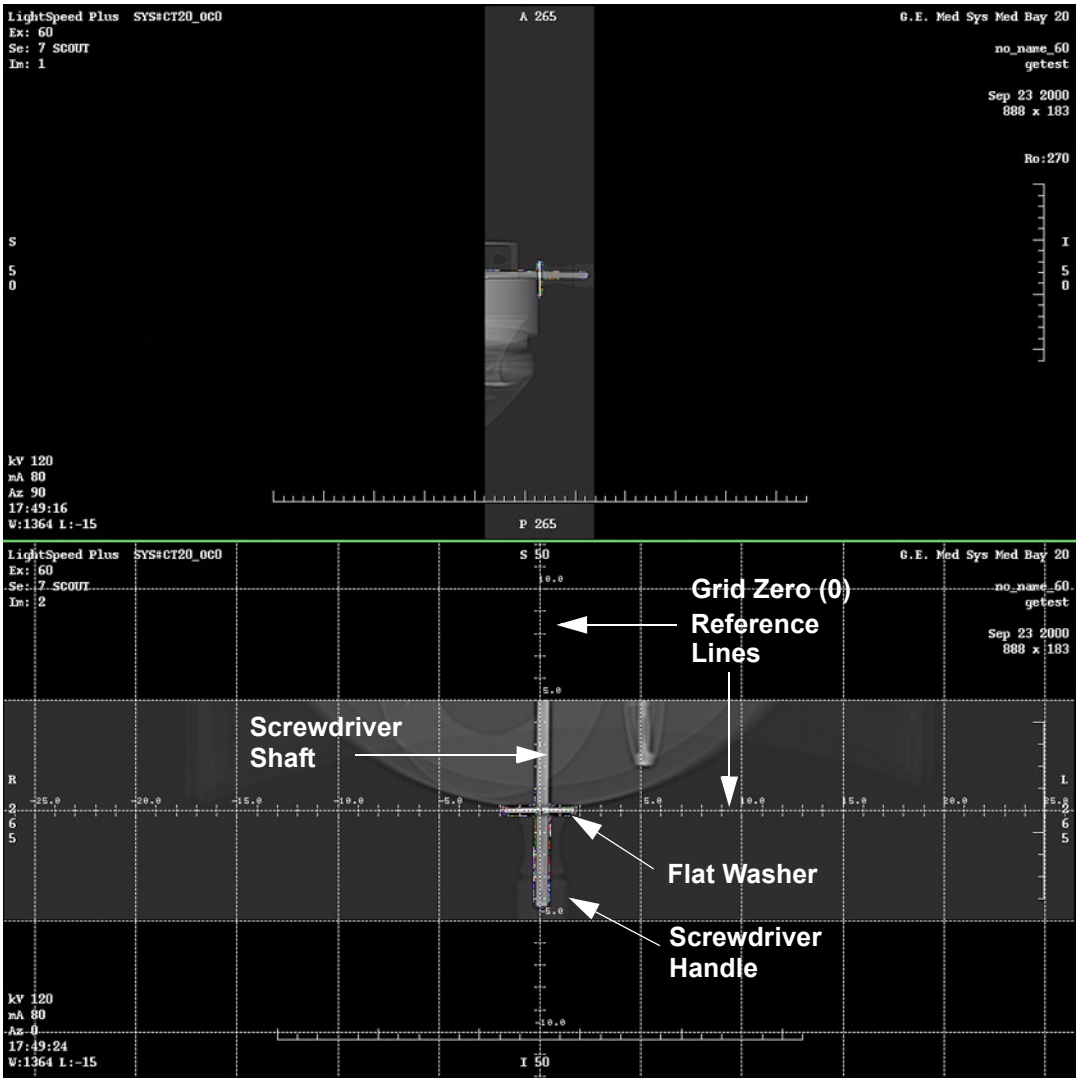


Figure 8-26 Aligning the Laser Adjustment Jig to ISO Center and the Z-Axis

12.) Write down the error delta from the Zero (0) grid lines to the center of the screwdriver shaft and washer edge. Use measure distance if desired.

13.) Position the jig exactly the error delta using gantry controls. **DO NOT MOVE THE PHANTOM.**

Note: Changing Elevation will post an error window. Ignore this and proceed.

14.) Select Repeat Series and scan.

15.) Repeat steps 8 through 14 until jig reference points are centered under the grid zero (0) lines.

⚠ **NOTICE** **Once the jig is aligned to ISO Center and the Z-Axis, do not disturb it. If it is disturbed, you will need to start over.**

16.) Press the Internal Landmark button to zero the cradle position display.

DANGER **VERIFY THAT ALL PERSONNEL ARE CLEAR OF THE SYSTEM, AND THE GANTRY ROTATES FREELY TO 180 DEGREES.**

17.) Press the Alignment Lights button.

18.) Turn off Axial Enable switch on the STC backplane.

DANGER **NEVER SERVICE THE GANTRY WITH THE AXIAL DRIVE ENABLED. UNEXPECTED GANTRY ROTATION CAN RESULT IN SERIOUS INJURY OR DEATH.**

19.) Adjust the Reference Internal Laser chosen in step 7 to shine on the washer's edge center. Reference Figure 8-27.

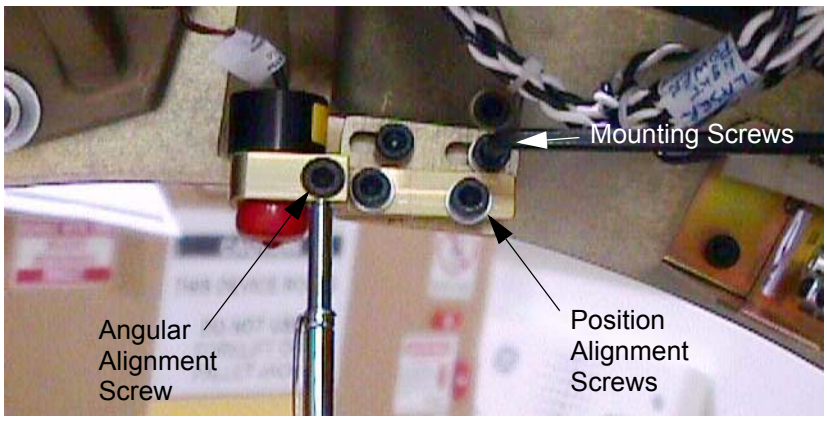


Figure 8-27 Laser Adjustment Screws

Note: Properly adjusted Lasers will bisect the output port of the other 2 Internal lasers.

20.) Adjust the Sagittal and Coronal lasers so they shine on the screwdriver shaft at ISO Center. Set Coronal lasers as level as possible and Sagittal laser as parallel to the cradle as possible. Tracking adjustments will be performed in later steps.

21.) Move the cradle out of the gantry to 240 mm position, using the gantry control panel.

22.) Adjust the Reference External Laser to shine on the washer's edge center.

Note: Properly adjusted Lasers will bisect the output port of the other External laser.

23.) After Reference Lasers have been adjusted, raise and lower the table, and verify both the External and Internal lasers track the washer's edge center.

WARNING **IF VERTICAL ANGLE ADJUSTMENT IS NECESSARY, MAKE SURE YOU CENTER THE JIG AT ISO CENTER BEFORE YOU ADJUST THE INTERNAL OR EXTERNAL REFERENCE LASERS.**

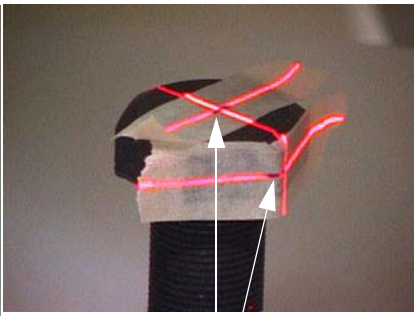
24.) Repeat steps 19 through 23 as needed.

25.) Remove the screwdriver jig without disturbing the phantom.

26.) Now that the reference lasers have been set, use a piece of notebook paper to adjust the other Internal and External lasers to coincide with the reference lasers. Refer to "Alignment Lights Visual Checks," on page 581.

27.) Place another object, such as a full contrast bottle or unopened soda can, on the phantom. Attach masking tape and position the object at ISO Center using the laser lights. Refer to Figure 8-28.

28.) Using a pen, carefully mark the laser intersection points on the masking tape. Once set, DO NOT DISTURB THE JIG.



Using a pen, carefully make reference marks at the laser intersection points.

Figure 8-28 Sagittal and Coronal Laser Alignment Jig Setup

29.) Using the gantry control panel, move the cradle out of the gantry to 240 mm. Verify the Sagittal and Coronal laser lights track your pen marks.

WARNING **IF SAGITTAL OR CORONAL ANGLE ADJUSTMENT IS NECESSARY, MAKE THESE ADJUSTMENTS ONE AT A TIME, AND VERIFY THE LASER TRACKS FROM INTERNAL TO EXTERNAL LANDMARKS BEFORE MAKING THE NEXT ADJUSTMENT. IF THE JIG IS DISTURBED, REPOSITION THE JIG AT ISO CENTER TO REESTABLISH YOUR REFERENCE. VERIFY BOTH SAGITTAL AND CORONAL LASERS SHINE ON THE PEN MARKS AT ISO CENTER BEFORE PROCEEDING. THE LOSS OF REFERENCE WILL REQUIRE REPEATING STEPS 5 – 15 AND 25 – 29. THIS WOULD BE NECESSARY TO ENSURE ACCURACY.**

30.) The last adjustment is the un-referenced Coronal laser to the Reference Coronal laser chosen in step 7. Refer to “Alignment Lights Visual Checks,” on page 581.

31.) Assemble the gantry.

2.9 Scan Window Alignment

NOTICE
Potential for Equipment Damage.

The cones of the front and rear gantry covers must be aligned within specification to ensure proper scan window fit. If the scan window is not fit properly, fluids can get in to the collimator causing permanent damage.

COLLIMATOR AND COVER DIFFERENCE

1.) With the front and rear covers secured in place and scan window removed, rotate the collimator to the 3 o'clock position.

2.) Using an appropriate (calipers or steel ruler), measure the distance (*d*) in millimeters (mm) from the collimator's surface to the metal scan window rim, on both the front and rear covers. Record measurements. See Figure 8-29

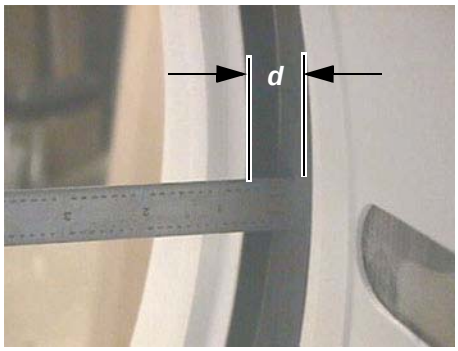


Figure 8-29 Collimator Cover Gap Distance

3.) If the difference $|d_f - d_r|$ between the front (f) and rear (r) measurements is greater than 3 mm, one of the cover must be shifted appropriate direction. On the cover that gives you the most adjustment, lightly loosen the screws securing each mounting plate. Slide the plates in the direction that will give you the appropriate shift and re-secure screws. See Figure 8-30

For example, if the distance between the collimator and the front cover is 1.5 mm and the distance between the collimator and rear cover is 10.5mm, then the difference is 5mm. The front cover must be shifted right at least 2mm. This means that mounting bracket on the front cover must shifted at least 2mm left.

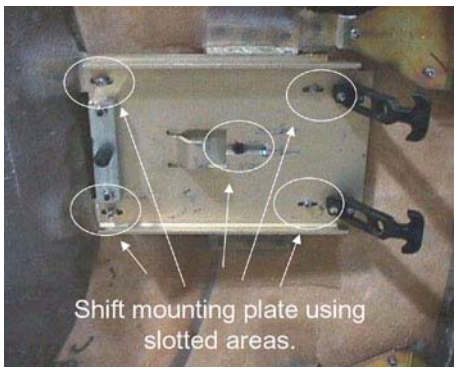


Figure 8-30 Gantry Cover Mounting Plate and Screws

4.) Repeat steps 2 and 3 until the difference between the two measurements is less than 3mm.

5.) Rotate the collimator to the 9 o'clock position.

6.) Repeat steps 2 through 4. Verify that a difference of less than 3 mm is obtainable with the collimator positioned at the 9 o'clock position.

SCAN WINDOW GAP

7.) Measure the distance (D) between front and rear covers of the scan window rims. Using a measuring device, measure the distance between the two covers at the bottom of the cone. See Figure 8-31

Figure 8-31 Scan Window Gap Distance

8.) If the spacing is the spacing is greater than 57 mm, bring the covers together using the bolts located on the end of each cover latch. See Figure 8-32

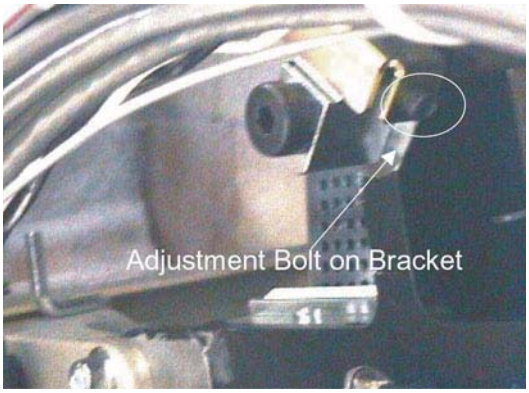


Figure 8-32 Cover Bracket Adjust Bolt Location

9.) Repeat steps 7 and 8 until the spacing is less than 57mm.

VISUAL INSPECTION

10.) Install the scan window and visually check that the scan window is not raised higher than the front or rear cover at any location on the circle, and that the window is not wrinkled. See Figure 8-33

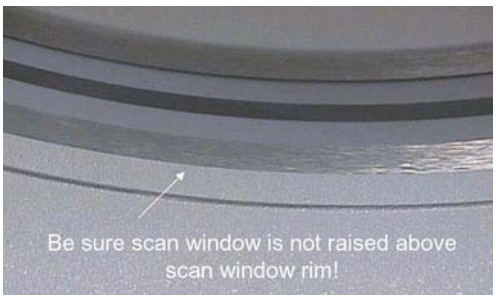


Figure 8-33 Correct Scan Window Alignment

2.10 Gantry Display Test

1.) Turn ON the gantry 120 VAC Enable Switch on the STC backplane.
2.) Make sure the gantry display goes through the power-up self-test. The display continues to cycle through its self-test until it completes the hardware reset and download.
3.) TURN ON “X-RAY DRIVES” power by pressing the RESET button on the gantry control panel.

2.11 Common Slip Ring Checks

2.11.1 Visual Checks

- Ensure cable connections are securely fastened.
- Terminator boards mounted correctly with correct screws.
- Fiber-optic cables connected and locked.
- Damaged components/ring/brushes.

2.11.2 Power and Grounding Checks

- Ground screws on ring # 6.
- Frame bonding ground on unused ring # 3.
- Ground and filter connections on back side of platter.
- Harness shield ground connections.

2.11.3 Basic Theory of Operation of LSCOM Boards

3-wire serial communication:

- Inbound
- Outbound
- Reference

2.11.3.1 Violations

A violation is created in one of three ways:

- An invalid command is received.
- The 2 command/data bits do not match for a byte.
- The parity bit is not correct.

2.11.3.2 Brush Disconnects

The serial communication is +5V to –5V during normal operation. If the line is disconnected or if the brushes are bouncing then the serial line will be at 0V compared to the reference line. The three types of disconnects indicate different times for the line at 0V.

(75ns < short < 200ns < medium < 4.4us < long)

2.12 Service Actions

2.12.1 Why Clean with Alcohol or Sand with Cratex Crayons

1.) Communication failures (TAXI Link Failures) after vacuuming failed.

2.) Cratex sanding is for mechanical damage to the ring **ONLY** (e.g. pits and arc marks).

2.12.2 Alcohol Clean

Alcohol cleaning should be done as a corrective (repair) action only. Alcohol cleaning is not a PM action and should only be done if necessary, and only AFTER vacuuming the slip ring and gantry has not corrected the problem.

1.) Vacuum ring per PM procedure.

2.) Check baseline.

3.) Remove brush block (the alcohol will contaminate the brushes). Refer to “Slipring Brush Block,” on page 638 for the proper removal procedure.

4.) Use specified alcohol (46-183039p1) and allow to AIR DRY for 15 min. DO NOT use the alcohol prep pads found in hospitals. They are often not PURE alcohol, and can contaminate the slip ring and brushes.

5.) Reinstall the removed components. Refer to “Slipring Brush Block,” on page 638. The proper replacement procedure is critical to the life of the slip ring components.

Note: Only Use GE Approved Alcohol 46-183039P1.

2.12.3 Cratex

WARNING **CRATEX SHOULD BE USED TO FIX PIT AND ARC MARKS ONLY.**

Note: Smoothing out the track surfaces is a time consuming task and if not done properly and completely will result in either permanent damage or will cause another arc. Do it right the first time. Removing the “clogged” end of the cratex stick with a coarse file will help speed up the process of smoothing out pitted areas. Reference “Inspection Criteria,” on page 590 before proceeding.

1.) Remove Brush Block Assembly before using Cratex. See “Slipring Brush Block,” on page 638.

2.) Using a Cratex fine abrasive stick (46-297961P2), attempt to smooth out the pitted area or areas with deposits on the slip ring. Do not attempt to clean areas larger than 2 centimeters at one time. ONLY use Cratex on the ring that is in need of repair. If an area is still not smooth, use Cratex medium abrasive stick (46-297961P1). After using the medium, repeat procedure with the fine.

3.) When done with the Cratex sticks, it is very important to remove ALL traces of abrasive with a thorough alcohol cleaning.

4.) Replace the brush block assembly. Refer to “Slipring Brush Block,” on page 638. The proper replacement procedure is critical to the life of the slip ring components.

2.12.4 Inspection Criteria

A normal ring will have a “patina” of brush material on the surface of the brass ring. This patina is about 3 mils thick and is self renewing. This is the natural lubricant and completely normal. Do not attempt to remove this, as future problems will arise and create a cycle of repeating failures on excess dust production.

Micro spots are acceptable, provided they do not exceed the following specifications, and their forms contain no burrs and depths no greater than D1, D2. Reference Figure 8-34.

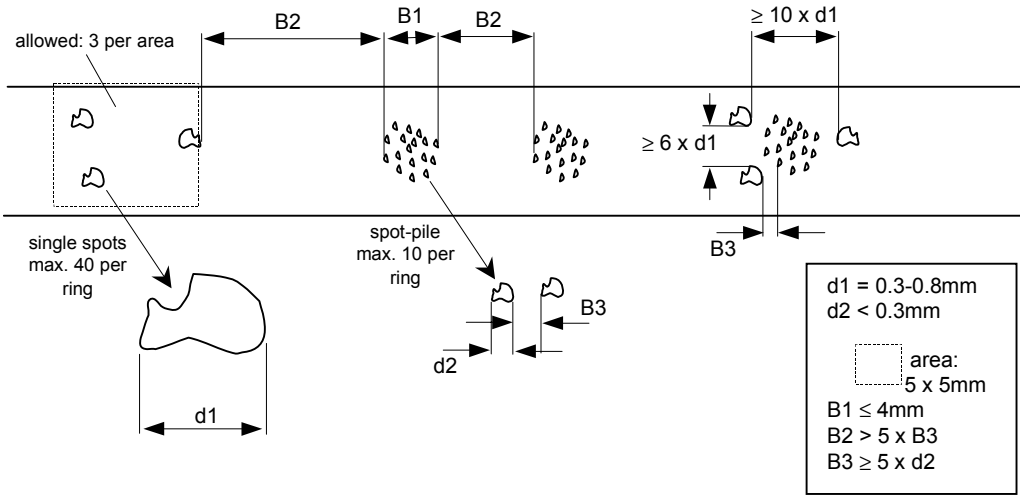


Figure 8-34 Slipring Inspection Criteria

2.12.5 Removal/Installation/Replacement

Refer to Section 3.0 - Replacement Procedures. The proper replacement procedure is critical to the life of the slip ring components.

2.13 S/A HSDCD Slip Ring Adjustments

2.13.1 S/A HSDCD Slip Ring Antenna Adjustment Procedure

This document describes the steps necessary to properly replace and adjust the position of the HSDCD antenna above the emitter traces on the rotating slip ring. Accurate placement of the HSDCD antenna is important to achieve the optimal data transfer performance and to avoid contact between the ring and the stationary antenna. The optimal position of the HSDCD antenna above the emitter traces on the ring is 1.41 mm height (.060 inches), and centered.

Under normal circumstances, the position of the HSDCD antenna should never need adjustment. Only adjust if there are indications of interference. Under no circumstances should the HSDCD antenna be allowed to contact the rotating components.

DANGER **ELECTRIC SHOCK! MAY CAUSE SERIOUS INJURY OR DEATH! UNLESS DISABLED, HIGH VOLTAGES ARE PRESENT ON THE SLIP RING. POWER ON THE SLIP RING INCLUDES 120VAC AND 750VDC.**

1.) Disable power to the gantry. Lock out and Tag.
2.) Remove mylar window, side, top and rear gantry covers.
3.) Make sure the HSDCD has no power applied - there should be no LEDs on.
4.) Loosen the axial adjustment screws and the radial adjustment screw for the HSDCD antenna.
5.) The HSDCD antenna should now be loose above the emitter. Insert the HSDCD adjustment tool between the HSDCD antenna and the emitter traces on the ring. The tool should fit snugly. The desired result is to space the HSDCD antenna above the emitter, at a height of 1.41 mm (.060 inches) above the emitter.

6.) Tighten the radial screws. Press slightly on the top of the HSDCD antenna as the adjustment screws are tightened. Reference Figure 8-35.

Figure 8-35 Radial Height Adjustment of HSDCD Antenna

7.) Carefully slide the adjustment tool from between the HSDCD antenna and the emitter.

8.) Using the alignment sights at each end of the HSDCD antenna, center it above the center trace on the emitter PCB. Reference Figure 8-36.

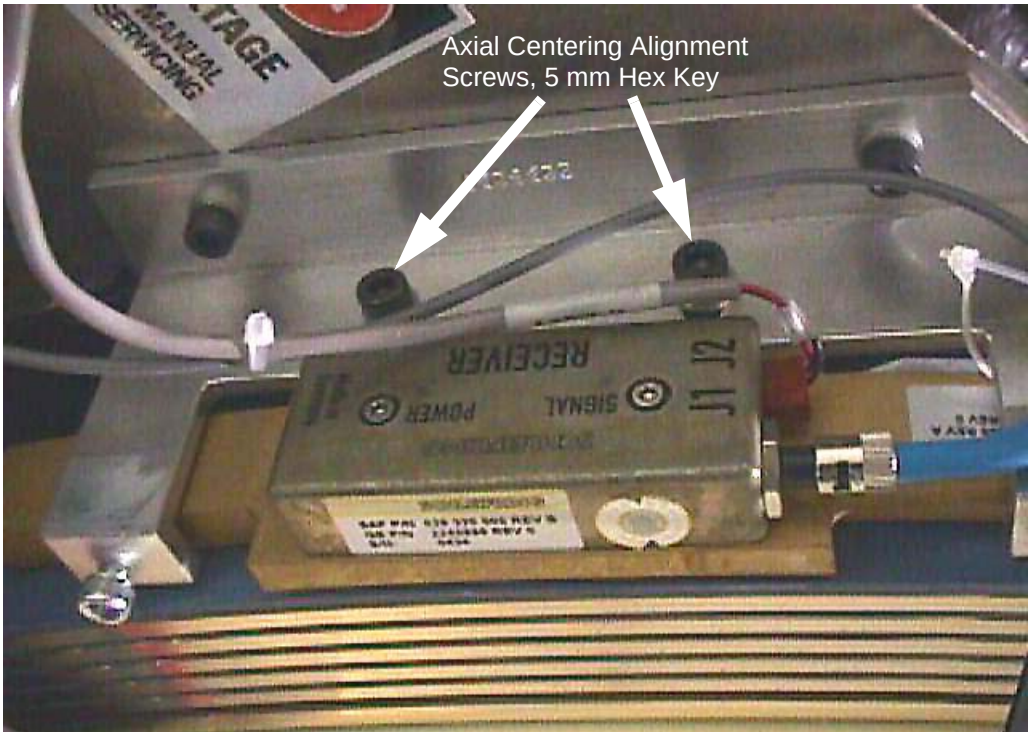


Figure 8-36 Axial Centering Adjustment of HSDCD Antenna

9.) While holding the position of the HSDCD antenna, tighten the axial alignment screws.

NOTICE
Potential for Ring Damage

Do not rotate the gantry with the adjustment tool installed. Damage to the delicate PCB traces will result. There is no method to repair ring boards in the field - a ring swap would be necessary.

10.) Inspect the air-gap between the HSDCD antenna and the ring as the gantry rotates. It may be necessary to disable the gantry brake to rotate the gantry more easily. Look for clearances between the emitter and the HSDCD antenna. While rotating the ring, check that the emitter trace is aligned with the HSDCD. During rotation, no parts of the HSDCD antenna should contact the emitter surface.

- The stationary and rotating components must never touch, even with the gantry tilted.
- The run-out of the platter slip ring traces should not exceed 0.83 mm axially, and 0.81 mm radially.
- Especially check clearances near the emitter solder and PCB connections.
- The HSDCD receiver has two LEDs. One LED indicates power is applied to the HSDCD and the other indicates the HSDCD is transmitting a signal.

11.) Restore power to the system. Verify proper operation by running verification scans. Verification procedure should consist of:

- Observe diagnostic “DIP Stats” information. Before starting, log raw ring error count, FEC correct-able counts, and the date/time of the last file update.
- Run 5 stationary and 50 rotational scans with x-ray. The technique is not important. It is important to exit the exam, because this triggers the “DIP Stats” update.
- Observe diagnostic “DIP Stats” information. There should be no additional raw HSDCD ring errors or FEC correctable events.

12.) Replace the gantry covers and secure. Re-install the mylar window.

2.13.2 S/A HSDCD Rotating Transmitter Power Measurements

1.) Locate the HSDCD Transmitter Power supply inside the Fuse Box Assembly.

2.) Measure the DC voltage on the wires leading to the HSDCD Transmitter. The specification is +15 volts DC ± 2.0 volts. Use indicator LEDs to ensure proper operation.

2.13.3 S/A HSDCD Stationary Receiver Power Measurements

1.) Locate the HSDCD Receiver Power supply on the rear of the right fan assembly

2.) Measure the DC voltage on the wires leading to the HSDCD Receiver. The specification is +15 volts DC, ± 2.0 volts. Use indicator LEDs to ensure proper operation.

2.14 Gantry Thermostat

The gantry thermostat is a self contained Electronic Thermostat Control Unit.

Figure 8-37 Gantry Temperature Fan Control Thermostat

ELECTRONIC THERMOSTAT CONTROL SETUP PROCEDURE

⚠ **WARNING** **THIS IS NOT A RECORDING DEVICE. FAILURE TO USE THE CORRECT SETTINGS CAN RESULT IN ARTIFACTS DUE TO INCORRECT DETECTOR TEMPERATURE DELTAS.**

1.) Press the **SET** key once to access the Fahrenheit/Celsius mode. The display will show the current status., either F for degrees or C for degrees Celsius. Then press either the **UP** or **DOWN** arrow keys to toggle between the F or C designation.

2.) Press the **SET** key again to access the setpoint. The LCD will display the current setpoint and S1 annunciator will be blinking to indicate that the control is in the setpoint mode. Press either **UP** or **DOWN** arrow keys to adjust the setpoint to the desired temperature.

3.) Press the **SE**t key again to access the differential. The LCD will display the current differential and the DIF 1 annunciator be blinking to indicate that the control is in the differential mode. Press either **UP** or **DOWN** arrow keys to adjust the differential setting.

4.) Press the **SET** key again to access the cooling or heating mode. The LCD will display the current mode either C1 for cooling or H1 for heating. Press either **UP** or **DOWN** arrow keys to toggle the setting.

5.) Press the **SET** key and programming is complete.

STEP	DESCRIPTION	GE DISPLAY SETTING
1	Fahrenheit or Celsius	C
2	Setpoint Temperature	26
3	Differential Temperature	2
4	Cooling or Heating Mode	C1

Table 8-21 Lightspeed Plus Thermostat Settings

Comment: The Electronic Thermostat Control will automatically end programming if no key has been pressed for a period of 30 seconds. Any settings that have been input to the control will be accepted at that point.

All control settings are retained in non-volatile memory, if power to the Electronic Thermostat Control is interrupted for any reason. Re-programming is not necessary after power outages or disconnects unless different control settings are required.

The Electronic Thermostat Control is provided with a lockout switch to prevent tampering by unauthorized personnel. When placed in the lock position, the keypad is disabled and no changes can be made. When placed in the unlock position, the keypad will function normally.

To access the lockout switch, disconnect the power supply and open the control. The switch is located on the inside cover about 50.8 mm above the bottom. To disable the keypad, slide the **SWITCH** to the left lock position. To enable the keypad, slide the **SWITCH** to the right unlock position. All Electronic Thermostat Controls are shipped with this switch in the unlock position. The settings shown in Table 8-21 are programmed at the factory during system staging.

2.15 STC CPU (Artesyn III) - GE Specific Settings

For OBC CPU, see "OBC CPU (Artesyn III) - GE Specific Settings," on page 773. For ETC CPU, see "ETC CPU (Artesyn III) - GE Specific Settings," on page 441.

2.15.1 STC CPU (Artesyn III) Board Layout

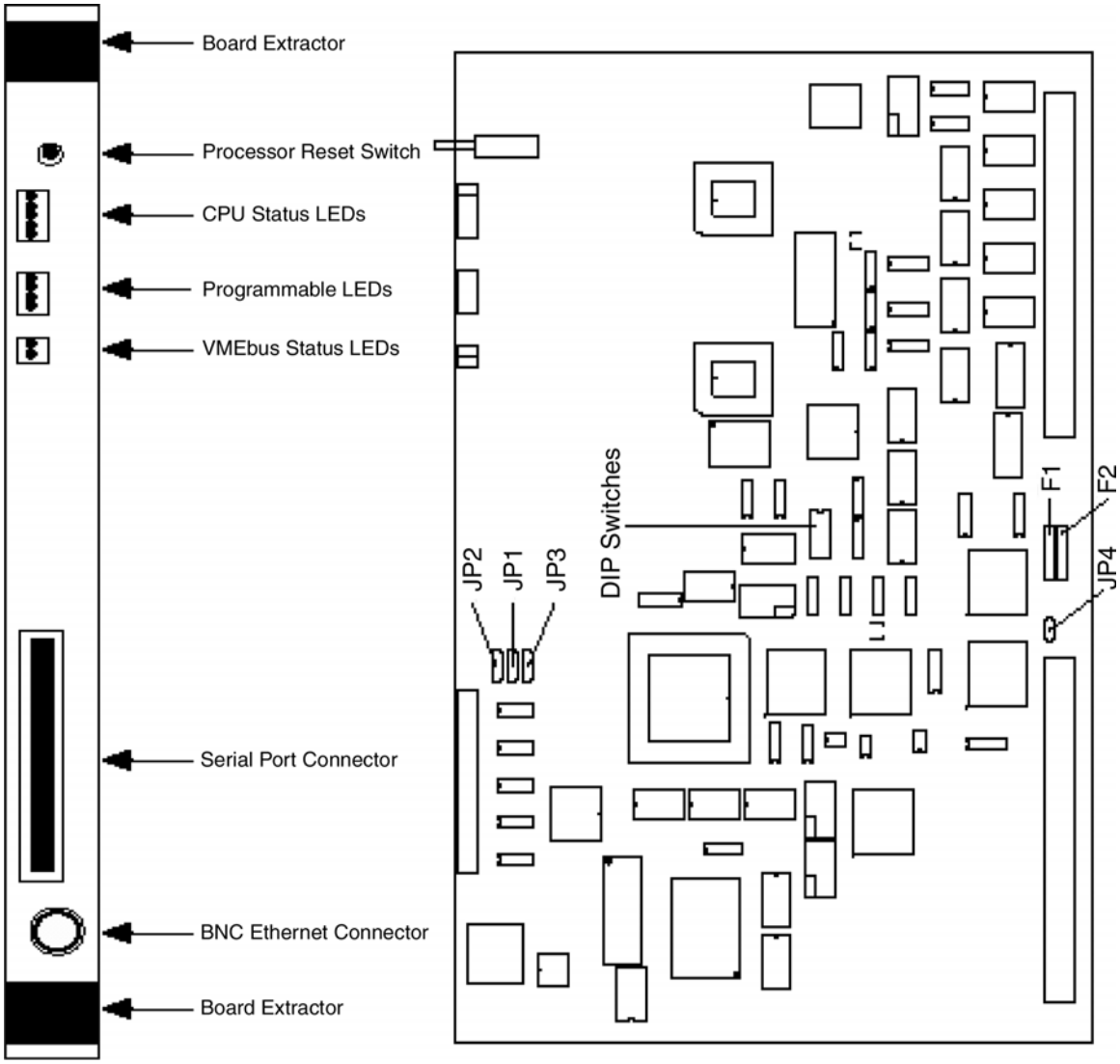


Figure 8-38 STC CPU (Artesyn III) Board Layout

2.15.2 CPU Board Jumpers

JUMPER	FUNCTION	GE CONFIGURATION	COMMENTS
JP1	Port A RI/DCD	J1:1-2	
JP2	Port B RI/DCD	J2:2-3	
JP3	RS-232 Handshaking	J3:1-2	
JP4	Watchdog Enable	removed	Watchdog Disable

Table 8-22 STC CPU (Artesyn III) Board Jumper Settings

2.15.3 DIP Switch Settings

See board (Figure 8-38, above).

SWITCH NUMBER	CONFIGURATION		FUNCTION	COMMENTS
1	ON	CLOSED	STC node	Selects board for STC Chassis
2	ON	CLOSED	STC node	Selects board for STC Chassis
3	OFF	OPEN	Primary Nodes	selects primary nodes
4	OFF	OPEN	n/a	Not applicable
5	ON	CLOSED	nbsClient view	View logs via nbsClient/LAN
6	OFF	OPEN	n/a	Not applicable
7	ON	CLOSED	Eprom Boot	Power Up view Eprom Boot
8	OFF	OPEN	Test Disable	Self Test Mode disabled

Table 8-23 STC CPU (Artesyn III) Board DIP Switch Settings

2.15.4 Power-Up Self-Test

The CPU board will undergo a Power-Up Self-Test that lasts approximately 18 seconds. After the proper setting of the EPROMS, DIP switches and board jumpers, the CPU board will be placed into a VME chassis. A properly terminated Thin-net cable must be attached to the board's BNC connector. This cable is necessary for the Ethernet self tests to complete successfully. The **LSCOM** board must be present for the successful completion of the Power-Up Self-Test.

Upon power-up, the self test begins, the LED display is at the value 'E' and the test will perform the instruction Set and EPROM Checksum Test. When the test is done, the LED value will proceed to the next descending value, 'D', and will perform the RAM verification test. In the same manner, when this test is done, the LED value will proceed to 'C', then 'B', then 'A' and finally to '9'. After the test at '9', the self test is now done.

When the test is completed, the LED values displayed will indicate if any tests have failed. If a failure is detected, the EPROMs, DIP-switch settings, Ethernet cable, and the board jumpers should be rechecked to ensure proper setup. Then the self test should be rerun. The board must pass the test before shipment. See Figure 8-38 for location of these LEDs.

LED# 1234	LED HEX	LED ASSIGNMENT	DURATION
xxxo	E	Instruction Set and EPROM Checksum Test	1 second
xxox	D	RAM Verification	13 seconds
xxoo	C	CIO Unit Test	0.3 seconds
xoxx	B	Internal Loop Back	1 second
oxox	A	External Loop Back	1 second
oxxo	9	Transmit Test	1 second
x = on o = off			

Table 8-24 STC CPU (Artesyn III) Board Power Up LEDs

2.15.5 Power-Up Self-Test Results

On Power-up, the STC controller displays the results of its self tests. Power must remain off to a controller for at least 60SEC or Self-test may not be run or results may be inaccurate. This is because the dynamic ram retains the CPON information. In this event, power-up tests are bypassed and the results of the last power-up test is displayed on LEDs.

1 2 3 4	HEX	LED ASSIGNMENT
• • • •	F	Not Available - - Do Not Use for a test
• • • o	E	Artesyn (see Table 8-26 for details)
• • o •	D	Artesyn (see Table 8-26 for details)
• • o o	C	Artesyn (see Table 8-26 for details)
• o • •	B	VME/LAN (see Table 8-27 for details)
• o • o	A	VME/LAN (see Table 8-27 for details)
• o o •	9	VME/LAN (see Table 8-27 for details)
• o o o	8	LSCOM (see Table 8-28 for details)
o • • •	7	LSCOM (see Table 8-27 for details)
o • • o	6	LSCOM (see Table 8-27 for details)
o • o o	4	spare for GE future use
o o • •	3	spare for GE future use
o o • o	2	spare for GE future use
o o o •	1	spare for GE future use
o o o o	0	Not Available - - Do Not Use for a test

• = LED ON, o = LED OFF, 1 = LED MSB, 4 = LED LSB

Table 8-25 STC Self-Test LED Outputs

2.15.5.1 ETC, STC & OBC (Artesyn) Tests

FUNCTION	LEDS	DESCRIPTION
Initialization	(F: • • • •)	Setup interrupt vectors & CIO
Failure	(E: • • • o)	CPU HALTS
Processor/PROM Checksum	(E: • • • o)	68000 Instruction set check (RAM used) ROM Verified using CRC16 based polynomial
Failure	(E: • • • o)	CPU HALTS
Ram Verification -	(D: • • o •)	Each word of memory R/W 16 times
Failure	(E: • • • o)	CPU HALTS
CIO Verification	(C: • • o o)	Checks interrupts, timers, counters (no VME)
Failure	(E: • • • o)	CPU HALTS

• = “on” o = “off”

Table 8-26 Artesyn Board Related LED Readouts

At this point the type of node (ETC, STC or OBCR) determines the tests that are run.

2.15.5.2 STC - VME/LAN Tests

FUNCTION	LEDS	DESCRIPTION
LAN controller tests	(B: • o • •)	Checks module present, controller & internal loops
Failure	(B: • o • •)	Flashes, possibly with other failures
LAN External loop-back	(A: • o • o)	Checks wire/ termination
Failure	(A: • o • o)	Flashes, possibly with other failures
TDR test	(9: • o o •)	Checks wire/ termination
Failure	(9: • o o •)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 8-27 STC VME/LAN Related LED Readouts

2.15.5.3 LSCOM/Communications Test

FUNCTION	LEDS	DESCRIPTION
Module Present test	(8: • o o o)	Checks for Presence of TAXI
Failure	(8: • o o o)	Flashes, possibly with other failures
VME FIFO test	(7: o • • •)	Checks VME path using loop-back
Failure	(7: • o o o)	Flashes, possibly with other failures
AP FIFO test	(6: o • • o)	Checks DAS path using loop-back
Failure	(6: • o o o)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 8-28 LSCOM/Communications Related LED Readouts

2.16 Remote Intercom Board

The intercom board has R19 preset to 5.5k ohm and R10 preset to 1.25k ohm. No adjustments are normally needed. Verify these values are set correctly by using a multi-meter to measure test points TP1 & TP2 (yellow), for R10, and TP3 & TP4 (red), for R19.

1.) At the console set the SCIM patient volume control to its midway point. You should not hear anything in the background when no one is speaking. If someone is talking at the gantry, the intercom should be activated.

2.) Next rotate the gantry at 0.5 sec. The intercom system will come on briefly while the system is accelerating but should shut off once it reaches the 0.5 sec speed.

3.) Verify the system will come on when someone is laying on the table and speaking into the microphone while the system is rotating at 0.5 seconds.

4.) If steps 2 and 3 are working correctly and you can hear the patient clearly there is no need to make any adjustments.

5.) If the intercom system comes on when the patient is talking but you are unable to hear the person clearly adjust R19 on the intercom board. Increase the resistance by 1K at a time until you can hear the person clearly. This will increase the sensitivity of ALC also.

6.) If the system comes on and stays on or if it comes on and off intermittently when rotating at 0.5 seconds you will need to adjust the R10 potentiometer on the intercom board in the gantry.

7.) Increase the resistance by 100 ohms at a time and repeat steps 1 through 6. Continue this process until the intercom system stays off when no one is talking, is activated when someone is speaking and the patient can be heard clearly.

Note: R19 is used to control the overall signal gain. Decrease the R19 value to decrease gain. Increase the R19 value to increase the gain (G). The gain is calculated by:

$$1 + R19(kohm) = G$$

R10 combined with R19 is used to control the sensitivity of Automatic Level Control (ALC). If the console speaker turns on frequently without patient speaking during 0.5 sec rotation increase the R10 value to desensitize ALC until the speaker turns off during gantry rotation without patient speaking. If patient has to yell to activate ALC, decrease the R10 resistance to increase sensitivity. The sensitivity (S) is calculated by:

$$\frac{1 + R19(kohm)}{1 + \left(\frac{0.1}{R10(kohm)}\right)} = S$$

2.17 Gantry Service Balance

WARNING GANTRY BALANCE MUST BE CHECKED FOR ANY COMPONENTS REPLACED ON OR REMOVED FROM THE ROTATING ASSEMBLY.

2.17.1 Prerequisites

Gantry balance can be *checked* without removing covers. Gantry balance *adjustments* require front and possibly rear gantry cover removal.

DANGER FAILURE TO TORQUE TRIM WEIGHT FASTENING HARDWARE WILL RESULT IN DAMAGING PROJECTILE EVENTS. THIS WILL RESULT IN SEVERE EQUIPMENT DAMAGE AND POSSIBLE PERSONAL INJURY.

2.17.2 Procedure

WARNING DO NOT USE THREADED RODS TO ROTATE GANTRY.

2.17.2.1 GUI Access

Figure 8-39 General Access

2.17.2.2 GUI Screens

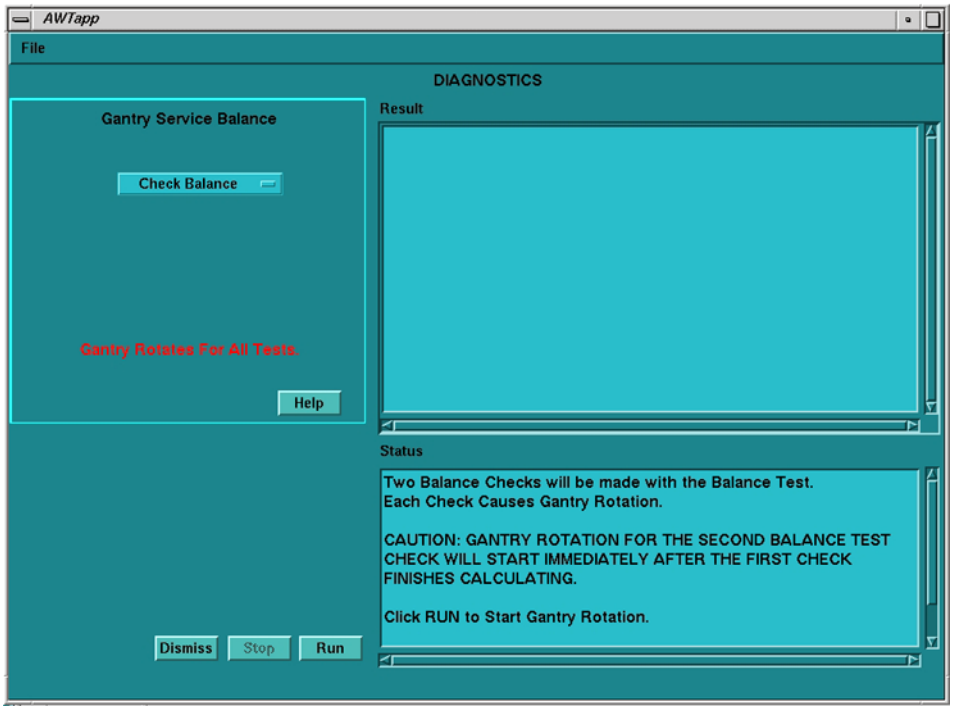


Figure 8-40 Gantry Balance Tool Opening Screen

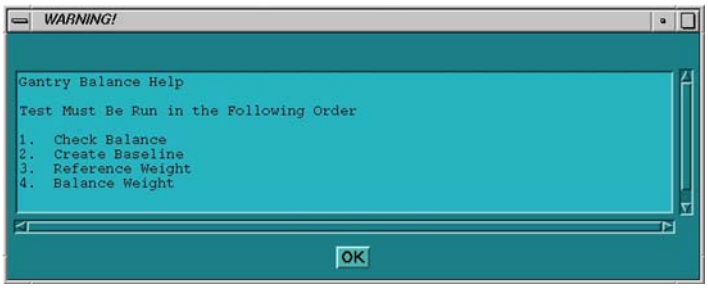


Figure 8-41 Gantry Balance Help Screen

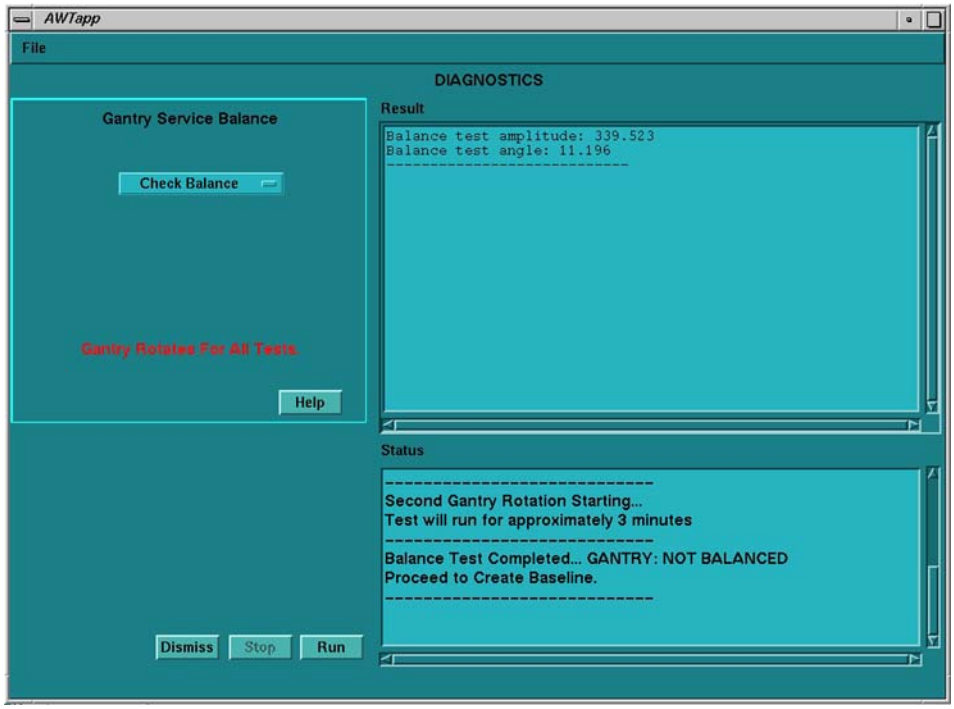


Figure 8-42 Check Balance Results

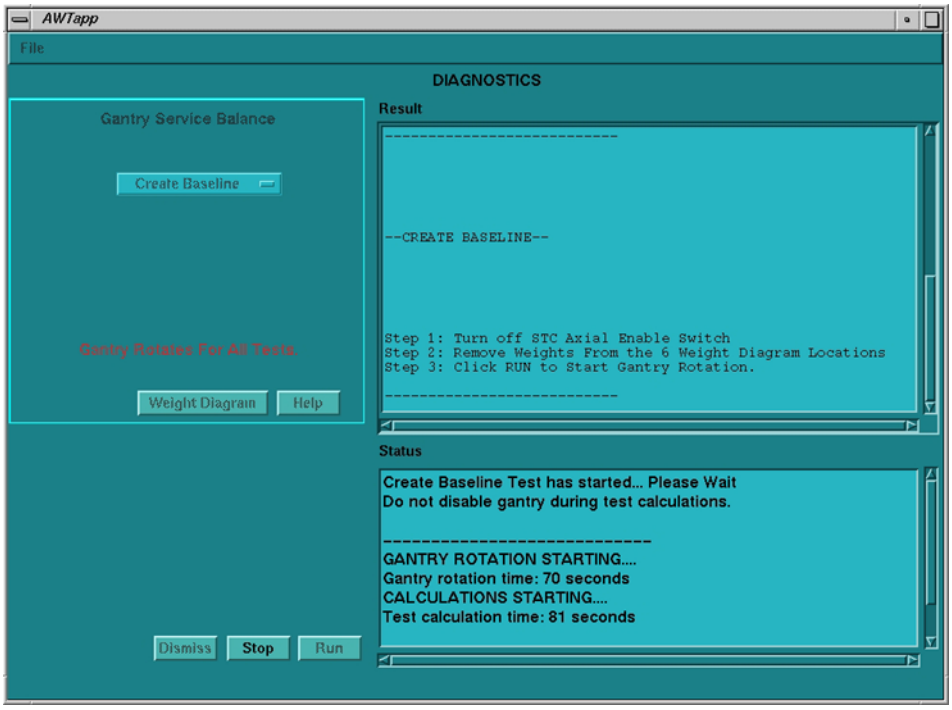


Figure 8-43 Create Baseline Instructions

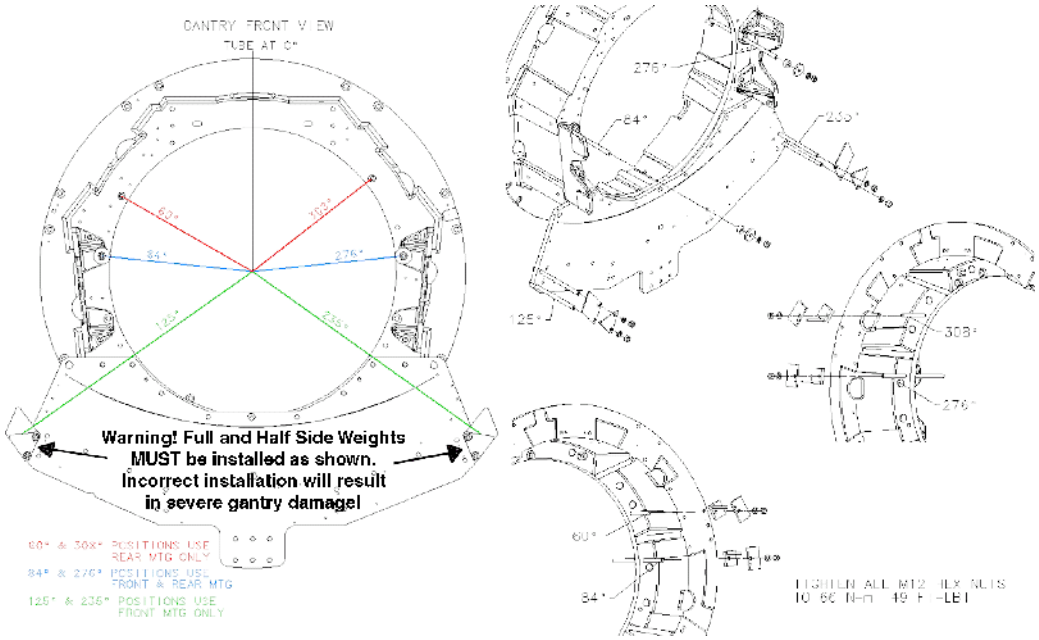


Figure 8-44 Weight Diagram

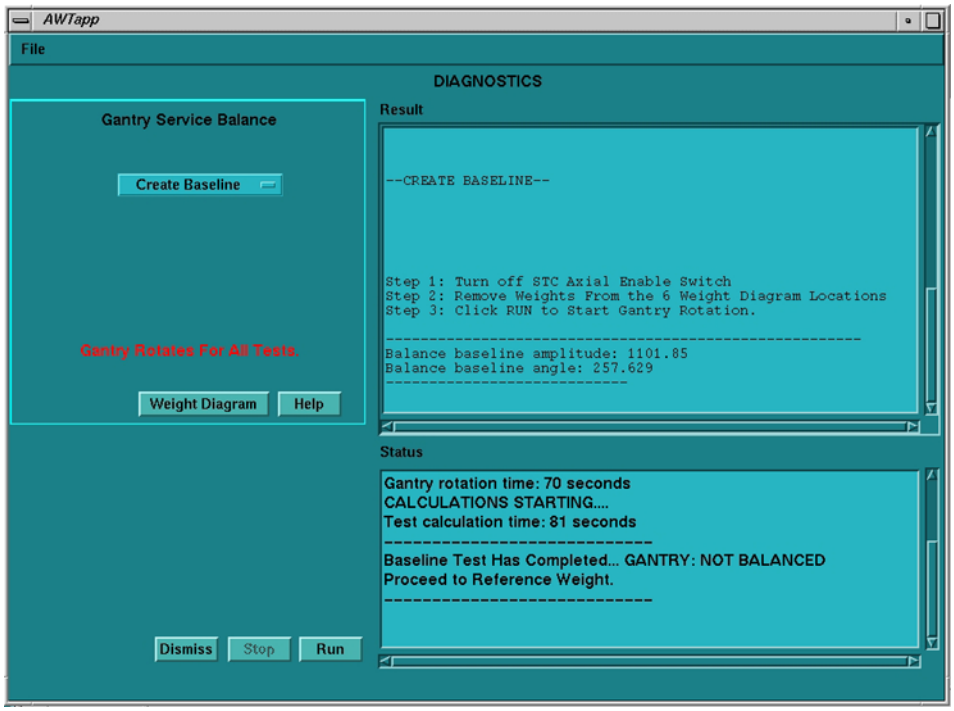


Figure 8-45 Create Baseline Results

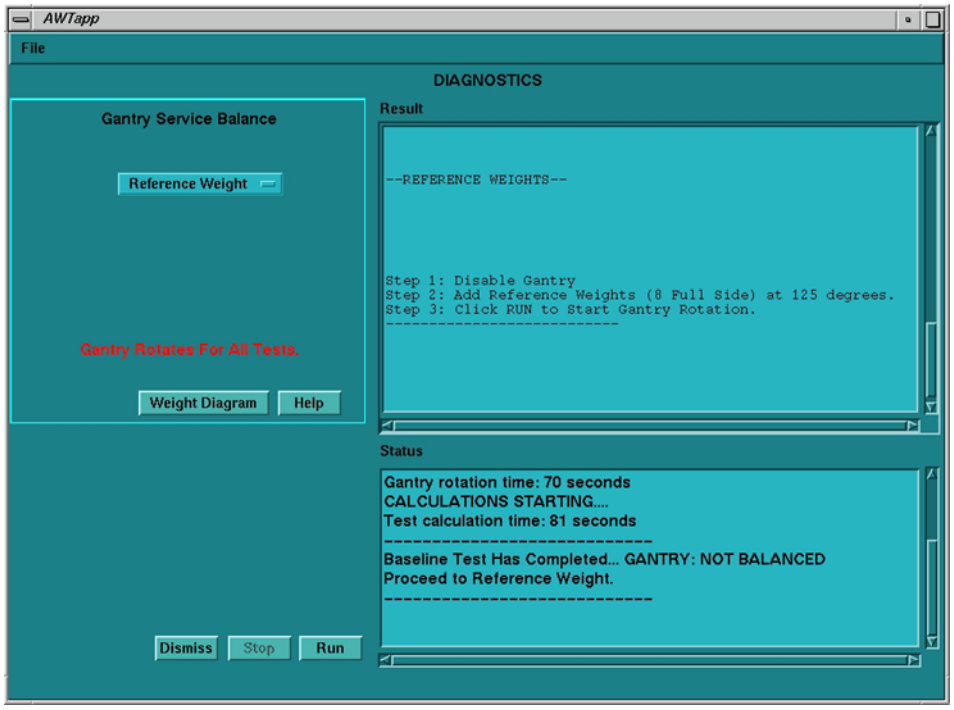


Figure 8-46 Reference Weight Instructions

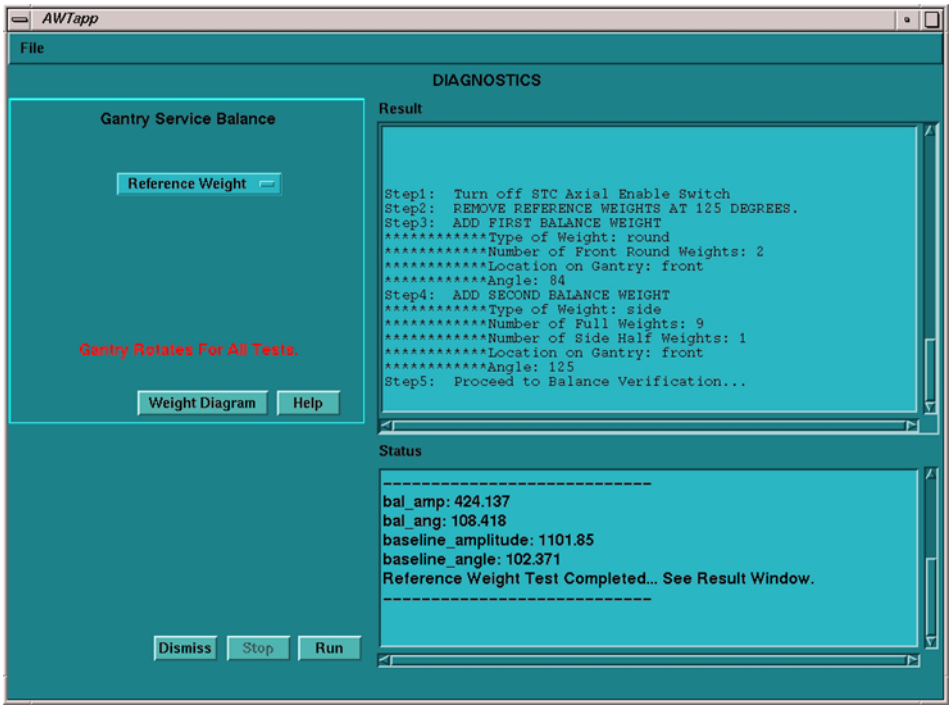


Figure 8-47 Calculated trim weight values and locations

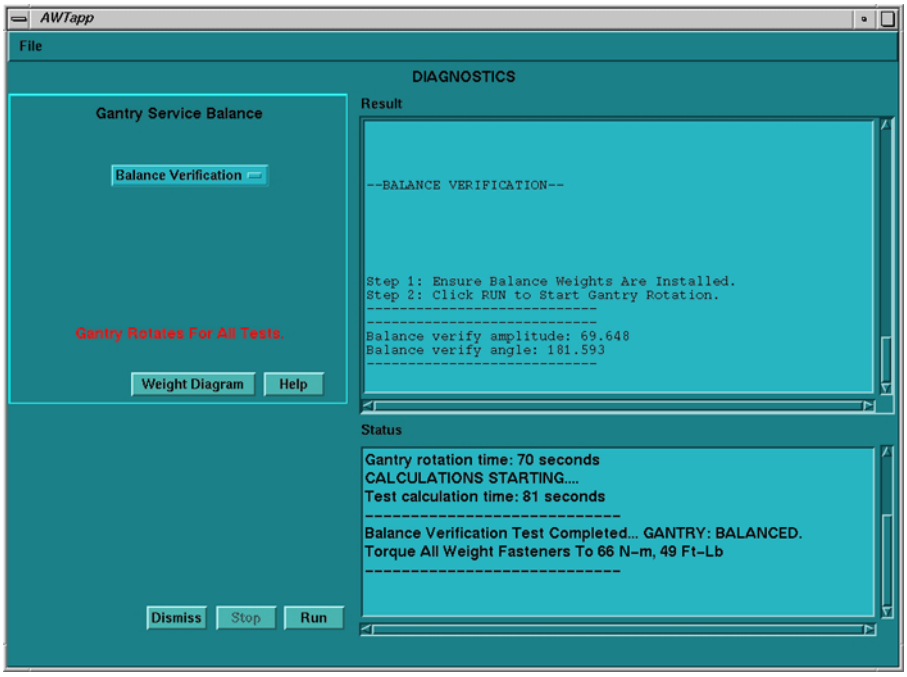


Figure 8-48 Balance Verification Successful Screen

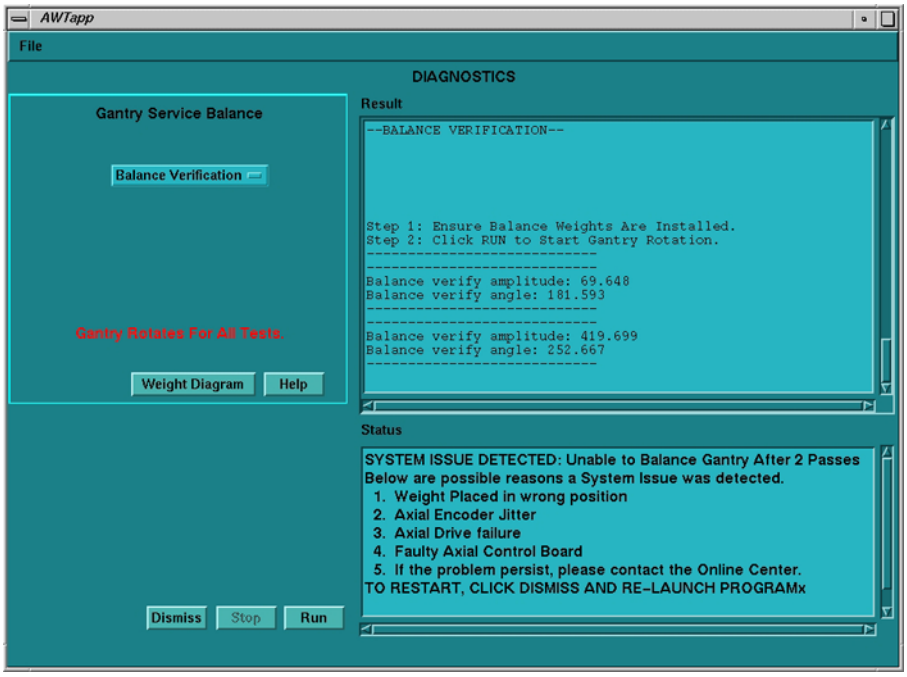


Figure 8-49 Balance Verification Failure Screen

GENERAL COMMENTS

This program is written to follow a specific path without deviation. Various generic error screens are presented to assist you to identify common mistakes, such as “Failure to energize axial enable switch between steps”. In the event of a System Issue Detected failure, the program directs you to investigate most likely items of failure. Those items must be repaired before the program can be successfully completed.

Section 3.0
Replacement Procedures

3.1 Covers

3.1.1 Side Covers

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

3.1.1.1 Side Cover Removal

1.) Lower table to home (lowest) position.

CAUTION
Potential for injury if covers removed and power is left "ON".

Always remove the right side cover first, and turn "OFF" power at the STC.

2.) Use an 8mm Hex wrench to unlatch the side cover from the front cover. See Figure 8-50.

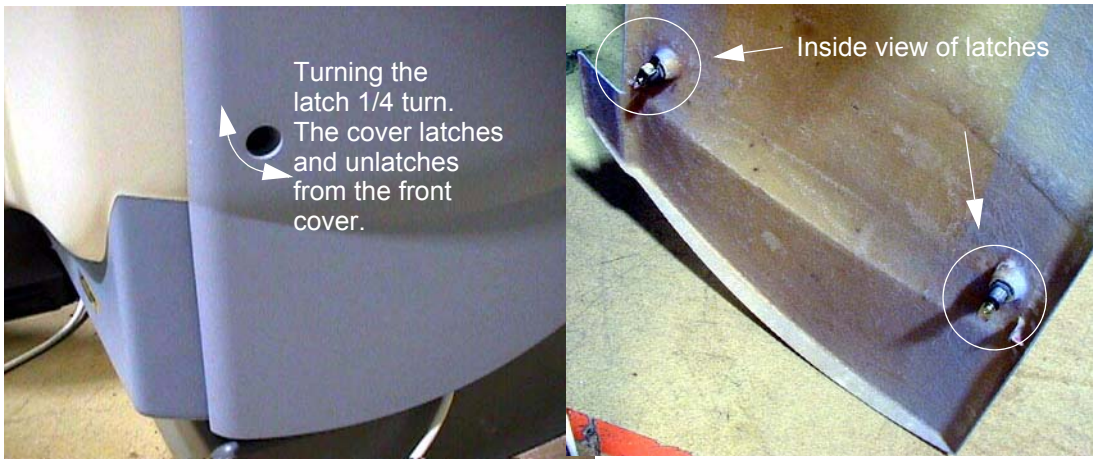


Figure 8-50 Side Cover Latches

3.) Remove the right side cover by lifting it upward to release the two (2) latches, located on the top edge of the cover. Once removed, the STC backplane should be exposed.

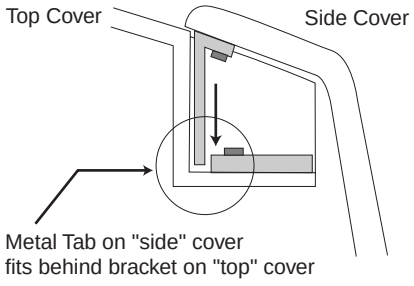


Figure 8-51 Side and Top Cover Clasp

4.) Turn off all three (3) power switches on the STC backplane.

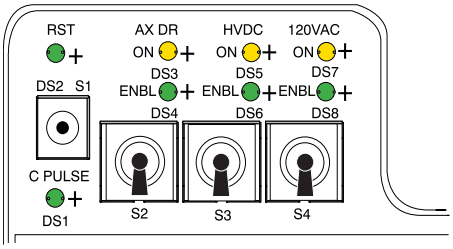


Figure 8-52 STC Power Switches

5.) Repeat steps 1-3 for the left side cover.

3.1.1.2 Side Cover Installation

1.) To install a side cover, place it over the top cover and let the two (2) side cover latches slide behind the metal tabs, located on the top cover. See Figure 8-51.

2.) Use Hex wrench to secure the side cover to front cover by turning the bolts a quarter turn. See Figure 8-50.

3.1.2 Top Covers

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

CAUTION **Before you remove top covers, always make sure the three (3) power switches have been turned off. (See Figure 8-52.)**

3.1.2.1 Top Cover Removal

1.) Remove the associated side cover if you have not already removed it.

2.) Take the end of the top cover nearest to the side cover and tilt upwards.

3.) Slide the cover down 75 millimeters. This allows the cover's tab to disengage from the mounting bracket. See Figure 8-53.

4.) Lift the cover clear and repeat the above steps for the other cover.

3.1.2.2 Top Cover Installation

The top cover consists of two (2) pieces. Install the front and rear gantry covers, if not already installed. See Section 3.1.3, on page 609, and Section 3.1.4, on page 619.

1.) Take one of the top covers and align the tabs on the cover with its associated bracket. Lift and slide the cover into place. Position the cover to fully engage the fan interlock switch.

Figure 8-53 Top cover tabs and bracket, plus fan interlock switch.

2.) Take the other top cover and align the tabs on the cover with its associated bracket. Lift and slide the cover into place, while being sure to engage the fan interlock switch.

3.1.3 Front Cover

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

NOTICE
Potential for front and rear cover damage.

Front and rear cover removal and installation can be safely accomplished by (1) person using the dollies provided with the system. Failure to use these dollies will significantly increase the likelihood of damage to the covers. Do not lean covers against walls.

3.1.3.1 Original Front Cover Dolly Setup

The front cover dollies are a folding design for easy storage. This design is stable and assembly/ disassembly can be done in 30 second

DANGER

DO NOT USE DOLLIES ON UNEVEN SURFACES SUCH AS STEPS OR ELEVATOR THRESHOLDS. THE DOLLIES ARE DESIGNED TO BE USED ON FLAT LEVEL FLOORS WITHIN THE SCANNING SUITE ONLY. MISUSE CAN RESULT IN PERSONAL INJURY OR DAMAGE TO COVERS OR OTHER FACILITY ITEMS.

WARNING

Rotating arms on the stand are supposed to be stiff. If they fall freely, tighten the tensioning nuts. Loose rotating arms will reduce the stability of the dollies when supporting the front cover. Do not lubricate.

Note: Rotating arms are shown in the inverted or upside down position for clarity.

1.) Arrange Dolly sections for assembly. The base and stand can be assembled only one way. Refer to Figure 8-54.
   - The stand has a large stud and 3 smaller studs that engage the base assembly.
   - The large stud provides stability.
   - The three small studs engage the base arms preventing them from folding under if accidentally tipped.
   - The Locking pin engages the 4th base arm and prevents accidental separation when assembled.

Figure 8-54 Front Cover Dolly base and stand disassembled

2.) Unfold the base as shown in Figure 8-54 and place on flat surface.

3.) Install Stand in base, insert base locking pin, unfold stand top and secure with palm screw. Ensure additional safety bracket and washer are installed. Reference Figure 8-55.

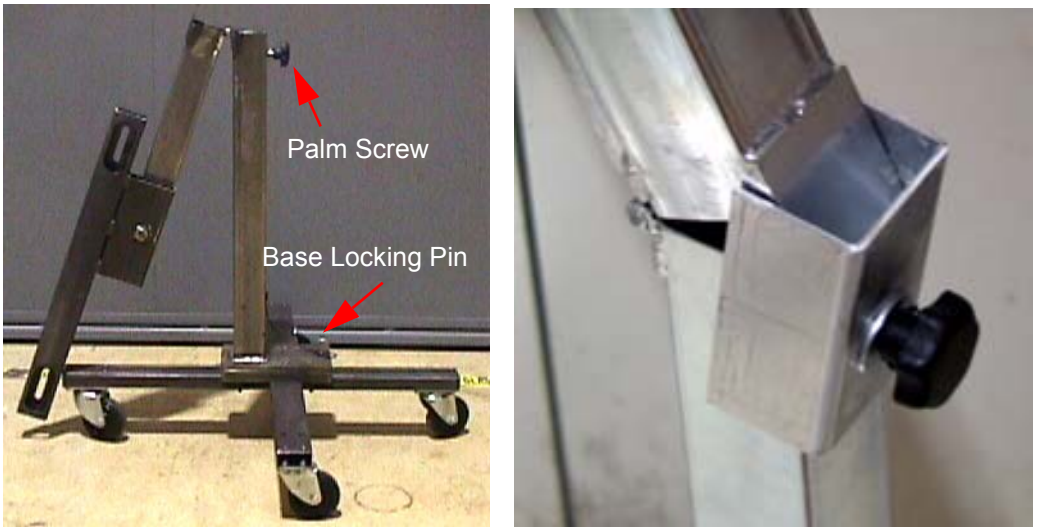


Figure 8-55 Front Cover Dolly Stand and Base with additional Safety Bracket

4.) Assemble second dolly. Both look similar as in Figure 8-56. However the stand portion of the dollies are side specific. The “Right” dolly has the locking pin for cover rotation. The “Left” dolly does not have a cover rotation locking pin.

- Both dolly stands should have an “R” or an “L” indicating right or left.
- The base assemblies are interchangeable.

Figure 8-56 Front Cover left and Right Fully Assembled

3.1.3.2 Redesigned Front Cover Dolly Setup

The Front Cover Dollies were redesigned for cost reduction and potential safety concerns. The new Front Cover Dollies can be ordered as replacements for the original design.

DANGER **DO NOT USE DOLLIES ON UNEVEN SURFACES SUCH AS STEPS OR ELEVATOR THRESHOLDS. THE DOLLIES ARE DESIGNED TO BE USED ON FLAT LEVEL FLOORS WITHIN THE SCANNING SUITE ONLY. MISUSE CAN RESULT IN PERSONAL INJURY OR DAMAGE TO COVERS OR OTHER FACILITY ITEMS.**

WARNING Rotating arms on the stand are supposed to be stiff. If they fall freely, tighten the tensioning nuts. Loose rotating arms will reduce the stability of the dollies when supporting the front cover. Do not lubricate.

1.) Arrange Dolly sections for assembly. The base and post can be assembled only one way. Refer to Figure 8-57 and Figure 8-58.
   - The base uses two (2) palm screws to clamp the four (4) legs in the open or usage mode.
   - The base also uses the same palm screws to prevent the legs from falling in storage mode.
   - The top post can be inserted in either base and is keyed for proper engagement.
   - The top post locking pin prevents the sections from separating during usage.

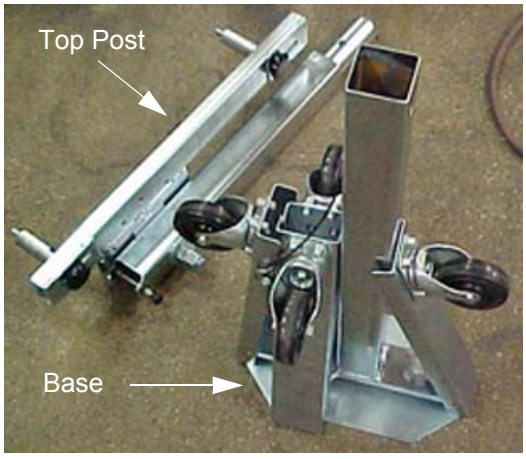


Figure 8-57 Redesigned Front Cover Dolly in Storage Mode

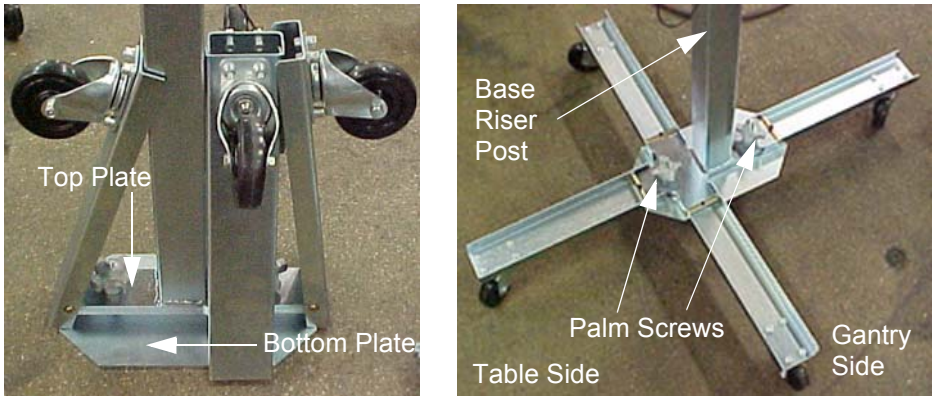


Figure 8-58 Redesigned Front Cover Dolly Base Assembly

2.) Unfold the base legs by loosening both palm screws to the top of their travel.

3.) Carefully unfold the legs so that the castors touch the floor.

4.) Tighten the palm screws to clamp the legs between the base top and bottom plates.

Note: Lifting the base by the riser post while leaving the castors on the floor will ease palm screw tightening. Reference Figure 8-58.

WARNING **ENSURE BOTH PALM SCREWS ARE TIGHTENED SECURELY AND THE LEGS ARE CLAMPED TIGHTLY BETWEEN THE BASE TOP AND BOTTOM PLATES. FAILURE TO DO SO WILL RESULT IN INSTABILITY DURING FRONT COVER HANDLING.**

5.) Insert top post into the base riser post. Align the key for complete engagement.

6.) Insert top post locking pin to secure both top and bottom sections.

7.) Reverse above steps to disassemble.

Note: For base storage only one (1) palm screw needs to be tightened. This will engage the bottom base plate and the leg ends preventing the legs from unfolding during transport and storage.

3.1.3.3 Removal

Note: For Mobile CT Front Gantry Cover Removal Procedure, refer to Appendix A - Mobile Service Concerns - Gantry.

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

1.) Position the table at its lowest position.

2.) Remove gantry side and top covers, if you have not already done so. See Section 3.1.1, on page 607. Make sure that the three (3) power switches have been turned off. See Figure 8-52.

3.) Assemble the front cover dolly.

a.) Tighten the two (2) shoulder bolts to the gantry securely. This will make cover installation easier. See Figure 8-59.

Figure 8-59 Front Side Dolly

b.) Attach side dolly to the shoulder bolts and secure assembly with two (2) wing nuts.

c.) Repeat steps a and b to assemble the other side dolly.

4.) Detach front cover J3 and J2 and front cover BKHD J1 cables.

5.) Remove front cover

a.) Disengage upper and lower cantrell brackets on both sides of the cover.

1.) Using steady but firm pressure, lift each of the lower cantrell brackets from their associated retainers. See Figure 8-60.

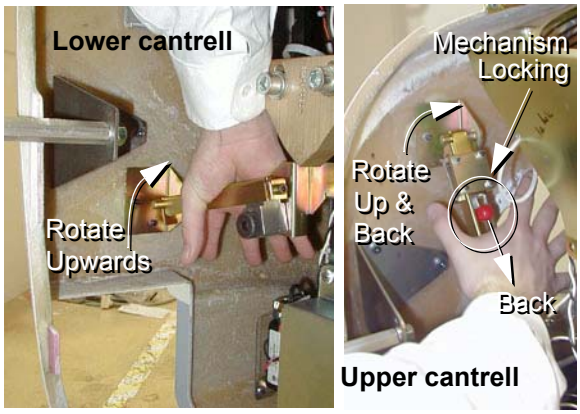


Figure 8-60 Releasing cover brackets

2.) Disengage the locking mechanism on the upper cantrell brackets by using your thumb to slide the trigger (red lever) back. This will release the locking mechanism and allow the cantrell to be rotated upwards with steady and firm pressure.

b.) Disengage the rubber retaining straps on both sides. You may find it helpful to lift “up” on the cover to align the stud while attaching the rubber retaining straps.

c.) Also lift and rotate cover locking arm to unlocked position.

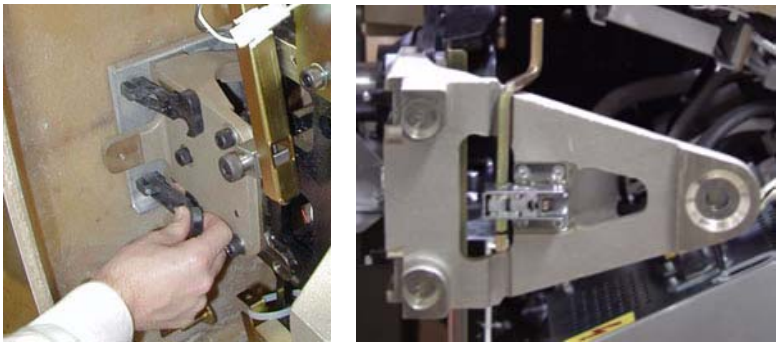


Figure 8-61 Rubber retaining straps and Cover Locking mechanism

6.) Rotate front cover away from gantry.

a.) Move front cover away from gantry, leaving space (about 5 feet) between cover and gantry.

b.) Pull the locking pin and rotate front cover away from gantry. Place locking pin in one of the side dolly perforations. See Figure 8-62.

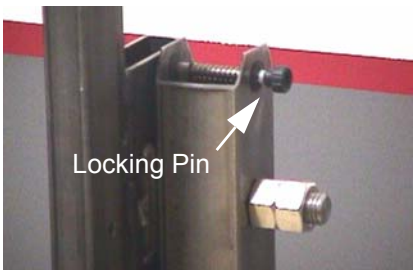
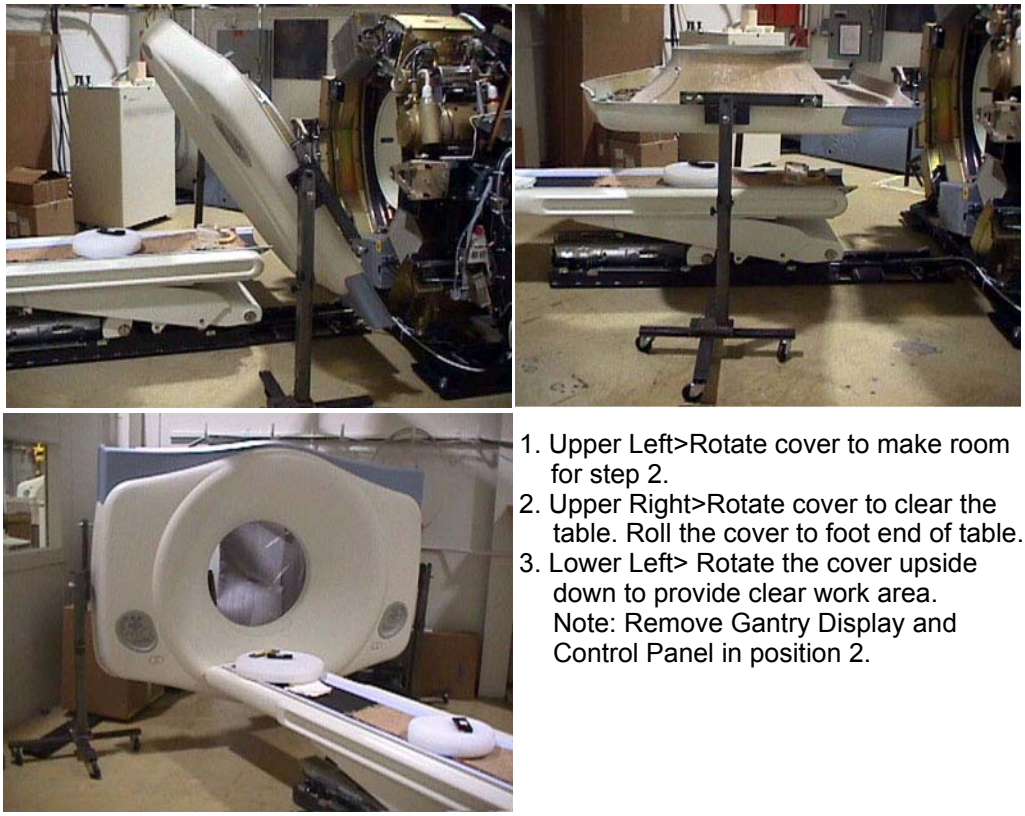


Figure 8-62 releasing Front Cover Dolly Hinge



1. Upper Left>Rotate cover to make room for step 2.
2. Upper Right>Rotate cover to clear the table. Roll the cover to foot end of table.
3. Lower Left> Rotate the cover upside down to provide clear work area.
   Note: Remove Gantry Display and Control Panel in position 2.

Figure 8-63 Front Cover Removal Sequence

7.) Rotate the cover horizontally and move it back and over the table to a safe location. Once in a safe location, you may over-rotate the cover full vertically but upside down.

8.) Remove the gantry display and one (1) of the cover's control assemblies, and place them into the service positions.

a.) Remove the gantry display and place it into its service position.

* The gantry display is held in place with (5) thumb screws. Use a flat-blade screwdriver to remove the Display. Reference Figure 8-64.
* Mount the Display on the Right Gantry Fan.
* There are (2) mounting methods. Both use the cables connected to the REAR GANTRY COVER.
* DIsconnect the cabling at the right rear gantry cover. Only (1) cable will connect to the Gantry Display.
* Position "A" - use one of the display T-hook to hang in the "T" slot on the side of the right Gantry Fan Assembly. Reference Figure 8-65.
* Position "B" - place the Display in the cradle across the top of the right Gantry Fan Assembly. Use thumb-screw to secure display on right side. Reference Figure 8-66.

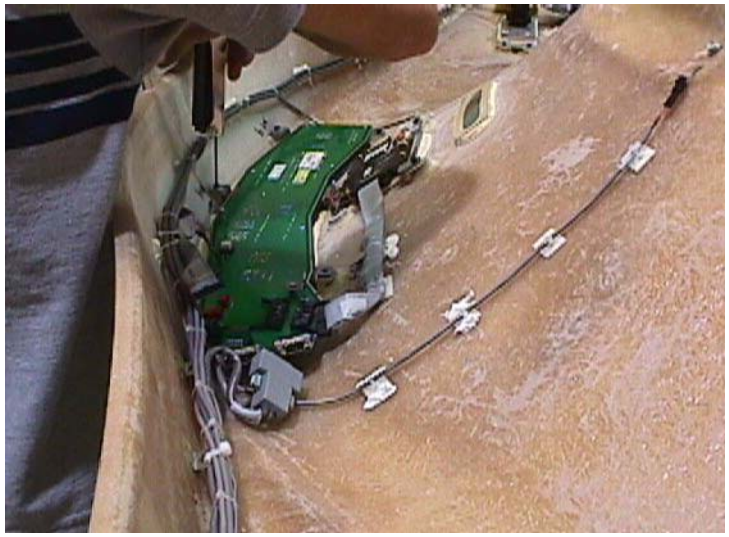


Figure 8-64 Gantry Display Removal

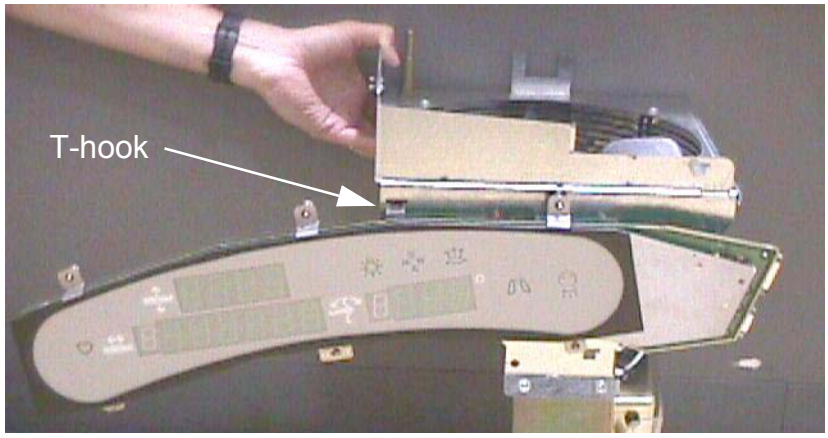


Figure 8-65 Gantry Display Service Mounting Location “A”

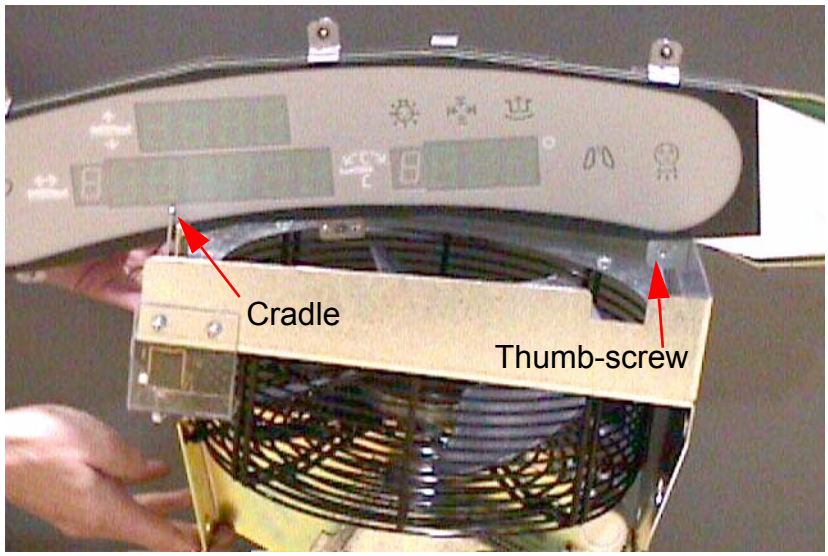


Figure 8-66 Gantry Display Service Mounting Location “B”

b.) Remove a gantry control and place it into its service position.

1.) Press on each ball stud until the panel is released. Keep one hand on the control panel at all times to prevent it from dropping to the floor.

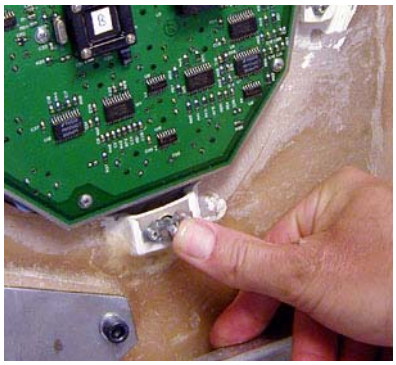


Figure 8-67 Gantry control panel removal

2.) Align the ball studs with their associated receivers and snap into place.

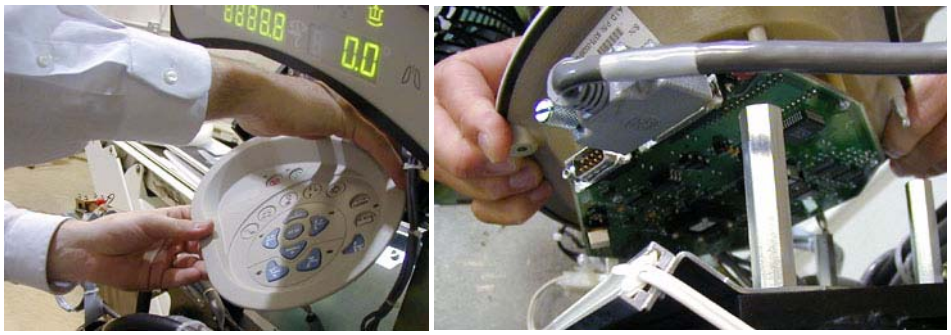


Figure 8-68 Control panel service position

3.) Connect cable to terminator located on the cantrell arm. Reference Figure 8-69.

Note: There are 3 cables, each of which is unique. The ribbon cable is not used in the Service configuration. The other 2 cables will only fit in the terminator or the control panel, not both.

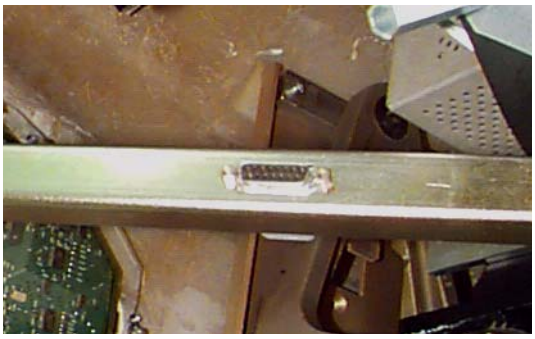


Figure 8-69 Gantry Service Mode Cable Terminator

3.1.3.4 Installation

1.) Remove the gantry display and control assembly from their service positions and reattach them to the gantry cover.

a.) Disconnect cables from Display and Gantry Control Panels.

b.) Install Gantry Display in front cover. Secure the 5 thumbscrews. With a flat-blade screwdriver, gently tighten past finger-tight.

c.) Install the gantry control panel, making sure the ball studs are secure within the receivers.

d.) Reattach cables.

2.) Rotate gantry back to its vertical position.

⚠ **NOTICE**
Potential for front cover damage.

When you rotate the gantry back to its vertical position, make sure not to scratch the front cover with the edge of the table cradle.

3.) Attach the front cover.

a.) Align the studs on both sides of the front cover with each associated receiver. Receiver is located on the gantry frame.

Figure 8-70 Cover stud and Mounting bracket receiver

b.) Insert the stud on one side into its associated receiver and attach the rubber retaining straps.Then insert the stud on the other side into its associated receiver and attach its rubber retaining straps.

You may find it helpful to lift "up" on the cover to align the stud while attaching the rubber retaining straps.

4.) Reattach upper and lower cantrell brackets on both sides.

a.) Remove upper Cantrell brackets from service position and rotate them into position over their associated retaining pins. See Figure 8-71.

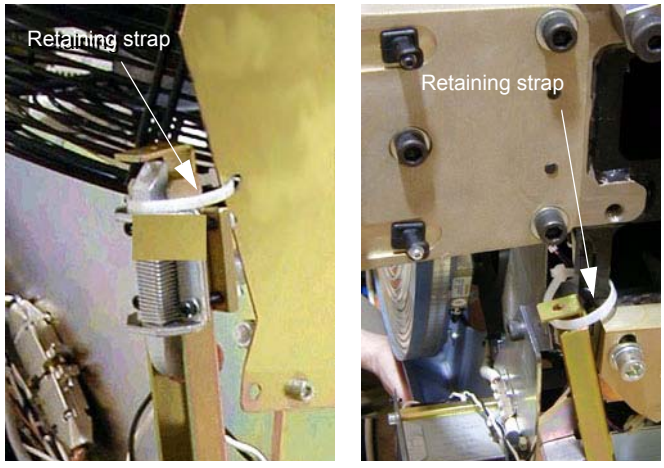


Figure 8-71 Service position of upper and lower cantrell brackets.

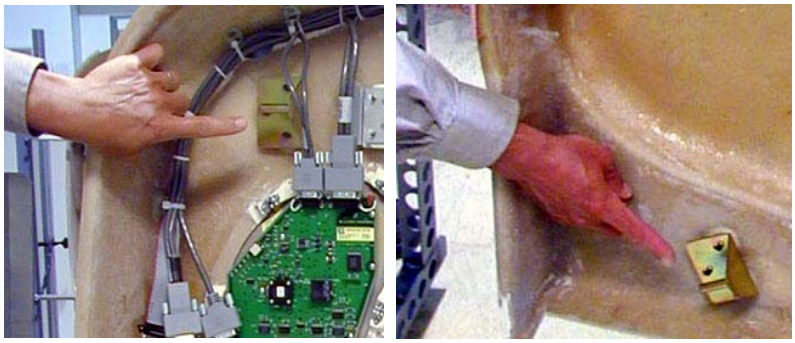


Figure 8-72 Cover retaining pins (top and bottom)

Press down firmly on the bracket and snap it into place. The locking mechanism on each upper bracket should lock the bracket securely into place. Do this on both sides. See Figure 8-73.

Figure 8-73 Locking the cover brackets into place.

b.) Remove lower cantrell brackets from service position (see Figure 8-71), and rotate them into position over their associated retaining pins. Press down firmly on the bracket and snap it into place. See Figure 8-73.

Note: Mis-adjustment of the cantrell brackets can cause misalignment of the top and side covers. The upper and lower cantrell brackets do not require adjustment during normal use.

5.) Remove dolly, disassemble and store safely away for later use.

6.) Reattach cables to cover.

3.1.4 Rear Cover

3.1.4.1 Removal

Note: For Mobile CT Rear Gantry Cover Removal Procedure, refer to Appendix A - Mobile Service Concerns - Gantry.

1.) Assemble the rear cover dolly.

a.) Tighten the two (2) shoulder bolts to the rear cover.

Figure 8-74 One side of the Rear cover dolly

b.) Fit side dolly through the shoulder bolts and secure assembly with two (2) wing nuts. See Figure 8-74

c.) Repeat steps a and b for the other side dolly.

⚠ **CAUTION**
Potential for injury if covers removed and power is left "ON".

2.) Disconnect cables on the right side of the rear cover.

3.) Remove rear cover.

a.) Disengage upper and lower cantrell brackets on both sides of the rear cover.

1.) Using steady but firm pressure, lift each of the lower cantrell brackets from their associated retainers. See Figure 8-60.

2.) Disengage the locking mechanism on the upper cantrell brackets by using your thumb to slide the trigger (red lever) back. This will release the locking mechanism and allow the cantrell to be rotated upwards with steady and firm pressure.

b.) Disengage the rubber retaining straps on both sides.

3.1.4.2 Installation

1.) Position cover in back of gantry

2.) Attach the rear cover

a.) Align the studs on both sides of the rear cover with the receivers located on the gantry frame.

b.) Insert the stud on one side into its associated receiver and attach the rubber retaining straps.Then insert the stud on the other side into its associated receiver and attach its rubber retaining straps.

Note: You may find it helpful to lift "up" on the cover to align the stud while attaching the rubber retaining straps.

3.) Reattach upper and lower cantrell brackets on both sides.

a.) Remove upper cantrell brackets from service position and rotate them into position over their associated retaining pins. Press down firmly on the bracket and snap it into place. The locking mechanism on each upper bracket should lock the bracket securely into place. Do this on both sides.

b.) Remove lower cantrell brackets from service position and rotate them into position over their associated retaining pins. Press down firmly on the bracket and snap it into place.

Note: Adjustment of the cantrell brackets can cause misalignment of the top and side covers. The upper and lower cantrell brackets do not require adjust during normal use.

4.) Remove dolly, disassemble and store safely away.

5.) Reattach cables to cover.

6.) Reinstall the mylar (scan) window. Carefully, bend the scan window and place it into the channel (groove) provided in the covers.

Figure 8-75 Installing the mylar window

3.1.5 Scan Window

3.1.5.1 Remove Scan Window

1.) Grab the window at the top and pull firmly downward.

2.) Continue to pull until the top of the scan window makes contact with the bottom portion of the scan window.

3.) Hold the top and bottom portions of the scan window together, grasp both sides of the scan window, move them together and lightly pull upward, until you can free the window from between the front and rear covers.

Figure 8-76 Scan Window Removal

3.1.5.2 Install Scan Window

NOTICE
Potential for Equipment Damage.

The cones of the front and rear gantry covers must be aligned within specification to ensure proper scan window fit. If the scan window is not fit properly, fluids can get in to the collimator causing permanent damage. See "Scan Window Alignment," on page 587**.**

1.) Install the front and rear covers.

2.) Deform the scan window, as shown in Figure 8-77, and nest the scan window at the bottom of the opening between the front and rear covers, (Figure 8-78) with the rivets in the 6 o'clock installation position. Remember the rivets must be in the 12 o'clock position when the mylar window is fully installed.

3.) After you complete the initial seating of scan window, let the window slowly unfold, and work both sides of the window into position, starting at the bottom and finishing at the top.

4.) Make sure you position the window with the rivets at the 12 o'clock position, and the mylar window slit at either the 3 or 9 o'clock position.

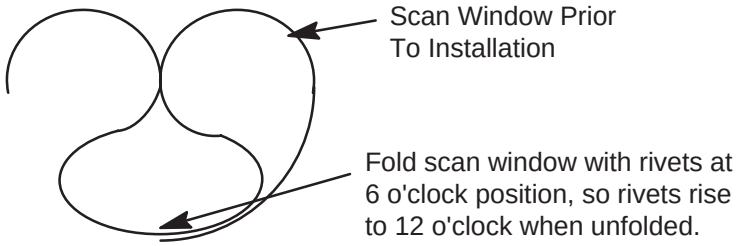


Figure 8-77 Install Scan Window

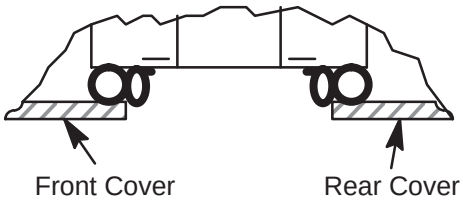


Figure 8-78 Scan Window Nested Between Front and Rear Cover

3.2 Axial

3.2.1 Axial Drive Motor Assembly

3.2.1.1 Required Tools

- 6mm, 10mm, 8mm hex keys
- 12 inch extension for 6mm hex key
- Hoist and 2 flexible lifting straps

3.2.1.2 Procedure Details

1.) Remove the right and back covers and lower slipring cover.

2.) Remove the tilting gantry bottom cover.

3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

DANGER **LETHAL VOLTAGES ARE PRESENT WITHIN THIS ASSEMBLY. ALWAYS REMOVE POWER BEFORE ATTEMPTING TO REMOVE ANY COVERS. SEVERE INJURY OR DEATH CAN RESULT.**

4.) Rotate the tube to the 3:00 position.

5.) Disconnect the Control and Dynamic Brake cabling at the Axial Drive Module. Reference "Axial Drive Module," on page 623.

6.) Remove the Drive Gear cover.

7.) Using the 6mm hex key and the 12 inch extension, fully loosen the elongated hex screw to loosen the drive belt.

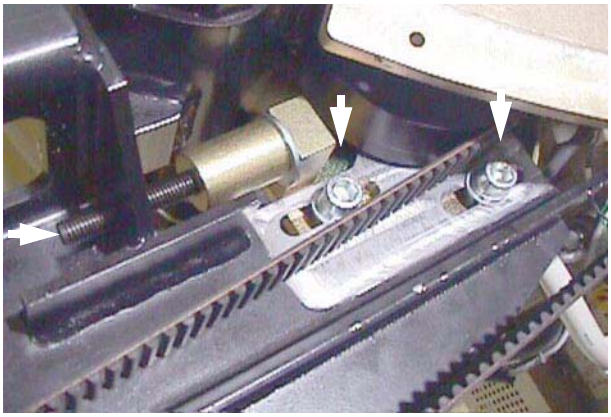


Figure 8-79 To loosen drive belt, loosen 2 screws and the long hex screw

8.) Remove the drive belt from the drive gear. Take care to not disturb the teeth engagement along the rotating assembly.

9.) Using a 10mm hex key, loosen 2 screws that will loosen drive belt.

10.) Assemble hoist and use it to support the motor.

WARNING **MAKE SURE THE MOTOR IS SUPPORTED WITH A HOIST.**

11.) Loosen 4 hex screws to release motor and remove ground cable.

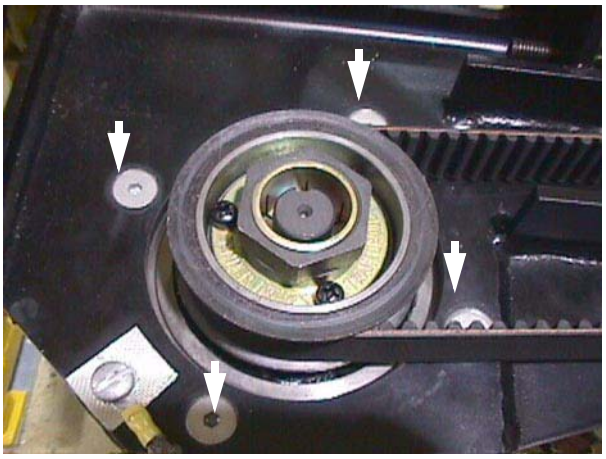


Figure 8-80 Removing the 4 hex screws will release motor

12.) Replace motor and secure it in place.

13.) Install the drive belt on the drive gear and tension belt. Reference "H2 Belt Removal and Installation," on page 627.

14.) Connect cabling to Axial Drive module. Reference "Axial Drive Module," on page 623.

15.) Reassemble gantry.

3.2.2 Axial Drive Module

3.2.2.1 Required Tools

- Screwdriver flat-blade
- Screwdriver Phillips #1 and #2
- 4 MM Hex Key

3.2.2.2 Procedure Details

1.) Remove gantry side, top and front covers.

2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

DANGER

LETHAL VOLTAGES ARE PRESENT WITHIN THIS ASSEMBLY. ALWAYS REMOVE POWER BEFORE ATTEMPTING TO REMOVE ANY COVERS. SEVERE INJURY OR DEATH CAN RESULT.

3.) Rotate the tube to the 3:00 position.

4.) Remove Axial Drive Module (ADM) cover by loosening the 4 thumb screws.

5.) Using the flat-blade screwdriver, carefully loosen and fully remove the lock nut from the electrical connector. Push the lock nut and male threads along the cables clear of the ADM housing assembly. Do not attempt to remove these from the cables. This will allow cable removal later.

6.) Disconnect the control cable from the outside bottom of the ADM assembly.

7.) Disconnect the 3 phase VAC power connections at TB1 R, S, T. Write down colors for later reference.

8.) Disconnect the output PWM cable to the motor at TB1 U, W, V. Write down colors for later reference.

9.) Disconnect the Axial Dynamic Brake cable connections at TB1 DC+, DC- and TB3 24, 25. Write down colors for later reference.

10.) Disconnect the molex connection at the holding brake relay.

11.) Carefully remove the cables from the ADM cover using the slots provided. Carefully cut and remove tie-wraps as needed.

12.) Remove the six (6) M6 screws using the 4mm hex key. Four (4) screws are on the bottom and two (2) are on the sides. This will separate the ADM assembly, including the two (2) trapezoid shaped support brackets, from the main support bracket.

13.) Verify the two (2) jumpers are in the 5V encoder position on the new ADM assembly. Reference Figure 8-5, on page 551.

14.) Assemble in reverse order. Remember to replace all removed tie-wraps.

15.) Restore system power, turn ON STC service switches and verify LEDs are illuminated on ADM.

16.) Reassemble gantry.

3.2.3 Axial Drive Holding Brake

3.2.3.1 Required Tools

9/16 socket wrench

3.2.3.2 Procedure Details

1.) Remove all gantry covers. (Front cover removal not needed for this procedure.)
2.) Turn off all three (3) switches (Axial Drive, HVDC, 120VAC) on the STC backplane.

DANGER VERIFY 120 VAC IS NOT PRESENT AT HOLDING BRAKE RELAY.

3.) Engage indexer lock to prevent unexpected gantry rotation.
4.) Disconnect 2 MOLEX connections to holding brake relay.
5.) Remove three (3) bolts that secure BRAKE motor to MOTOR.
6.) Slide assembly off shaft.
7.) Check the collar alignment on the NEW Holding Brake, before installing on motor shaft. The hexagonal opening should be centered, to ensure that there are no grinding noises from the brake, when in operation.
8.) If the Hexagonal opening is not centered, perform the following steps:

DANGER 120 VAC IS PRESENT AT HOLDING BRAKE RELAY.

a.) Connect two (2) Molex connectors to the new Holding Brake, while it is not attached to the motor shaft. This will release the brake.
b.) Center the Hexagonal opening with respect to the circular shaft opening.
c.) Remove the two (2) Molex connectors. The brake will engage when power is removed.

9.) Install new brake.
10.) Reassemble gantry.

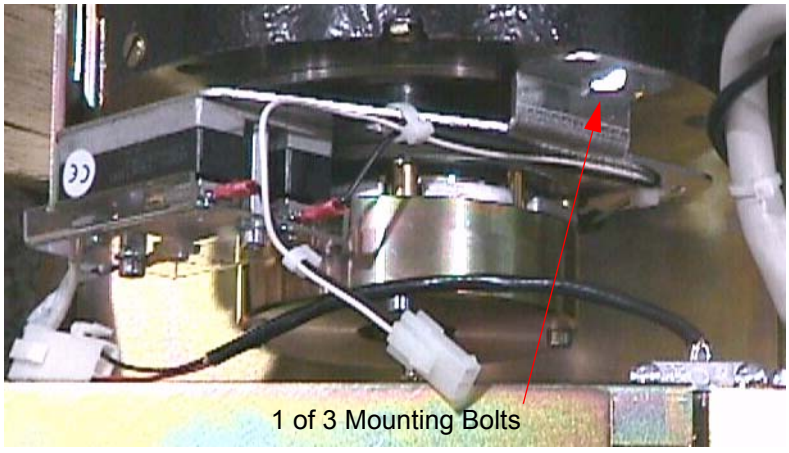


Figure 8-81 Axial Holding brake

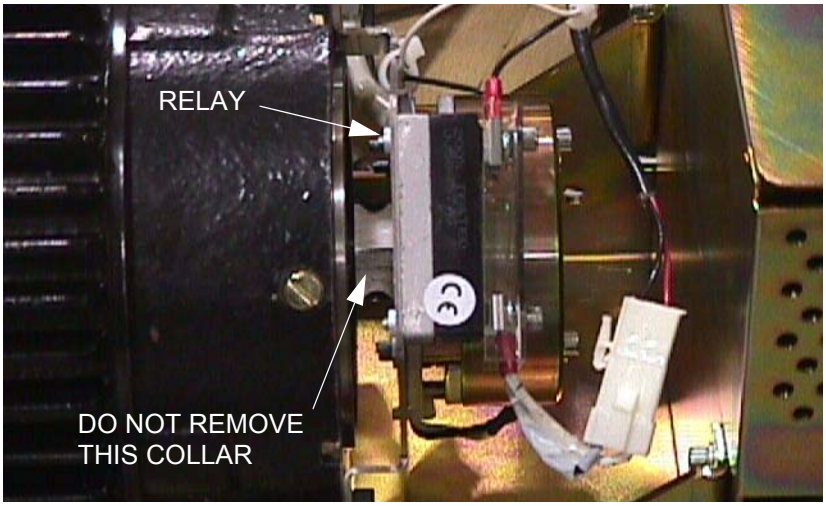


Figure 8-82 Axial Holding Brake Relay

3.2.4 Axial Dynamic Braking Module

This procedure describes the proper method for safe access to the components of this assembly. Always use proper service practices in ESD, power control, and assembly/disassembly procedures. Verify all connections are correct and tightened prior power application.

3.2.4.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 MM. Hex Key

3.2.4.2 Procedure Details

1.) Move table to its lowest elevation.

2.) Remove right and left side covers. Rear cover removal is optional.

3.) Tilt gantry forward to allow sufficient clearance for assembly cover removal.

4.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

DANGER **LETHAL VOLTAGES PRESENT WITHIN THIS ASSEMBLY. ALWAYS REMOVE POWER BEFORE ATTEMPTING TO REMOVE ANY COVERS. SEVERE INJURY OR DEATH CAN RESULT.**

5.) Loosen 4 slot binder screws located on the side metal cover.

6.) Carefully remove side metal cover.

Once the side metal cover has been removed, the HEMRC-IF board and Chopper circuit components will be exposed.

The chopper load resistors are located behind the HEMRC-IF mounting panel.

7.) Remove the screws and chopper load resistor cover as necessary.

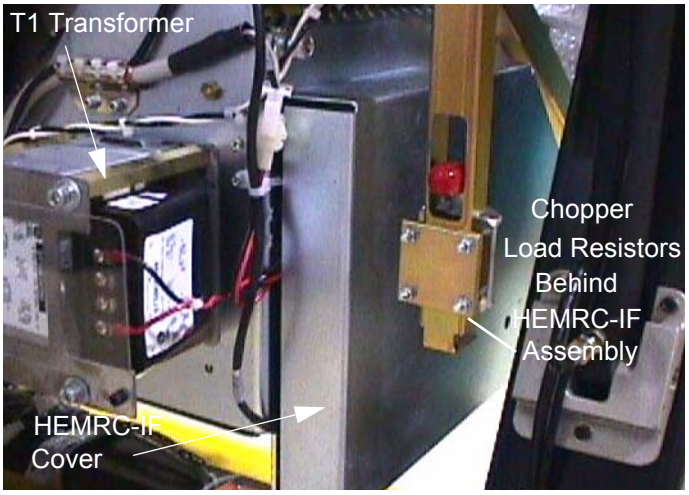


Figure 8-83 Axial Dynamic Brake Assembly.

8.) Replace failed components.
9.) Replace covers and reassemble gantry.

3.2.5 Home Flag and Sensor Board Assembly

3.2.5.1 Required Tools

- ESD wrist-band
- 2.5mm, 5mm hex keys

3.2.5.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove right and left covers.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Locate the home flag by rotating gantry. Replace if any damage is visible.
5.) Locate the Home Flag Sensor assembly, refer to Figure 8-84.
6.) Disconnect the harness.
7.) Remove the M6 screws attaching the bracket to the frame.

Figure 8-84 Home Flag Sensor Assembly

8.) Replace Sensor Assembly and Home Flag as necessary.
9.) Slowly rotate gantry by hand and adjust flag position to pass through the center of the opto-sensor on the sensor board. Make sure the flag is parallel to the opto-sensor.
10.) Perform "Resetting the C-Pulse," on page 574.
11.) Reassemble gantry.

3.2.6 Axial Encoder Assembly

3.2.6.1 Required Tools

- 8 mm hex key
- Flat-blade screwdriver, thin

3.2.6.2 Procedure Details

1.) Remove gantry side and top covers.
2.) Tilt gantry back to 30 degrees.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Disconnect the Encoder DB 9 pin connect from the gantry harness.
5.) Carefully cut tie-wraps as necessary.
6.) Using the 8 mm hex key, remove the shoulder screw on which the encoder assembly pivots.
7.) Install in reverse order.
8.) Perform "Resetting the C-Pulse," on page 574 in Procedures and Adjustments.

3.2.7 H2 Belt Removal and Installation

3.2.7.1 Required Tools

- 12 inch extension for hex key
- 10mm, 8mm 6mm, 5mm hex keys

3.2.7.2 Procedure Details

1.) REMOVAL

a.) Remove the gantry covers (reference "Covers," on page 607) and lower slipring cover.
b.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.
c.) Remove the Home Flag assembly to prevent damage. Reference "Home Flag and Sensor Board Assembly," on page 626.
d.) Remove the Axial Encoder to prevent damage to the encoder gear teeth. Reference "Axial Encoder Assembly," on page 627.
e.) Disconnect power connector to OBC power distribution board.
f.) Remove the HEMRC cover.
g.) Rotate the tube to the 3:00 position. Do not engage the rotational lock.
h.) Loosen the two (2) M12 screws with the 10mm hex key. Reference Figure 8-79, on page 622.
i.) Using the 6mm hex key and the 12 inch extension, fully loosen the elongated hex screw to remove the drive belt from the drive gear. Reference Figure 8-79, on page 622.
j.) Remove the drive belt from the drive gear.

Note: To remove the drive belt requires no slack around the rotating assembly. You will need every millimeter of length to clear the corner of the HEMRC. This is very tight, but it can be done, as shown in Figure 8-85.

k.) Work the belt toward the table on the rotating assembly. Keep all slack at the tube side of the gantry.

CAUTION **Use caution around the OBC to prevent damage to the OBC Power-I/F board. Patience is the key.**

l.) Work the belt around and behind the OBC to provide enough length to cross the tube.

m.) Work the belt between the HEMRC and the tube radiator.

n.) Once belt is over the hose, work belt around cathode end of the tube and radiator. You need to get in front of the tube to clear the corner of the HEMRC.

o.) Once the belt is past the tube, carefully gather all the slack to clear the HEMRC corner.

p.) When the HEMRC is cleared, then carefully work the belt around the rest of the rotating gantry, completing the removal process.

2.) INSTALLATION

a.) Install the belt using the removal steps, 1k through 1p, in reverse order.

b.) Connect the power connector to the OBC Power-I/F board.

c.) Install the home flag, axial encoder and the HEMRC cover.

d.) Slide the belt over the main drive gear and align it towards the back of the rotating assembly teeth. Check both top and bottom.

e.) Work the belt through the pulley tensioner assembly and place on motor drive gear.

f.) Tighten the elongated hex screw using a 6mm hex key and a 12 inch extension. Apply enough tension so the washer can be rotated with your fingers.

g.) Rotate gantry by hand several times and check tension. Make sure the belt does not slip off tensioning pulley and is tracking correctly toward the rear of the gantry. Repeat step 2g as needed.

h.) Correct tension is achieved when the washer can be turned with some difficulty with your fingers.

i.) Tighten the two (2) M12 screws to 30 Ft-lbs. This locks the tensioner assembly.

j.) Install the home flag assembly. Reference “Axial Home Flag Check,” on page 573.

k.) Install the axial encoder and adjust. Reference “Resetting the C-Pulse,” on page 574.

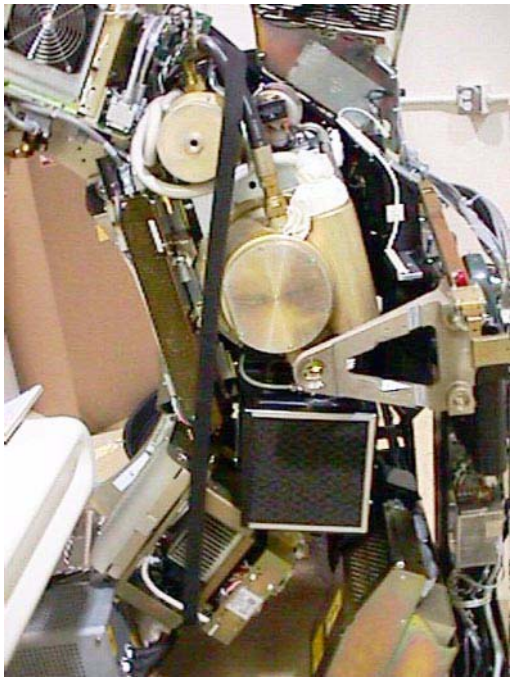


Figure 8-85 H2 Axial Drive Belt Installation/Removal Critical Path

3.3 STC

3.3.1 STC Boards

3.3.1.1 Required Tools

- ESD wrist-band
- Phillips #2 screwdriver, if replacing the Artesyn-3 board

3.3.1.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.

THE FOLLOWING PROCEDURE IS FOR THE ARTESYN-3 BOARD:

1.) Unplug serial and ethernet cables.
2.) Loosen top and bottom fasteners with a Phillips #2 screwdriver.
3.) Pull Artesyn board out using black plastic tabs located on top and bottom of the board.
4.) Install new Artesyn board and reassemble gantry.
5.) Retest matrix.

THE FOLLOWING PROCEDURE IS FOR THE LSCOM & H2 AXIAL BOARDS:

1.) Turn off all the 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
2.) Pull two latches to release the board.
3.) Remove the defective board.
4.) Install the new board. Secure the newly installed board using the two latches.
5.) Retest matrix.

3.3.2 STC Backplane

3.3.2.1 Required Tools

- Phillips #2
- Flathead
- ESD Wristband
- 5 mm. hex key
- 3 mm. hex key

3.3.2.2 Procedure Details

1.) Remove all gantry covers. (Front cover removal is unnecessary for this procedure)
2.) Completely shutdown power. (A1, Lockout/Tagout)
3.) Disconnect all control harness cabling.
4.) Remove STC
5.) Unscrew tie-wrap that secures cabling with hex key.
6.) Remove circuit boards.
7.) Remove hex screws from base assembly and 3 screws behind the tilt riser.
8.) Carefully pivot STC backwards and slide assembly out.
9.) Remove 3 hex screws that secure chassis to backplane.

10.) Remove chassis.
11.) Install new STC Backplane.
12.) Install in reverse order.
13.) Perform retest matrix.

3.3.3 STC Power Supply

3.3.3.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 mm. hex key
- ESD Wrist Band

3.3.3.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Remove plastic safety cover.
4.) Disconnect 4 cables that connect to power supply
5.) Remove 4 hex screws.
6.) Remove STC Power Supply.
7.) Install new Power Supply.
8.) Reference adjustment procedures, "STC Power Supplies," on page 568.

3.3.4 E-Stop Button

1.) Remove right side cover.
2.) Remove front cover.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Loosen two screws to remove 2 cables.
5.) Loosen 4 hex screws that fasten the emergency stop button to the cover.
6.) Replace the emergency stop button and reconnect cables.
7.) Reassemble gantry.

3.3.5 STC AC Filter

3.3.5.1 Required Tools

- Phillips #2 short screwdriver
- Flat-blade screwdriver
- 3 mm. Hex Key
- 8 mm. socket wrench
- 9/32 socket wrench
- ESD Wrist Band

3.3.5.2 Procedure Details

1.) Remove right side cover.
2.) Remove plastic safety cover.
3.) Disconnect 4 cables that connect to power supply
4.) Remove 3 hex screws.
5.) Remove STC Power Supply.
6.) Use socket wrench to remove 4 nuts on top and bottom of AC Filter.
7.) Use socket wrench to remove 2 nuts on top and bottom of AC Filter.
8.) Remove STC AC Filter.
9.) Install new STC AC Filter.
10.) Reference adjustment procedures.

3.4 Slip Ring

3.4.1 Slipring Platter

3.4.1.1 Required Tools

- Phillips #1 and #2 screwdriver
- Flat-blade screwdriver
- 5 mm, 8 mm, 10 mm Hex Key
- Side Cutter pliers
- Tie-wraps Medium, Long
- ESD Wrist Band
- Magnetic mount Dial Indicator with 2 adjustable arms

3.4.1.2 Procedure Details

1.) Remove all gantry covers.
2.) Remove slipring safety covers.
3.) Tilt Gantry forward to +30 degrees.
4.) Completely shutdown system power. (A1, Lockout/Tagout)
5.) Remove rear cover mounting brackets, both sides. Three (3) 12mm bolts on each mount.
6.) Remove brush block and tie-wrap the brush block to the stationary member out of harms way. You can remove the brush block assembly entirely if you choose.

7.) Remove all wiring tie-wraps on the ring inside diameter.
- Write down all filter and cabling connections.
- Write down tie-wrap locations and sizes.

Figure 8-86 Slipring Filter

8.) Disconnect all cables from slipring.

9.) Remove antenna bracket with antenna assembly.

⚠ **CAUTION** **FOLLOW THIS PROCEDURE EXACTLY. DO NOT TAKE SHORT CUTS. BOTH AXIAL AND RADIAL RUNOUT AS WELL AS GANTRY BALANCE ARE AT STAKE.**

10.) Rotate gantry so signal PCB is in 12 o'clock position. This puts the tube at 12 o'clock also.

11.) Engage axial rotating lock to prevent gantry rotation.

12.) Mark slipring, slipring cast mounting brackets, and rotating casting with numbers 1 through 6.
- Start at 12 o'clock and write "1" on all three surfaces.
- Continue clockwise with the next mount with number 2. Do this for all remaining mounts.
- This will ensure everything will be installed in the same locations.

13.) Open new slipring box.
- Place top cover on the floor foam side up.
- Flip the new slipring over in the box, so that brass is face down.
- Install the signal PCB.

14.) On the gantry, remove all twelve (12) 12mm bolts securing the cast mounting brackets to the rotating casting.

Leave the bolts at the 12 o'clock position for last.

15.) After removing last bolts, carefully remove slipring and cast mounting bracket assembly.

⚠ **DANGER** **THE SLIPRING AND CAST MOUNTING BRACKETS WEIGH ABOUT 150 LB (68 KG). 3 PEOPLE MINIMUM ARE NEEDED TO REMOVE THIS ASSEMBLY.**

Remember there are 3 mounts with pins, so pull ring straight off! Use a flat-blade screwdriver to separate the brackets from the rotating casting if necessary.

16.) Place the old ring, brass side down, on top of foam cover.

Align the signal PCB with the replacement ring to simplify the transfer of the cast mounting brackets to the new slipring.

CAUTION **INSPECT ALL INTERFACES FOR BURRS, DEBRIS OR OTHER IMPERFECTIONS. THESE ITEMS CAN RESULT IN RUNOUT FAILURES. THIS WOULD MEAN YOU GET TO DO THIS PROCEDURE ALL OVER AGAIN.**

17.) Transfer each of the cast mounting brackets one at a time. Ensure these brackets are installed in the same position from old to new slipring.

a.) Place cast mounting bracket number 1 on the new slipring aligning 6mm pin in slot.

There are four holes that attach the cast mounting bracket to the slipring. The hole diagonal from the pin is 6.2mm. The other three are 7mm. The 6.2mm hole and 6mm pin are to help you align the ring.

b.) Place the 6mm bolt in the 6.2mm hole and align over slipring insert.

c.) Gently pull or push the cast mounting bracket radially out (away from ISO). Use the pin slot as the stop and the 6.2mm hole for alignment.

d.) Tighten the 6mm bolt until the lock washer starts to compress. Just tighten (snug) enough so that bolts are engaged.

e.) Then install the other three 6mm bolts and snug until they are engaged.

Once the slipring is installed, torque all of the bolts to 6 N-m (53 in-lbs or 4.45 ft-lbs).

18.) Repeat step 17 for all six (6) cast mounting brackets.

19.) Align new slipring and cast mounting brackets with the rotating casting.

- Ensure marked numbers are aligned, 1 to 1, 2 to 2 etc.
- Align guide pins with holes on each of the three (3) cast mounting brackets to rotating base.
- Push until seated. Maintain pressure against the ring & hand tighten all 12 mm bolts.

20.) Release axial rotational lock.

Rotate gantry by hand as needed to ease access to slipring mounting bolts.

21.) Final torquing. Reference Figure 8-87.

Start with the three (3) pinned cast mounting brackets.

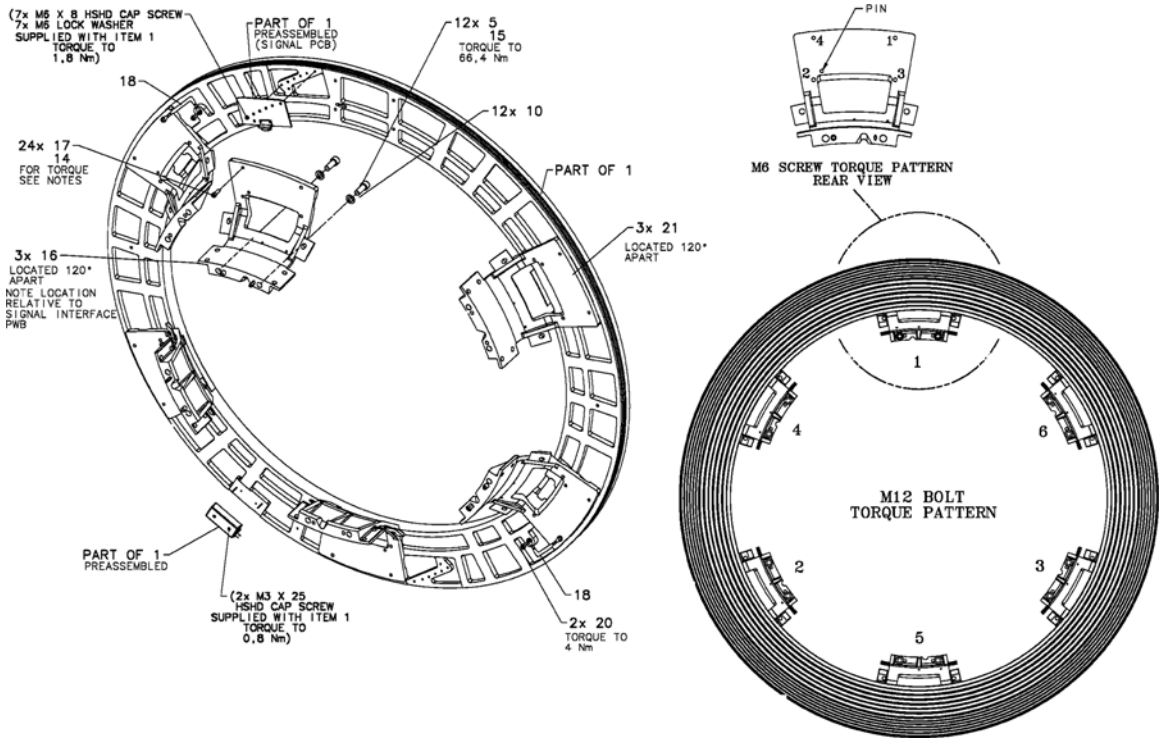


Figure 8-87 Slipring Platter Torque Pattern

22.) Start with bracket location # 1 and torque the two (2) 12 mm bolts to 68 N-m (49 ft-lbs).
23.) Repeat step 21 for cast mounting bracket # 2 through # 6 in order.
24.) Start with bracket location # 1 and torque the four (4) 6mm bolts in order 1, 2, 3, 4. Reference Figure 8-87. Torque to 6 N-m (53 in-lbs or 4.45 ft-lbs).
25.) Repeat step 24 for location # 2 through # 6 in order.
26.) Connect the filters, wiring harnesses and ground clamps to the slipring.
27.) Mount and adjust the Dial Indicator so that the plunger tip rides on the Blue edge of the HSDCD ring.
28.) Rotate the gantry by hand and measure the Radial Runout.
- Radial runout should not exceed .0319 inches (32 mils, 0.81 mm).
- Reference “Radial Runout Adjustment,” on page 634 if out of specification.

29.) Adjust the Dial Indicator and place the plunger tip directly on the brass surface of ring 12.
30.) Rotate the gantry by hand and measure the Axial Runout.
- Axial runout should not exceed .0327 inches (33 mils, 0.83 mm).
- Reference “Axial Runout Adjustment,” on page 635 if out of specification.

31.) Secure all rotating harnesses with tie-wraps as observed at start of this procedure (Figure 8-86).
32.) Install Antenna/Receiver assembly. Reference “S/A HSDCD Slip Ring Antenna Adjustment Procedure,” on page 591.
33.) Install brush block assembly. Reference “Slipring Brush Block,” on page 638.
34.) Install slipring safety covers.
35.) Restore power to system.
36.) Refer to “Retest Matrix for Slipring Components,” on page 663.

Radial Runout Adjustment

DANGER **PROPERLY SHUT DOWN THE SYSTEM, AND FOLLOW LOCKOUT/TAGOUT PROCEDURES.**

1.) Identify the “High” and “Low” physical locations on the slipring.
2.) With the gantry tilted forward + 30 degrees, place the “High” location at 12 o’ clock.
3.) Loosen—do not remove—the four (4) 6 mm bolts at the cast mounting bracket to slipring interface.
4.) Loosen—do not remove—the four (4) 12 mm bolts on each of the six (6) cast mounting brackets.
5.) Physically lift/push/pull the ring to release binding tension.
At + 30 degree tilt, gravity effects are minimized.
6.) Re-torque bolts per steps 20 through 24 of section 3.4.1 - Slipring Platter “Procedure Details,” on page 631. Tightening sequences must be followed for desired results.

Axial Runout Adjustment

DANGER **PROPERLY SHUT DOWN THE SYSTEM, AND FOLLOW LOCKOUT/TAGOUT PROCEDURES.**

1.) Identify the “High” and “Low” physical locations on the slipring.
2.) With the gantry tilted forward + 30 degrees, place the “Low” location at 6 o’ clock.
3.) Loosen—do not remove—the four (4) 6 mm bolts at the cast mounting bracket to slipring interface.
4.) Loosen—do not remove—the four (4) 12 mm bolts on each of the six (6) cast mounting brackets.
5.) Physically lift/push/pull the ring to release binding tension.
    At + 30 degree tilt, gravity effects are minimized.
6.) Re-torque bolts per steps 20 through 24 of section 3.4.1 - Slipring Platter “Procedure Details,” on page 631. Tightening sequences must be followed for desired results.

NOTICE **If readings are still out of specification continue with step 7.**

7.) Inspect the one (1) or two (2) closest cast mounting brackets for proper seating at both the slipring and rotating casting interfaces.
    - All bolts should be properly torqued.
    - No gaps greater than .005 inches (0.127 mm) at any interface edge.
8.) Correct any “High” gaps greater than .005 inches (0.127 mm) at any interface edge.
9.) Recheck both Radial and Axial runout.
10.) Using standard notebook paper (0.003 inches (0.076 mm) thick nominal) make shims for one (1) or two (2) mounting locations on either side of the “Low” location.
    A single sheet folded in half when compressed will be 0.005 inches (0.127 mm) nominal.
11.) Remove the four (4) 6 mm bolts at the cast mounting bracket to slipring interface.
12.) Slide shim between the slipring and cast mounting bracket to block the two (2) outside diameter holes.
13.) Carefully puncture, remove, trim and reinstall shim.
14.) Install the 6 mm bolts and torque per step 24 of section 3.4.1 - Slipring Platter “Procedure Details,” on page 631.
15.) Repeat this procedure as needed.

Notes:
- **IF YOU NEED TO SHIM MORE THAN TWO (2) LOCATIONS, THERE IS SOMETHING ELSE WRONG.**
- **REMOVE AND DISASSEMBLE THE SLIPRING ASSEMBLY, PER** “Slipring Platter,” on page 631**.**
- **INSPECT ALL CONTACT POINTS FOR BURRS, DEBRIS OR OTHER OBSTRUCTIONS CAUSING RUNOUT FAILURES.**

3.4.2 Slipring Receiver

3.4.2.1 Required Tools

- ESD wrist-band
- 2.5mm hex key

3.4.2.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove rear gantry cover.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane A1 and follow Lockout/Tagout procedures.
4.) Remove J1 and J2 cables.
5.) Remove 2 hex screws holding the gold receiver plate to the silver plate.

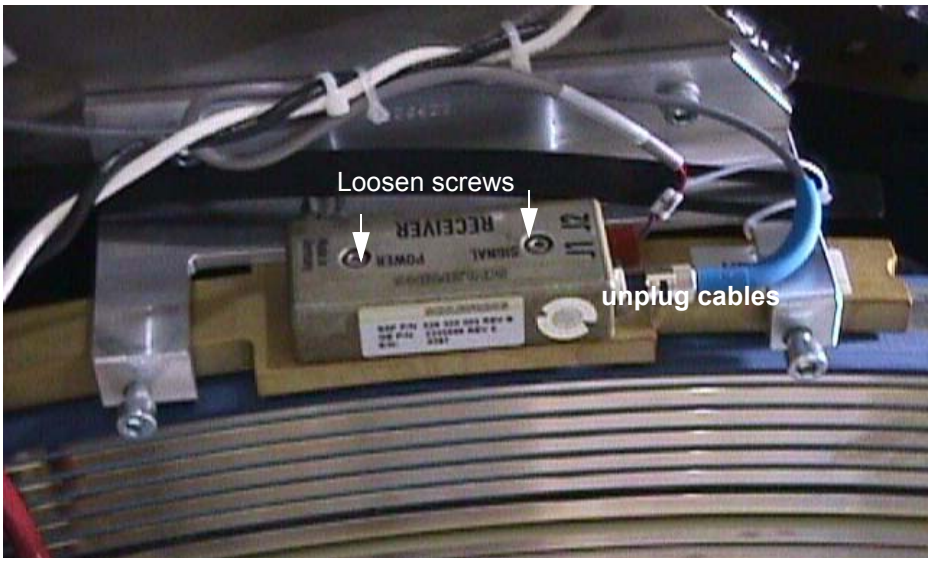


Figure 8-88 Slipring Receiver

6.) Replace receiver.
7.) Verify antenna gap and alignment adjustments.
8.) Refer to “Slip Ring Component Replacement Verification,” on page 663.

3.4.3 Slipring Transmitter

3.4.3.1 Required Tools

- ESD wrist-band
- 2.5mm hex key

3.4.3.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove rear gantry cover.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane, A1 and follow Lockout/Tagout procedures.
4.) The transmitter is located on the back of the slipring. Locate it by rotating gantry.

NOTICE **Be careful not to contaminate slipring or signal.**

5.) Remove J1 and J3 cables.
6.) Using a 2.5mm hex key, remove 2 screws holding the gold transmitter plate to the gantry.

Figure 8-89 Remove two screws holding the transmitter in place.

7.) Replace transmitter.
8.) Refer to “Slip Ring Component Replacement Verification,” on page 663.

3.4.4 Slipring Power Supply Assembly

3.4.4.1 Required Tool

2.5mm hex socket

3.4.4.2 Procedure Details

1.) Remove rear cover and right side cover.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane. Follow Lockout/Tagout procedures.
3.) Using the hex socket, remove 2 cap screws from the back side of supply located on the rear right fan assembly.
4.) Remove safety plate.
5.) Disconnect wiring.
6.) Replace the slipring power supply assembly.
7.) ****Adjustment Procedures****

3.4.5 Slipring Brush Block

3.4.5.1 Required Tools

- Flat-blade screwdriver
- 5 mm, 10mm Hex Key

3.4.5.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove side, top and rear gantry covers.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Remove Rear Gantry cover support bracket.
5.) Remove Slipring covers.
6.) Disconnect all connections to Brush block.
7.) Remove (4) 6mm cap screws that secure brush block assembly to gantry.
8.) Carefully remove brush block.
9.) Inspect each brush tip for wear. Each tip will have a triangle stamped on one side. When the brush wears to the point of the triangle the brush must be replaced.
10.) Remove individual brushes from the block as necessary by unscrewing brush cap and extracting brush.

NOTICE **Do not touch brushes with your fingers. The skin oils will contaminate the brush and reduce usable life and potentially create future failures.**

Note: Since brushes are spring-loaded to ensure constant contact with the slipring during operation, when the block is removed, the springs will relax causing brushes to bound outwards.

If brush is to be re-used make sure you install it in the same orientation as removed. The brush was seated/conditioned in that position.

11.) Carefully install brush block by exerting even pressure perpendicular to the ring surface.

NOTICE **Brush tips are extremely brittle. Do not apply sideways force as they will break. You must replace any brush that has been damaged in this fashion.**

12.) Secure brush block with the (4) 6 mm cap screws. Do not tighten yet.
13.) Carefully push brush block against the position adjustment set screws in the mounting bracket.
14.) Remove (3) brushes total, (2) brushes from the inside HVDC ring top and bottom and (1) brush from ring 10 bottom (2nd from the outside). Remember the orientation for later installation.
15.) Use a flashlight to verify block position is adjusted so the brushes ride in the center of their tracks.
16.) Torque (4) 6 mm cap screws to 5.5 N-m (48.7 in-lbs or 4 ft-lbs).
17.) Reassemble gantry.
18.) Refer to “Slip Ring Component Replacement Verification,” on page 663.

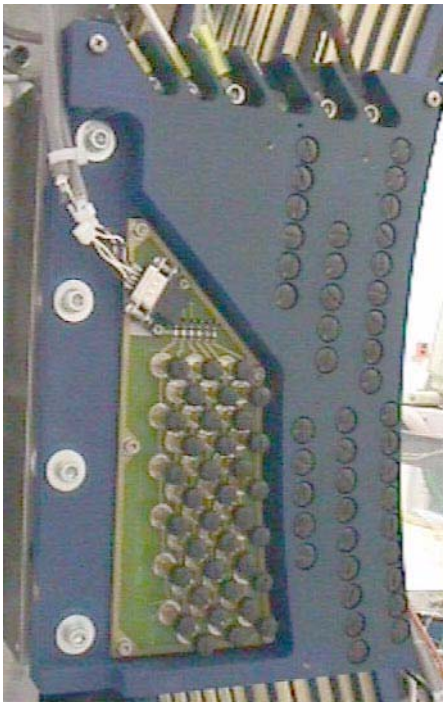


Figure 8-90 Slipring Brush Block Assembly

3.5 Tilt

3.5.1 Tilt Relay Board

3.5.1.1 Required Tools

- ESD wrist-band
- Phillips #2 short and flat blade screwdriver

3.5.1.2 Procedure Details

1.) Remove right and base covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Tilt gantry back 20 degrees.

CAUTION **Wear a grounded wrist strap when you handle a circuit board.**

4.) Use a short #2 phillips screwdriver to loosen the 4 screws that fasten plastic cover to the Tilt Relay Board.
5.) Remove J2 and J3 connectors.
6.) Loosen 4 screws that secure the 4 cables to the relay board.
7.) Loosen 8 screws to release the Tilt Relay board.
8.) Install new Tilt Relay board and reassemble gantry.
9.) Retest Matrix

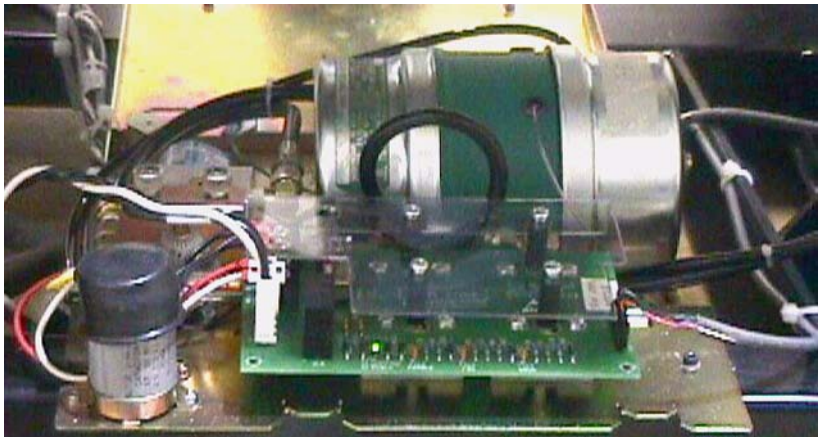


Figure 8-91 Tilt Relay Board

3.5.2 Hydraulic Tilt Motor Assembly Replacement

3.5.2.1 Required Tools

- 2.5mm, 5mm, 10mm hex key
- Flat-blade screwdriver
- Phillips #1 and #2 screwdriver
- Hydraulic oil (2227239)
- Oil absorption material/spill kit, as defined by HAZMAT processes and procedures
- Paper towels

3.5.2.2 Procedure Details

⚠ **DANGER** **DANGER: CRUSH HAZARD. THIS SERVICE PROCEDURE REQUIRES THE GANTRY TO BE TILTED ALL THE WAY BACK IN ITS MINUS 30 DEGREE POSTION AND PLACED ON ITS MECHANICAL STOPS.**

⚠ **DANGER** **DANGER: CRUSH HAZARD. NEVER INTENTIONALLY INTRODUCE AIR INTO THE HYDRAULIC SYSTEM.**

⚠ **DANGER** **DANGER CRUSH HAZARD. NEVER EXTEND THE HYDRAULIC PISTONS BY HAND. DOING SO WILL CAUSE INSUFFICENT HYDRAULIC PRESSURE IN THE SYSTEM WHEN TILT FUNCTION IS RESTORED.**

DANGER

DANGER: CRUSH HAZARD. THE NEWLY REPLACED HYDRAULIC CYLINDERS MAY NOT BE UNDER FULL HYDRAULIC PRESSURE. THIS MAY RESULT IN THE GANTRY TILTING SUDDENLY OR ERRATICALLY WHEN THE GANTRY IS MOVED FOR THE FIRST TIME, PAST THE ZERO DEGREE (FULLY UPRIGHT) POSITION. REMAIN CLEAR OF THE GANTRY UPON INITIAL STARTUP AFTER THE HYDRAULIC TILT ASSEMBLY REPLACEMENT.

DANGER

ELECTROCUTION HAZARD. 120 VAC IS PRESENT AT THE TILT RELAY BOARD. TURNING OFF THE STC SERVICE SWITCHES WILL NOT REMOVE THIS POWER.

Note: For an accurate description of spatial orientation with regard to the proper servicing of this product, refer to the Preface: "Spatial Orientation While Servicing the System," on page 31

1.) Remove the gantry side and any base covers to gain access to the gantry tilt hydraulic assembly located in the base of the gantry.

2.) To proceed:

a.) If the gantry tilt function allows, use the controls on the gantry to drive the gantry to the minus 30-degree (all the way back) position. Refer to Figure 8-92 for a side view and exact location of the gantry:

1.) On the Tilt Control Board (located on the Tilt Motor Control Board in the gantry base near the tilt motor) locate and place the Service Switch in the "Service" position.

2.) Use the Manual Tilt Drive switch on the Tilt Control Board to drive the gantry to the mechanical stops.

b.) If the gantry tilt function is not operational, use the Service Switch on the Gantry Control Board to drive the gantry to the minus 30-degree (all the way back) position. Refer to Figure 8-92 for a side view and exact location of the gantry.

1.) On the Tilt Control Board (located on the Tilt Motor Control Board in the gantry base near the tilt motor) locate and place the Service Switch in the "Service" position.

2.) Use the Manual Tilt Drive switch on the Tilt Control Board to drive the gantry to the mechanical stops.

Note: When standing at the back of the table facing the Gantry Display Board, looking through the gantry, the top of the gantry must be tilted away from you, (all the way back). Refer to Figure 8-92 for a side view and exact location of the gantry.

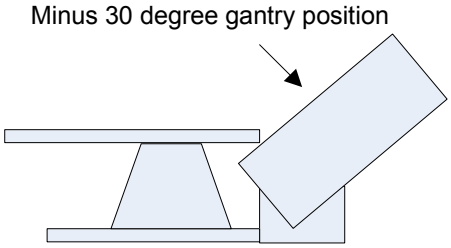


Figure 8-92 Gantry in tilt hydraulic service position

3.) Once the gantry is in the correct position, disable the gantry tilt function, high voltage, and 120VAC on the Service Switch Panel.

4.) Shutdown the system software and turn off the console power switch under the console table top.

5.) Remove all system power at the main disconnect (A1) panel. Perform proper Lockout/Tagout

power control procedures.

6.) While viewing the gantry from the rear, the gantry tilt hydraulic assembly is located inside the right gantry base assembly of the gantry. Label the wires located on the Gantry Tilt Control Board for later assembly.

7.) While viewing the gantry from the rear, disconnect the three-phase power plug at the side of the gantry power pan, located inside the left side of the gantry base assembly.

8.) Remove the rear screws securing the gantry tilt hydraulic assembly to the gantry base frame.

9.) Loosen the front screws securing the gantry tilt hydraulic assembly; (their complete removal is not necessary).

10.) Disconnect and remove the cable connections and wires at the terminal on the Tilt Control Board.

11.) Identify all tie wraps and fasteners securing the hydraulic lines to the gantry frame and take note of the routing of these hydraulic lines.

12.) Remove any fasteners and tie wraps securing the hydraulic lines to the gantry base frame and hydraulic cylinder. Be careful not to puncture or kink any of the hydraulic lines.

13.) While viewing the gantry from the rear, the STC Assembly will be on the left. To proceed, it may be easier to remove the STC Assembly by removing the three (3) screws securing it to the gantry frame. No cable removal should be necessary from the STC.

14.) While viewing the gantry from the rear, loosen the four (4) hex socket caps at the top of the left hydraulic cylinder mount bracket, and the three (3) screws of the mount bracket at the bottom of the left hydraulic cylinder. Keep your hands clear of potential gantry pinch points at all times.

15.) Remove the left hydraulic cylinder and its lines from the gantry base.

16.) Carefully install the new left hydraulic cylinder in place. Make sure the lines are properly routed along the gantry frame. Do not tie wrap them in place at this time.

17.) While viewing the gantry from the rear, loosen the four (4) hex socket caps at the top of the right hydraulic cylinder mount bracket, and the three (3) screws of the mount bracket at the bottom of the right hydraulic cylinder. Keep your hands clear of potential gantry pinch points at all times.

18.) Remove the right hydraulic cylinder and its lines from the gantry base.

19.) Completely remove the gantry tilt hydraulic pump assembly from the gantry base.

20.) To proceed, inspect the replacement gantry tilt hydraulic unit and hydraulic cylinders for any damage in shipment. There should be no leaking oil and no residual oil in the shipping crate. The hydraulic pistons should be fully compressed into their cylinders. (Do not extend the pistons by hand).

   a.) If you suspect that the replacement unit is not in proper condition for installation, or appears damaged in any way, stop the replacement process and escalate by calling Field Leadership for further direction.

   b.) If you do not see any damage, remove the replacement unit from its shipping crate being careful not to kink the hydraulic lines.

21.) Move the replacement unit to the back of the gantry.

22.) Install the gantry Tilt Motor Assembly into the base. Secure the gantry Tilt Motor Assembly with its four screws.

23.) Install the right hydraulic cylinder.

24.) Loosely secure all hydraulic lines with tie wraps. Do not tighten the tie-wraps at this time. Make sure to leave approximately 2.5 cm (1 in) of slack on both the left and the right cylinder lines to prevent hose damage during forward tilt.

25.) Attach all wires and cables removed from the gantry Tilt Control Board.

26.) While viewing the gantry from the rear, torque the M12 screws for the upper left cylinder mount bracket to 66.4 N-m (49 ft-lbs).

27.) While viewing the gantry from the rear, torque the M12 screws for the upper right cylinder

bracket to 66.4 N-m (49 ft-lbs).

28.) If the STC Assembly was removed, re-attach the STC Assembly to the gantry frame. If any tie wraps were removed from the cables, re-install new ones.

29.) Remove Lockout/Tagout following all lockout/tagout procedures to restore main power.

DANGER

DANGER: CRUSH HAZARD. THE NEWLY REPLACED HYDRAULIC CYLINDERS MAY NOT BE UNDER FULL HYDRAULIC PRESSURE. THIS MAY RESULT IN THE GANTRY TILTING SUDDENLY OR ERRATICALLY IF THE GANTRY IS MOVED PAST THE ZERO DEGREE (FULLY UPRIGHT) POSITION. REMAIN CLEAR OF THE GANTRY UPON INITIAL STARTUP AFTER THE HYDRAULIC TILT ASSEMBLY REPLACEMENT. NEVER INTENTIONALLY INTRODUCE AIR INTO THE HYDRAULIC SYSTEM.

DANGER

ELECTROCUTION HAZARD. 120 VAC IS PRESENT AT THE TILT RELAY BOARD. TURNING OFF THE STC SERVICE SWITCHES WILL NOT REMOVE THIS POWER.

30.) Enable the gantry tilt function, High voltage and 120VAC at the Service Switch Panel.

31.) While viewing the gantry from the rear, locate the Tilt Control Board on the replacement tilt hydraulic assembly.

32.) On the Service Switch Panel, set the Service Switch to the "Service" position.

33.) Use the manual tilt switch to drive the gantry off of its stops approximately 2.5 cm (1 in).

34.) On the Service Switch Panel, set the Service Switch to the "Normal" position.

35.) Turn on the console using the power switch under the console table top. The system software should automatically boot the system up to full operation.

36.) To proceed:

a.) If another field engineer is available on site, have one person stand behind and clear of the gantry while observing the hydraulic lines and gantry motion during the first tilt. If another field engineer is not present, proceed to step 36b.

1.) Have the other person stand at the side of the gantry (clear of tilt motion) and use the tilt feature on one of the operator control panels on the front of the gantry to tilt the gantry forward to the -10 degree position for first time and stop.

2.) Check the hydraulic lines periodically to ensure that there is enough slack to accommodate further tilting.

Note: It may be possible for the gantry to move erratically when it passes through the zero degree (fully upright) position the first time and its weight becomes supported by the new hydraulic system.

3.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the zero degree (fully upright) position and stop. During the tilt, the observer should stop the tilt if he or she observes any problem with the hydraulic lines, or the gantry encounters any obstructions.

4.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the +10 degree position and stop.

5.) Check the hydraulic lines for proper slack and the gantry in general for any other obstructions.

6.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the +30 degree position where it should come to a complete stop.

7.) At this time tighten the tie wraps holding the hydraulic lines.

b.) If another field engineer is not available to observe the gantry tilt for the first time, periodically stop titling the gantry and check the gantry movement for obstructions and slack in the hydraulic lines.

1.) Stand at the side of the gantry (clear of tilt motion) and use the tilt feature on one of the operator control panels on the front of the gantry to tilt the gantry forward to the -20 degree position for first time and stop.

2.) Check the hydraulic lines to ensure that there is enough slack to accommodate further tilting.

3.) Stand at the side of the gantry (clear of tilt motion) and use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the -10 degree position for first time and stop.

4.) Check the hydraulic lines to ensure that there is enough slack to accommodate further tilting.

Note: It may be possible for the gantry to move erratically when it passes through the zero degree (fully upright) position the first time and its weight becomes supported by the new hydraulic system.

5.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the zero degree (fully upright) position and stop

6.) Check the hydraulic lines to ensure that there is enough slack to accommodate further tilting.

7.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the +10 degree position and stop. Be prepared for possible erratic tilt motion during this step.

8.) At the +10 degree position, check the hydraulic lines for proper slack and the gantry in general for any other obstructions.

9.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to continue tilting the gantry forward to the +30 degree position, where it should come to a complete stop.

c.) At this time tighten the tie wraps by hand holding the hydraulic lines.

37.) While viewing the gantry from the rear, torque the M6 screws for the lower left cylinder mount bracket to 7.9 N-m (5.8 ft-lbs).

38.) While viewing the gantry from the rear, torque the M6 screws for the lower right cylinder bracket to 7.9 N-m (5.8 ft-lbs).

39.) While viewing the gantry from the rear, locate the Tilt Control Board on the replacement tilt hydraulic assembly.

40.) On the Service Switch Panel, set the Service Switch to the "Service" position to test the manual tilt function under the full weight of the gantry.

41.) Use the Manual Tilt Switch to drive the gantry to the zero degree (fully upright) position and stop.

42.) On the Service Switch Panel, set the Service Switch to the "Normal" position.

43.) While staying clear of the gantry, (stand at its side) use one of the operator control panels on the front of the gantry to resume tilting the gantry, exercising the new tilt hydraulic assembly completely through its full range of motion.

44.) Exercise the tilt function at least 6 full cycles (-30 degrees to +30 degrees) to purge any air from the hydraulic system.

45.) Place the gantry at its zero degree (fully upright) position and stop.

46.) When the tilt pump is warm to the touch, make final speed adjustments.

47.) Refer to the "Tilt Speed Adjustment Procedure," on page 579.

48.) Reassemble the gantry by replacing any covers that were removed.

49.) Refer to "Clean-up and Personal Hygiene," on page 49, for proper disposal of contaminated materials.

3.5.3 Tilt Pot Assembly

3.5.3.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3/32 Hex Key
- 3 mm hex key
- 5 mm hex

3.5.3.2 Tilt Potentiometer Procedure Details

Reference Figure 8-93.

1.) Remove gantry side covers.

2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.

3.) Remove 3 hex screws that secure tilt pot cover and remove.

4.) Loosen the 2 hex screws that tension the belt.

5.) Remove belt off the small pulley.

6.) Disconnect tilt pot connector.

7.) Cut tie-wraps as necessary.

8.) Remove hex screws that secure tilt pot.

9.) Remove tilt pot assembly.

10.) Install new tilt pot assembly and adjust per "Tilt Pot and Belt Adjustment," on page 575.

11.) Reassemble gantry.

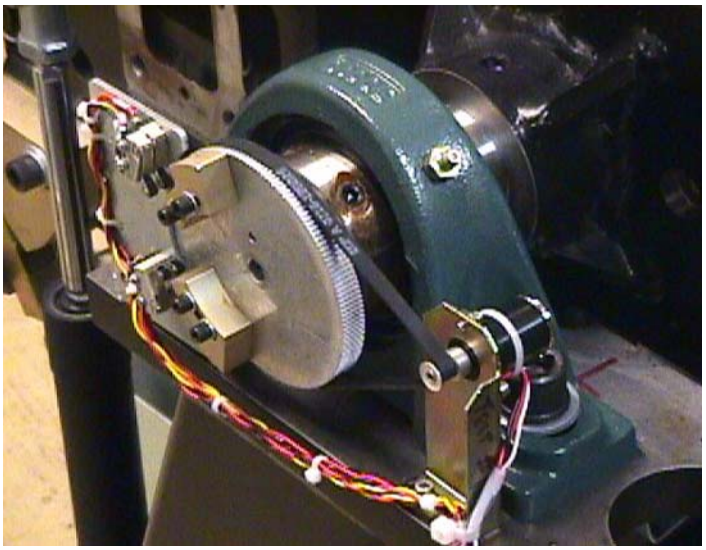


Figure 8-93 Gantry Tilt Pot Assembly 2178677

3.5.3.3 Tilt Interference and Limit Switches

3.5.3.4 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3/32 Hex Key
- 3 mm hex key
- 5 mm hex

3.5.3.5 Tilt Interference/Limit Switches Procedure Details

Reference Figure 8-93.

1.) Remove gantry side covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Remove 4 slotted screws to loosen the dual-switch bodies.
4.) Disconnect outside switch. (Black and white wires in top and bottom locations.)
5.) Disconnect inside switch. (Yellow and red wires in top and bottom locations.)
6.) Disconnect molex connector to replace harness.
7.) Cut tie-wraps as necessary.
8.) Install new switch assembly and adjust per “Tilt Limit/Interference Adjustments,” on page 576.
9.) Reassemble gantry.

3.6 Fuse Box Switch Assembly

3.6.1 Required Tools

- Phillips #2
- Flathead
- 10 MM. hex key

3.6.2 Procedure Details

1.) Remove all gantry covers.
2.) Rotate Fuse Box Assembly to 10 o’clock.
3.) Remove 2 hex screws that secure Fuse Box Assembly.
4.) Slide fuse box up so that washers fit through aperture on fuse box, and then release the fuse box.
5.) Cut any necessary tie-wraps.
6.) Disconnect all associated terminals and cables.

3.7 Display

3.7.1 Display Assembly

1.) Remove right side cover.
2.) Remove front cover.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Remove 4 cables.
5.) Loosen 6 screws that fasten the display assembly to the cover.

6.) Replace the display assembly panel and reconnect cables.
7.) Reassemble gantry.

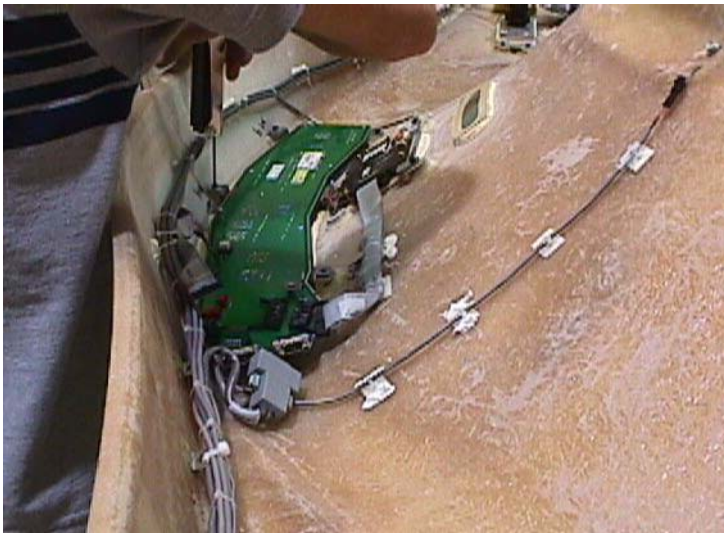


Figure 8-94 Display Removal

3.7.2 Control/Scan Start Panel

1.) Remove right side cover.
2.) Remove front cover.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Disconnect J1 and left control cables.
5.) Loosen 5 screws that fasten the start panel to the cover.
6.) Replace control panel and reconnect J1 and left control cables.
7.) Reassemble gantry.

3.7.3 Breathing Light Assembly

1.) Remove gantry side and top covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Remove gantry front or rear cover as needed.
4.) Remove 2 cables.
5.) Loosen 4 screws that fasten the breathing light assembly to the cover.
6.) Replace the breathing light assembly panel and reconnect cable.
7.) Reassemble gantry.

Figure 8-95 Gantry Breathing Light Assembly

3.7.4 Gantry Cover Touch Pad

3.7.4.1 Required Tools

Socket wrench

3.7.4.2 Procedure Details

1.) Remove side, top, and front covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Disconnect touch strip cable.
4.) Remove 2 nuts that secure touch pad to outside of gantry.
5.) Install new touch pad.
6.) Reassemble gantry.

3.8 Intercom

3.8.1 Intercom Board

3.8.1.1 Required Tools

- ESD Wrist-Band
- Phillips #1 screwdriver
- Quarter inch ratchet
- 6 inch extension
- 7mm socket

3.8.1.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Use the quarter inch ratchet to loosen but not remove the 2 lower nuts and washers.

Note: Be careful not to lose the nuts and washers. Also notice that the flat washer is installed first, then the lock washer and then the nut.

4.) Remove 2 upper nuts and washers.
5.) Disconnect control cable.
6.) Remove 4 screws that secure intercom board.
7.) Reinstall intercom board in reverse order.
   - Verify that J2 jumper is in auto position.
   - Be sure to torque nuts to 9 inch-pounds, for rotational force integrity.
8.) ***Retest Matrix****

3.8.2 Remote Intercom X Board

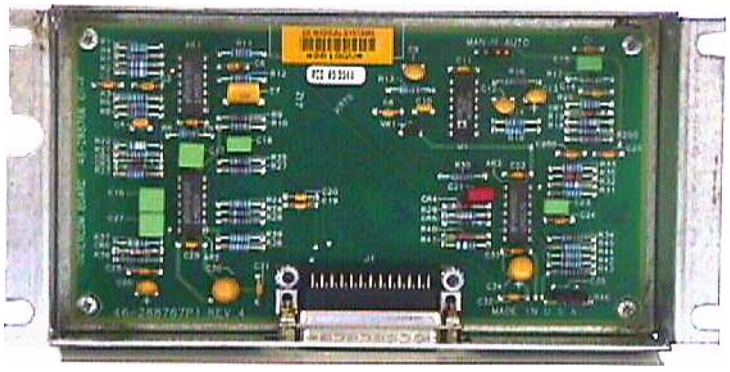


Figure 8-96 Remote Intercom X Board - Obsolete (no adjustments available)

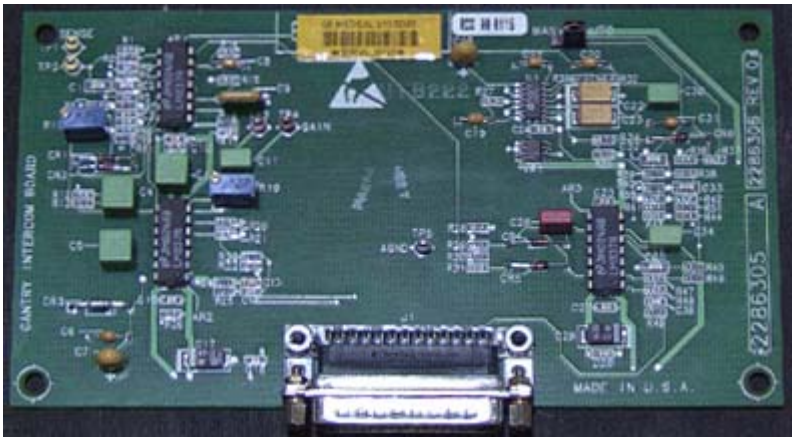


Figure 8-97 Replacement Remote Intercom X Board (with adjustments available)

3.8.3 Remote Intercom X Board Test Points

- There are no test points, switches or LEDs on this board
- J2 AGC control Normal setting is Auto

3.9 Laser

3.9.1 Laser Lights

3.9.1.1 Required Tools

5mm hex key

3.9.1.2 Procedure Details

1.) Remove gantry covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Disconnect the electrical connection to the defective laser assembly
4.) Loosen laser clamp nut.
5.) Attempt to remove the laser from clamp using the 5mm hex key. If additional clearance is needed, loosen 2 mounting screws NOT alignment screws. Remove mounting bracket IF necessary.

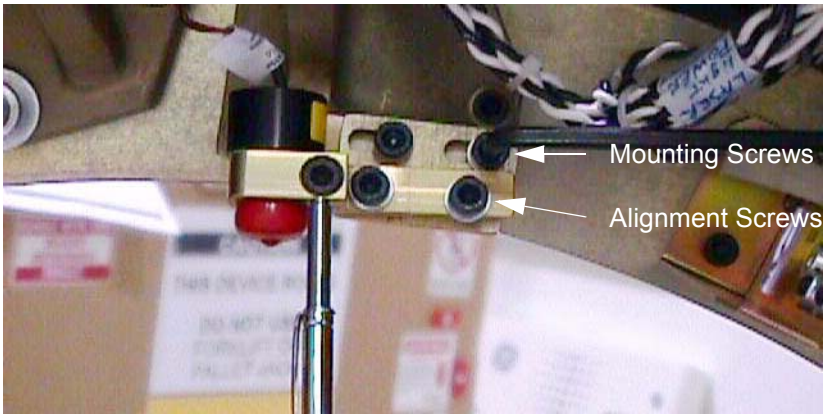


Figure 8-98 Laser Mount Assembly

3.9.2 Coronal Laser Assembly

1.) Move table to its lowest elevation.
2.) Remove right and back covers.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Disconnect the electrical connection to the defective laser assembly
5.) Loosen 2 hex screws holding laser assembly in place.
6.) Replace the defective laser assembly.
7.) Reconnect electrical connection to new laser assembly.
8.) Align laser light.
9.) Reassemble gantry.

3.9.3 Internal Laser Assembly

1.) Move table to its lowest elevation.
2.) Remove right and back covers.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Disconnect the electrical connection to the defective laser assembly
5.) Loosen 2 screws holding laser assembly in place.
6.) Replace the defective laser assembly.
7.) Reconnect electrical connection to new laser assembly.
8.) Align laser light.
9.) Reassemble gantry.

3.9.4 Sagittal/External Laser Mount)

1.) Move table to its lowest elevation.
2.) Remove right and back covers.
3.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
4.) Disconnect the electrical connection to the defective laser assembly
5.) Loosen 4 hex screws holding laser assembly in place.
6.) Replace the defective laser assembly.
7.) Reconnect electrical connection to new laser assembly.
8.) Align laser light.
9.) Reassemble gantry.

3.10 Cooling Fan

3.10.1 Cooling Fan - Left/Right

3.10.1.1 Required Tools

- 3mm hex key
- 1/2 hex socket cap.

3.10.1.2 Procedure Details

1.) Remove right and left covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.

3.) Unplug the cable connecting the fan to the rest of the assembly.
4.) Remove the four (4) 4mm cap screws.
5.) Remove the hex nut that fastens capacitor to the assembly.
6.) Replace fan and capacitor.
7.) Turn on all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
8.) Carefully depress fan cover switch and verify fan operation.

Note: Left fan is thermostatically controlled.

9.) Reassemble gantry.

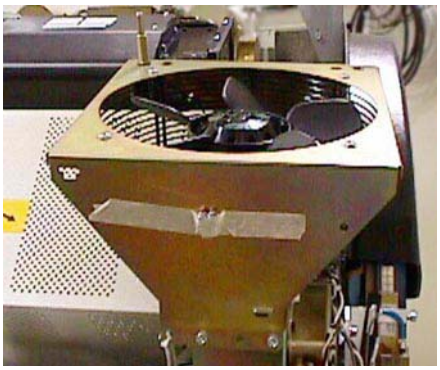


Figure 8-99 Fan Assembly

3.10.2 Fan Switch

3.10.2.1 Required Tools

5/16 socket

3.10.2.2 Procedure Details

1.) Remove rear cover and right side cover.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane. Follow Lockout/ Tagout procedures.

Note: The Plunger height is adjusted at factory.

3.) Remove two (2) nuts. Remove screws carefully to avoid dropping screws.
4.) Disconnect 2 connections (normally open and common).
5.) Replace switch and reassemble.
6.) Depress switch plunger and fan should start.

Note: Left fan is thermostatically controlled.

3.11 OBC

3.11.1 OBC Circuit Boards

- KV Board - 2143147
- MA Board - 2154834
- HEMRC Control Board - 2179860
- GENTRY I/O 46-288512G1
- ARTESYN III (CPU) - 2224296-3
- LSCOM Board - 2233488

3.11.1.1 Required Tools

- ESD wrist-band
- Flat-blade screwdriver
- Phillips #2 screwdriver, if replacing the Artesyn-III board

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

3.11.1.2 Procedure Details

1.) Remove the right gantry side cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Remove right top gantry cover.
4.) Position OBC at the 2:00 o'clock position
5.) Put on grounding wrist strap.
6.) Loosen the 8 captive screws, and remove the OBC Front Cover.

THE FOLLOWING PROCEDURE IS FOR THE ARTESYN-III BOARD:

1.) Unplug serial and ethernet cables.
2.) Loosen top and bottom fasteners with a Phillips #2 screwdriver.
3.) Pull Artesyn board out using black plastic tabs located on top and bottom of the board.
4.) Place the board in an Anti-Static bag.
5.) Install the new board.
6.) Install OBC Cover. Torque to 2 N-m (17.7 in-lbs).

THE FOLLOWING PROCEDURE IS FOR THE GENTRY I/O, HEMRC, KV, MA, AND LSCOM BOARDS.

1.) Remove the right gantry side cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Remove right top gantry cover.
4.) Position OBC at the 2:00 o'clock position
5.) Put on grounding wrist strap.
6.) Loosen the 8 captive screws, and remove the OBC Front Cover.
7.) Pull two latches to release the board.
8.) Place the board in an Anti-Static bag.
9.) Install the new board. Secure the newly installed board using the two latches.
10.) Install OBC Cover. Torque to 2 N-m (17.7 in-lbs).

3.11.2 OBC Power Supply

3.11.2.1 Required Tools

- Flat-blade screwdriver
- Phillips #2 screwdriver
- 3 mm, 5 mm Hex key sockets

3.11.2.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Position OBC at 3:00 o'clock.
5.) Remove the 4 mm cap screw and washer securing the front mounting bracket.
6.) Remove mounting bracket.
7.) Remove the 4 mm cap screws and washers that secure AC plastic shield.
8.) Remove plastic shield.
9.) Disconnect input/output (IO) wiring from power supply strips.
Write wiring down for reassembly.
10.) Remove (2) 6 mm cap screws and washers on rear gold mounting bracket.
11.) Remove power supply and gold bracket from OBC assembly.
12.) Remove (3) Phillips screws that secure mounting bracket to the power supply.
13.) Remove mounting bracket.
14.) Reassemble assembly in reverse order.
- Torque the 6 mm cap screws and washers to 7.9 N-m (5.8 ft-lbs).
- Torque the 4 mm cap screws to 2.3 N-m (20.35 in-lbs).
15.) Restore power and verify per adjustment procedure.
16.) Refer to "OBC Power Supplies," on page 570.

Figure 8-100 OBC Power Supply and Mounting Brackets

3.11.3 OBC Backplane

3.11.3.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 mm, 5 mm, 10 mm Hex key socket
- Loctite 242 (46-170686P2)

3.11.3.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position OBC at 2:00 o'clock.
6.) Engage gantry rotational lock.
7.) Remove 4 mm cap screws (including washers) at the front of the mounting bracket.
8.) Remove mounting bracket.
9.) Remove 4 mm cap screws that secure AC plastic shield.
10.) Remove plastic shield.
11.) Disconnect input/output (IO) wiring from power supply strips.
12.) Cut tie-wrap mounts as necessary.

Note: Pay close attention to routing of cables as you cut theses tie-wraps.

13.) Disconnect all power connections at OBC Power I/F board.
14.) Disconnect J11, J16, and J17 connectors from backplane.
15.) Cut any necessary tie-wraps.
16.) Remove all circuit boards.
17.) Remove (4) M12 cap screws securing chassis to rotating base casting.
18.) Carefully lift chassis off gantry.
19.) Place OBC on flat table back plane facing up.
20.) Remove (12) 4 mm cap screws securing backplane to the chassis.

⚠ **NOTICE** **This includes the flat and lock washer on each of the screws. These washers are important to the grounding integrity of the backplane.**

21.) Remove backplane.
22.) Install new backplane. Torque (12) 4 mm cap screws and washers to 2.3 N-m (20.35 in-lbs).
23.) Install Chassis on gantry. Apply Loctite 242, and torque (4) M12 cap screws to 66.4 N-m (49 ft-lbs).

Note: Make sure all harnesses are routed and secured in the same fashion prior to disassembly.

24.) Complete re-assembly.
25.) Torque 4 mm cap screws (dry) to 2.3 N-m (20.35 in-lbs).
26.) Torque 6 mm cap screws (dry) to 7.9 N-m (5.8 ft-lbs).
27.) Torque OBC Cover to 2 N-m (17.7 in-lbs).

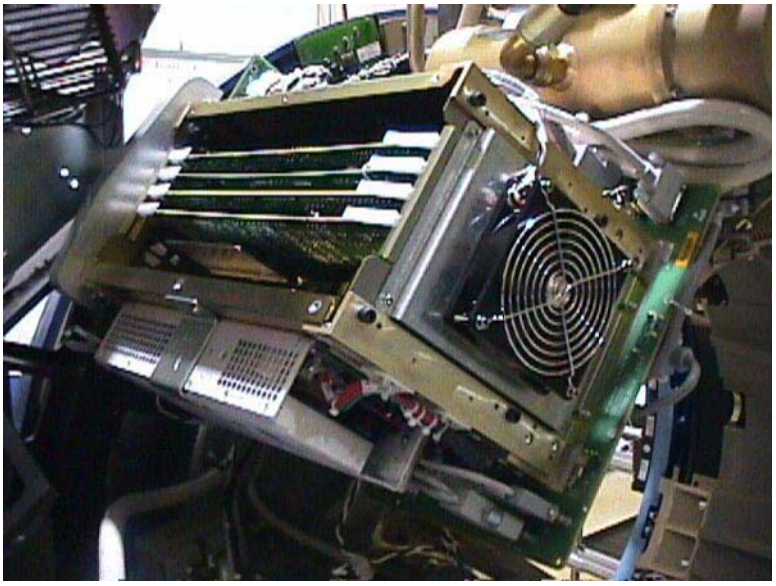


Figure 8-101 OBC Chassis at 10 O'Clock

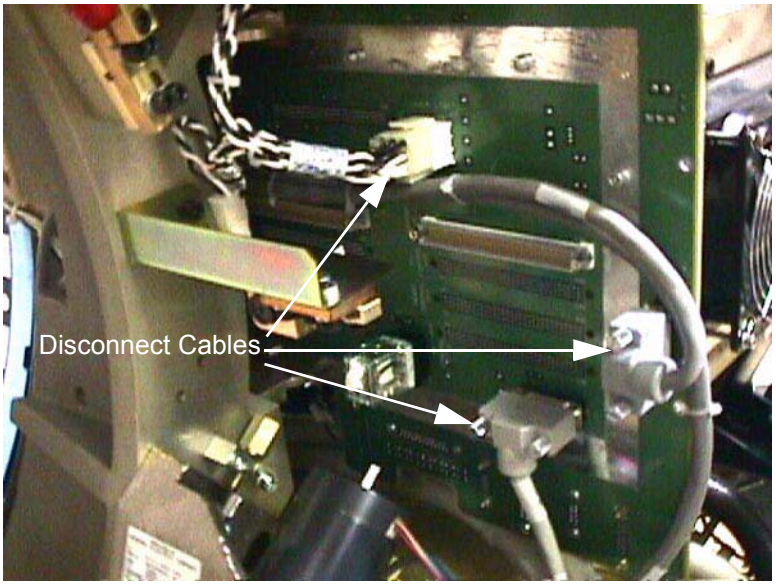


Figure 8-102 OBC Backplane Cabling

3.11.4 OBC Power I/F

3.11.4.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- Metric Hex Key Set

3.11.4.2 Procedure Details

1.) Remove all gantry covers. (Front cover removal is unnecessary for this procedure)
2.) Completely shutdown power. (A1, Lockout/Tagout)
3.) Position OBC at 3:00.
4.) Use to remove cap screws that secures AC plastic shield.
5.) Remove plastic shield.
6.) Remove fuse from fuse holder.
7.) Install new fuse.
8.) Reassemble assembly in reverse order.
9.) Restore power and verify per adjustment procedure.

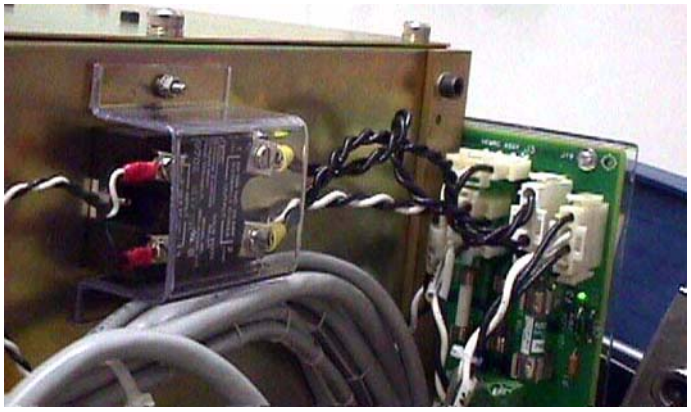


Figure 8-103 OBC Power I/F Board and Tube Fan Pump Relay

3.11.5 OBC Thermistor

3.11.5.1 Required Tools

- Flat-blade screwdriver
- 3 mm Hex key socket
- 3/16” open end wrench

3.11.5.2 Procedure Details

⚠ **DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Tilt Gantry forward to 30 Degrees. (For easier access)
4.) Turn **OFF** Axial Enable and HVDC on the STC backplane.
5.) Position OBC at 2 o’clock. (OBC boards will be removed).

6.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
7.) Remove OBC cover and all circuit boards.

NOTICE **Use proper ESD procedures when handling circuit boards.**

8.) Disconnect all OBC Power I/F connections.
9.) Remove the (4) 4 mm cap screws and washers securing the OBC Power I/F board.
10.) Remove the (3) 4 mm cap screws securing the CPU mounting bracket.
11.) Disconnect the thermistor harness from internal backplane J9.
12.) Cut tie-wraps and carefully unscrew the thermistor from the bracket.
13.) Install new thermistor and secure with very small tie-wraps.
14.) Install internal J9 backplane connector and mount cpu bracket with (3) 4 mm cap screws finger tight.
15.) Carefully insert LSCOM board and seat in backplane connectors. This will align the CPU bracket.
16.) Tighten the (3) 4 mm cap screws for the CPU bracket.
17.) Remove the LSCOM board.
18.) Install the OBC Power I/F board. Tighten (4) 4mm cap screws and washers.
19.) Complete OBC assembly.
20.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
21.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
22.) Perform hardware reset.
23.) Assemble gantry.
24.) No specific retest procedures.

3.11.6 OBC Ambient Thermistor (Tube Fan Pump Relay Control Harness)

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 MM. Hex Key

3.11.6.1 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Position OBC at 2:00 o'clock.
5.) Remove (2) 4 mm cap screws that secure safety cover over tube fan/pump and relay.
6.) Disconnect cable J15 on OBC backplane.
7.) Cut the 3 mounting tie-wraps.
8.) Disconnect the black and white wires from terminal 3 and 4. The terminal 3 wire is white and the terminal 4 wire is black.
9.) Remove harness.
10.) Remove J15 connector.
11.) Remove ambient thermistor assembly.
12.) Install new ambient thermistor assembly.

NOTICE **Make sure new thermistor is mounted in the same position as the original was mounted.**

3.11.7 OBC Fan

3.11.7.1 Required Tools

- Flat-blade screwdriver
- 3 mm Hex key socket

3.11.7.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Tilt Gantry backward to 30 Degrees. (For easier access)
4.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
5.) Position OBC at 2:00 o'clock.
6.) Engage gantry rotational lock.
7.) Disconnect Power Cord from Fan.
8.) Remove (4) 4 mm cap screws that fasten Fan and Grill in place.
9.) Transfer grill to new fan, if necessary, and install new Fan.
10.) Reassemble Gantry.
11.) Turn **ON** 120 Vac on the STC backplane. Verify Fan is operational.
12.) Assemble gantry.
13.) No specific retest procedures.

3.11.8 OBC Chassis Assembly

Reference 3.11.3 - OBC Backplane.

3.12 Thermostat Assembly

3.12.1 Required Tools

- Phillips #2
- Flathead
- 5 MM. hex key

3.12.2 Procedure Details

1.) Remove Left side cover.
2.) Remove 2 hex screws that secure assembly to gantry.
3.) Disconnect power from thermostat.
4.) Remove thermostat.
5.) Install new thermostat.

Note: When installing new thermostat, synchronize settings from old thermostat with new thermostat.

Figure 8-104 Gantry Ambient Temperature Fan Control Thermostat

3.13 Gantry Rotation Interference Touch Strip

1.) Remove side, top, and front covers.
2.) Turn off all 3 switches (Axial Drive, HVDC, 120VAC) on the STC backplane.
3.) Disconnect touch strip cable.
4.) Remove gantry rotation touch strip.
5.) Install new gantry rotation touch strip.

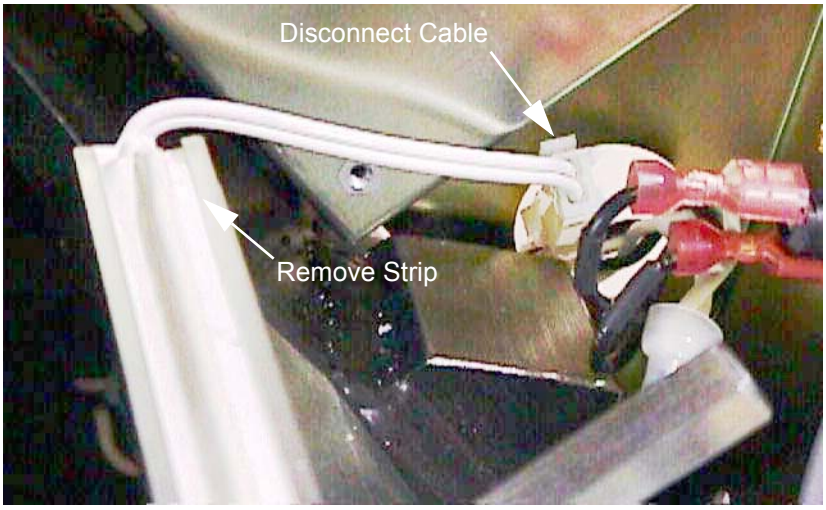


Figure 8-105 Gantry Rotation Interference Touch Strips

Section 4.0
Retest Matrix

4.1 System Scanning Test

Use the System Scanning Test to verify hardware functionality. Review images for visible artifacts, and review the message log for unacceptable errors.

1.) Place the QA phantom on the cradle.
- Drive the table to an elevation of 100.
- Align the reference line on the phantom with the internal laser lights.

NOTICE
Avoid Detector Damage

Never scan above 50 mA without first placing a phantom in the field of view. Levels in excess of 50 mA can cause temporary radiation damage to the detector that lasts several hours. If you acquire image series cals with a radiation damaged detector, the cals may cause artifacts in subsequent image series scans.

2.) Manually select the scan parameters in Table 8-29.

Scan Type	kV	mA	SFOV	Thickness	Scan Time	Start Location	End Location	Tilt/Pitch
Scout	120	40	-	-	-	S200	I800	0°, HQ
Scout	120	40	-	-	-	S200	I800	90°, HS
Cine	120	50	Large	4x5	30sec	S0	S0	1.0, HQ
Axial	120	50	Large	4x5	1.0sec	S0	S0	I30, HS
Axial	120	50	Large	4x1.25	1.0sec	S0	S0	S30, HQ
Helical	120	50	Large	4x1.25	30sec	S70	I75	HS

Table 8-29 System Scanning Test scan parameters

3.) Complete the scans.

4.2 OBC Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

OBC SYSTEM COMPONENT	TASK	VERIFICATION TESTS
Artesyn III (CPU) board	Replacement, "OBC Circuit Boards," on page 651.	Successful Hardware reset. System Scanning Test on page 660.
LSCOM board	Replacement, "OBC Circuit Boards," on page 651.	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/ 40mA, 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/ 40mA., 30 sec. Scan) 5.) Acquire 10 axial scans: (120kV/400mA., 4 sec. Scan) 6.) Verify NO increase in Link errors
Gentry I/O board	Replacement, "OBC Circuit Boards," on page 651.	1.) Verify mA meter 2.) Verify kV meter 3.) kV and mA verification 4.) Exposure time accuracy 5.) System Scanning Test, see page 660. 6.) X-Ray Functional Test
OBC Backplane	Replacement, "OBC Backplane," on page 653. Check empty chassis power supplies, all slots "OBC Power Supplies," on page 570.	1.) Verify mA meter 2.) Verify kV meter 3.) Auto mA Cal 4.) System Scanning Test, see page 660.
OBC Thermistor	Replacement, "OBC Thermistor," on page 656.	None
OBC Fan	Replacement, "OBC Fan," on page 658.	None
OBC Ambient Thermistor	Replacement, "OBC Ambient Thermistor (Tube Fan Pump Relay Control Harness)," on page 657.	None

Table 8-30 OBC Component Retest Matrix

4.3 STC Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

COMMUNICATION FRU	TASK	VERIFICATION TEST
Artesyn CPU Board	Replacement, "STC Boards," on page 629	System Scanning Test on page 660.
LSCOM	Replacement, "STC Boards," on page 629, to replace LSCOM in OBC refer to "OBC Circuit Boards," on page 651.	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/ 40mA., 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/ 40mA., 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA., 4 sec. Scan) 6.) Verify NO increase in Link errors
Axial Board	Replacement, "STC Boards," on page 629	Exposure time accuracy and System Scanning Test on page 660.
STC Backplane	Check empty chassis power supplies – all slots.	System Scanning Test on page 660.

Table 8-31 Retest Matrix for LSCOM Communication FRU

4.4 Slip Ring Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

COMMUNICATION FRU	TASK	VERIFICATION TEST
Slip Ring Assembly	Replacement "Slipring Platter," on page 631.	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/ 40mA., 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/40mA., 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA., 4 sec. Scan) 6.) Verify NO increase in LSCOM errors. 7.) Verify NO increase in corrected or uncorrected FEC errors
Brush Tips and Brush Block	Replacement and Alignment, "Slipring Brush Block," on page 638.	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/ 40mA., 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/40mA., 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA., 4 sec. Scan) 6.) Verify NO increase in LSCOM errors.

Table 8-32 Retest Matrix for Slipring Components

COMMUNICATION FRU	TASK	VERIFICATION TEST
HSDCD Electronics (Transmitter or Receiver)	Replacement, "Slipring Transmitter," on page 637, to replace HSDCD receiver refer to page "Slipring Receiver," on page 636.	1.) Hardware Reset 2.) Acquire 10 scouts: (120kV/ 40mA., 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/40mA., 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA., 4 sec. Scan) 6.) Verify NO increase in corrected or uncorrected FEC errors 7.) Reset DIP Stats: Perform the following procedure to reset cumulative DIP Stats (shown on the Common Service Desktop Home Page): a.) Open a Unix shell. b.) Type: **cd /usr/g/service/log** c.) Type: **mv dip.stats dip.stats.old** d.) Shutdown and restart the system. This will reinitialize the dip.stats file. Save System State.

Table 8-32 Retest Matrix for Slipring Components

4.5 Intercom Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

GANTRY FRU	TASK	VERIFICATION TEST
Microphone	Replacement, "Breathing Light Assembly," on page 647.	Verify patient can be heard at the console.
Intercom Board	Replacement, "Intercom Board," on page 648.	Play canned AUTOVOICE messages.

Table 8-33 Retest Matrix for Gantry Intercom Components

4.6 Axial Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

GANTRY FRU	TASK	VERIFICATION TEST
Axial Motor Drive	Replacement, "Axial Drive Module," on page 623.	Axial Control Functional, page 573. System Scanning Test, page 660.
Drive Belt	Replacement, "H2 Belt Removal and Installation," on page 627. To set C-Pulse, Axial Home Flag physical position, "Resetting the C-Pulse," on page 574.	Run Microphonics, a test under DAS Tools, found under Trouble Shoot. System Scanning Test, page 660.
Axial Encoder	Replacement, "Axial Encoder Assembly," on page 627. Adjustment, "Resetting the C-Pulse," on page 574.	Axial Encoder Check, page 573. Axial Control Functional, page 573. System Scanning Test, page 660.
Home Flag	Replacement, "Home Flag and Sensor Board Assembly," on page 626. To set C-Pulse, Axial Home Flag physical position refer to "Resetting the C-Pulse," on page 574.	Axial Home Flag Check, page 573.
Axial Brake	Replacement, "Axial Drive Holding Brake," on page 624. Axial Brake check. on "Axial Brake Check," on page 573.	Axial Brake Check, page 573. Exercise alignment lights, and acquire several 1 second scans.
Axial Dynamic Brake Module	To verify gantry does not coast to a stop.	Perform one (1) 0.5 sec scan. Verify gantry stops in less than 10 seconds. Axial Control Functional, page 573.

Table 8-34 Retest Matrix for Gantry Axial Drive Components

4.7 Power Components Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
DAS DC Power Supply (+12 V)	Measure unloaded and loaded voltages, "DAS Power Supplies (2225212-2 ±5 vdc, 2225217 (2) 12 vdc)," on page 572.	System Scanning Test, page 660.
Collimator/ Detector Power Supply	Measure unloaded and loaded voltages, "Collimator/Detector Heater Power Supply," on page 740.	System Scanning Test, page 660 DAS Tools – Aux channel test to confirm 34 degrees C.
STC DC Power Supply +5 volt	Replacement, "STC Power Supply," on page 630. Measure unloaded and loaded voltages "STC Power Supplies," on page 568.	System Scanning Test, page 660.
OBC DC Power Supply (+5 volt,± 15 volt, +24 volt)	Replacement, "OBC Power Supply," on page 652. Measure unloaded and loaded voltages. "OBC Power Supplies," on page 570.	System Scanning Test, page 660.

Table 8-35 Retest Matrix for Gantry Power Supplies

4.8 Tilt Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Hydraulic Tilt Assembly	Replacement, "Hydraulic Tilt Motor Assembly Replacement," on page 640. Adjustment, "Tilt Speed Adjustment Procedure," on page 579. Fluid level check, "Hydraulic Fluid Check and Fill Procedure," on page 580	Verify full range of tilt operation.
Tilt Relay bd	Replacement, "Tilt Relay Board," on page 639.	Verify full range of tilt operation.
Tilt Pot	Replacement, "Tilt Potentiometer Procedure Details," on page 645. Tilt Characterization, "Mechanical Characterization - Gantry Tilt," on page 581.	Verify full range of tilt operation.
Tilt switches	Replacement, "Tilt Interference and Limit Switches," on page 646. Adjustment, "Tilt Limit/Interference Adjustments," on page 576.	Verify full range of tilt operation.

Table 8-36 Retest Matrix for Gantry Tilt Components

4.9 Laser Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Laser Lights	Replacement, "Laser Lights," on page 649. Adjustment, "Alignment Light Adjustment Procedure," on page 582.	Verify Laser, "Alignment Lights Visual Checks," on page 581.

Table 8-37 Retest Matrix for Gantry Components

4.10 Display Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Gantry Display Assembly	Replacement, "Display Assembly," on page 646.	Verify self test and counts change for table up/down, in/out and gantry tilt.
Breathing Lights	Replacement, "Breathing Light Assembly," on page 647.	Verify patient can be heard at the console. Test using Breath Display button on gantry control panel.

Table 8-38 Retest Matrix for Gantry Components

4.11 Safety Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Axial Enable Interlock	Replacement, "STC Backplane," on page 629.	Test Axial Enable by exercising alignment lights. They won't come on if axial functions are inoperable.

Table 8-39 Retest Matrix for Gantry Components

4.12 Gantry Miscellaneous Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Mylar Window	To replace, see "Scan Window," on page 620.	Perform (10) slices at 10mm aperture.

Table 8-40 Retest Matrix for Gantry Components

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GE Healthcare

LightSpeed 2.X

Service Manual - General

OPERATING DOCUMENTATION

2243314-100
Rev 22

Book 5 of 6:

- Chapter 9 (X-Ray Generation)
- Chapter 10 (PDU)

Pages # - 850

Effectivity

The information in this manual applies to the following GE Healthcare LightSpeed 2.X CT Scanners:

- LightSpeed Plus (SDAS)
- LightSpeed QX/i (SDAS)

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Chapter 9
X-Ray Generation

Section 1.0
General Lightspeed Plus

The High Voltage subsystem for the Lightspeed Plus is the same basic subsystem introduced in the HSA product line. The High Voltage subsystem has undergone several quality improvements throughout the CT product development. This evolution is HSA, HSARP, CTI, Lightspeed families.

The Theory Section has been provided basically intact as its basic content is unchanged. Please note that references to older style boards are still true with the current configuration. Specific items—such as legacy specific tables, screens or examples—have been removed.

The Lightspeed Plus supports the following OBC (On Board Controller) circuit boards:

- KV Board - 2143147
- MA Board - 2154834
- HEMRC Control Board - 2179860
- GENTRY I/O 46-288512G1
- ARTESYN III (CPU) - 2224296-3
- LSCOM Board - 2233488

Section 2.0
Theory

2.1 kV Troubleshooting Theory

2.1.1 Reported vs. Actual Tube kV

The kV (and mA) reported to the software, which includes the reported kV to the console, does not have to be what is actually across the x-ray tube. The kV reported to the software does not have to be what is seen by the bleeder.

Reported kV comes from the Anode and Cathode kV Test points on the kV Control Bd. Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from “SELECTED VALUE” (± 2.999%). This is the node that the loop uses to regulate. Because the gain of the electronic monitoring devices between the x-ray tube and this test point may not be 1, the kV reported here **IS NOT THE ACTUAL kV SEEN ACROSS THE X-RAY TUBE.** It is what the system **THINKS** is the actual tube voltage. The purpose of kV gain adjustment is to get a gain of one between x-ray tube and TP10.

Note: It is uncommon, but possible to get the kV gain pots out of adjustment as much as ± 15kV.

The purpose of the kV Feedback Gain Pot is to ensure a gain of one in the feedback circuit. A gain of one will ensure that the voltage across the x-ray tube (and bleeder) is what gets reported to the kV Feedback Test Point. The closed loop regulates to these test points, if these test points are wrong the system will change inverter current to compensate for the wrong kV.

Improperly adjusted kV Gain Pots can result in the kV being off as much as ±30kV total from what the system (software) thinks is across the tube. This means that the system is cooling for 120kV, and actual kV across the tube can be as high as 150kV. Tube life would be very low with this scenario.

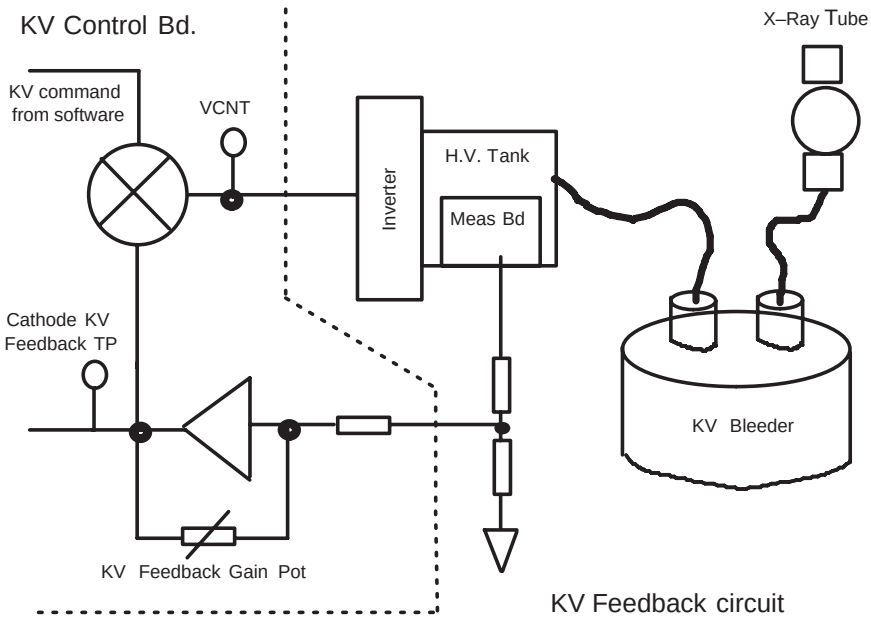

Figure 9-1 Why Reported kV may not be the Actual kV Across the Tube

EXAMPLE: kV Feedback Gain Pot is adjusted for a gain of.90. A kV command of 100 kV is received (50kV anode, 50kV cathode). With 50kV across kV Bleeder (as read with the scope), and a gain of 0.90 the kV Test Point will only see 45kV. The error mux will command a higher inverter current until kV Test Point is 50kV. HOWEVER the kV across the bleeder (x-ray tube) is really 55.5kV.

Tweaking the kV Gain Pot for a gain closer to one will cause the error mux to reduce the inverter current, therefore compensating for the kV Test Point. The kV Gain Pots are adjusted correctly when the kV across the bleeder is the same as the kV Test Points.

2.1.2 kV Gain Pot Adjustment

2.1.2.1 Purpose of This Information

To reinforce that the kV feedback test points DO NOT reflect actual kV across the tube. The purpose of the kV gain pot is to ensure that there is a gain of 1 (one) between the tube kV measurement (meas bd) and tube kV reporting (kV test points.)

The reason that kV test points (on a normally operating system) will never be different than commanded, is that this is the node the closed loop uses to regulate the kV. If this test point is wrong the system will change inverter current to compensate. It takes milliseconds to do this, therefore it looks like these test points never change.

Another reason for this documentation is to emphasize how far off the kV gain pots can be adjusted and the system still think that the kV across the tube is what the cooling algorithm thinks it is.

2.1.2.2 Definitions

Definitions for columns labelled in Table 9-1:

Turns cw - The kV gain pot was turned fully ccw, then turned clockwise one turn at a time.

Bleeder - kV bleeder installed in system. This is actual kV across the tube.

Kvan and Kvca - anode and cathode test points on the kV control board.

Note: One turn cw (from fully ccw) will bring the gain closer to one, resulting in the bleeder voltage come up closer to the test point. This is true up until 15 turns when the gain is less than one. Now the actual kV across the tube is GREATER THAN the test points (measurement gain less than one).

2.1.2.3 Summary

A properly adjusted kV gain pot should be in the neighborhood of about 15 turns.

Example: kV FEEDBACK POT Values

ANODE			CATHODE		
FULLY CCW (starting pt)			FULLY CCW (starting pt)		
TURNS CW	BLEEDER	KVAN	TURNS CW	BLEEDER	KVCA
2	44.854	5.9823	2	45.036	6.0004
3	45.751	5.9095	3	45.438	6.0192
4	47.008	5.9711	4	46.473	6.0306
5	48.266	5.9639	5	47.47	6.0232
6	49.543	5.9631	6	48.576	6.0274
7	50.614	5.9601	7	49.731	6.0244
8	51.613	5.9493	8	50.84	6.0235
9	52.615	5.9554	9	51.835	6.0238
10	53.705	5.9445	10	52.749	6.0327
11	54.883	5.9449	11	54.065	6.0235
12	56.103	5.9442	12	55.337	6.0241
13	57.32	5.9361	13	56.49	6.0225
14	58.315	5.9324	14	57.861	6.0207
15	59.532	5.931	15	58.917	6.0309
16	60.527	5.9238	16	60.06	6.0192
17	60.763	5.9081	17	61.354	6.0263
18	62.041	5.9359	18	62.695	6.0324
19	63.041	5.9328	19	63.68	6.0213
20	64.108	5.9361	20	65.114	6.0253
21	65.136	5.9479	21	66.429	6.0213
22	66.118	5.955	22	67.334	6.0327
23	67.122	5.9636	23	68.731	6.0293
24	68.134	5.9706	24	69.827	6.0303
25	69.164	5.986	25	70.917	6.0238
26	70.081	5.9981	26	71.974	6.0275
27	71.157	5.9385	27	73.147	6.0297
28	72.092	5.9854	28	74.256	6.0235
29	73.171	5.9808	29	74.961	6.0241
30	74.155	5.9801	30	75.041	6.0244

Table 9-1 Typical kV Feedback Pot Values

2.1.3 SW & HW Tools Available for Troubleshooting

2.1.3.1 Diagnostics

kV & mA (X-Ray) Results Screen on the Troubleshoot menu is the ****Primary tool** for kV related problems other than Overcurrents or Shoot-thrus. Overcurrents or Shoot-thrus will terminate scans, resulting in no data collection also OBC BLDs

2.1.3.2 Schematics

Direction 2243317

- kV Control Bd. (Newer Style Bd.) Schematics 2143147SCH
- kV Inverter Gate Driver Bd. Schematics 46-264662-S
- kV Inverter Capacitor Bd. and Schematics 46-264664-S
- OBC Backplane list
- Gantry Rotating Member Block Diagram
- Gantry_Rotating_Interconnect
- X-Ray Tube 120 Vac

Equipment Needed

- Bleeder
- Bleeder/O'Scope combination can cause aliasing with the bleeder kV signal, resulting in kV ripple as high as 20kV.
- Multi-meter
- Oscilloscope

2.1.4 Explanation of kV/mA Results Screen

This is an example of a results screen from a 120kV, 200mA, 10 second scan. (This example is from a "**newer style**"—i.e., 46-321198—kV Control board, with 550vdc DCRGS.)

HIGH VOLTAGE STATUS				
NO.	DEVICE	AVERAGE VALUE	SELECTED VALUE	LAST SAMPLE
1.	Total kV:	119.4 kV	120.0 kV	119.4 kV
2.	Cathode kV:	59.7 kV	60.0 kV	59.7 kV
3.	Anode kV:	60.1 kV	60.0 kV	60.1 kV
4.	Cathode mA:	193.7 mA	200 mA	193.7 mA
5.	Anode mA:	193.7 mA	200 mA	193.7 mA
6.	Cathode inverter current:	30.7 A	–	30.7 A
7.	Anode inverter current:	30.7 A	–	30.7 A
8.	Approx. kV inverter frequency(VCNT):		(1.6V)	xx.x KHz
9.	Cathode inverter duty cycle:	100%	–	100%
10.	Anode inverter duty cycle:	83%	–	83%
11.	Rail voltage:	540 V	550 V	540 V
12.	Exposure duration:	–	10000 mS	10001 mA
13.	Exposure number:	–	1	1

Table 9-2 kV/mA Results Screen - 46-321198 kV Control bd.

Definitions of Column Headings:

AVERAGE VALUE: The average taken over the duration of the scan (see Exposure Duration).

SELECTED VALUE: The value prescribed by the user, or the value required to perform the scan.

LAST SAMPLE: The last value read during an ACTIVE exposure.

1. Total kV Explanation:	119.4kV	120.0kV	119.4kV

On the 46-321198G1-F board this signal comes from TP11. It is an op-amp sum of Anode kV (TP9) and Cathode kV (TP10). Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from "SELECTED VALUE" (± 2.999%). **DO NOT TROUBLESHOOT "Total kV" low** (or high). Instead troubleshoot either the anode or the cathode being low (or high), they are the inputs to this value.

"Total kV" gets reported to the software through the Gentry I/O and OBC Backplane.

2. Cathode kV Explanation:	59.7kV	60.0kV	59.7kV

On the 46-321198G1-F board this signal comes from TP10. Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from "SELECTED VALUE" (± 2.999%). This is the node that the loop uses to regulate. Because the gain of the electronic monitoring devices between the x-ray tube and this test point may not be 1, the kV reported here **IS NOT THE ACTUAL kV SEEN ACROSS THE X-RAY TUBE.** It is what the system **THINKS** is the actual tube voltage. The purpose of kV gain adjustment is to get a gain of one between x-ray tube and TP10.

Note: It is uncommon, but possible to get the kV gain pots out of adjustment as much as ± 15kV.

Inverter current is commanded by (VCNT). Compare these three readings (cathode kV, Cathode inverter current and (VCNT)) and troubleshoot. Nominal values are attached.

3. Anode kV Explanation	60.1kV	60.0kV	60.1kV

On the 46-321198G1-F board this signal comes from TP9. Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from "SELECTED VALUE" (± 2.999%). This is the node that the loop uses to regulate. Because the gain of the electronic monitoring devices between the x-ray tube and this test point may not be 1, the kV reported here **IS NOT THE ACTUAL kV SEEN ACROSS THE X-RAY TUBE.** It is what the system **THINKS** is the actual tube voltage. The purpose of kV gain adjustment is to get a gain of one between x-ray tube and TP9.

Note: It is uncommon, but possible to get the kV gain pots out of adjustment as much as ± 15kV.

Inverter current is commanded by (VCNT). Compare these three readings (Anode kV, Anode inverter current and (VCNT)) and troubleshoot. Nominal values are attached.

4. Cathode mA Explanation:	193.7mA	200.0mA	193.7mA

This value comes from the mA Control Bd. 2154834 TP4, through the backplane and Gentry I/O bd. Since the cathode is in series with the anode, TP4 should be the same value as the anode mA. The scale is 1v/100mA.

In closed loop mode TP4 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP4 is actually the cathode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Cathode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

If cathode and anode mA are different, suspect mA measurement electronics (use mA Meter Test), or suspect a shattered x-ray tube insert shorting out the filament (cathode) or the anode.

5. Anode mA Explanation 193.7mA 200.0mA 193.7mA

This value comes from the mA Control Bd. 2154834 TP10, through the backplane and Gentry I/O bd. Since the anode is in series with the cathode, TP10 should be the same value as the cathode mA. The scale is 1v/100mA.

In closed loop mode TP10 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP10 is actually the anode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Anode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

6. Cathode Inverter Current Explanation: 30.7A – 30.7A

This value comes from the kV Control Bd. 46-321198G1-F TP21, through the backplane and Gentry I/O bd. The scaling is 25A/volt. Values over 8 amps will result in an overcurrent error. Locate the “OVERCURRENT” toroid/transformer. This toroid monitors the current leaving the inverter and going to the tank primary.

7. Anode Inverter Current Explanation: 30.7A – 30.7A

This value comes from the kV Control Bd. 46-321198G1-F TP20, through the backplane and Gentry I/O bd. The scaling is 25A/volt. Values over 8 amps will result in an overcurrent error. Locate the “OVERCURRENT” toroid/transformer. This toroid monitors the current leaving the inverter and going to the tank primary.

8. Approx. kV Inverter Frequency (VCNT) Explanation: (1.60V) xx.xKHz

This value comes from the kV Control Bd. 46-321198G1-F TP24, through the backplane and Gentry I/O bd. This is the input voltage to the voltage controlled oscillator. the operating range is from 0-5v, which will give a frequency range of 19.5khz to 31.5khz.

A (VCNT) of 0.2v is a command for a lower frequency, a lower frequency will allow more current through the primary resulting in more kV output. To summarize, a (VCNT) 0f 0.2v is max current command, should have max inverter current, should have max kV.

A (VCNT) of 5v (or more) is a command for a higher frequency, a higher frequency will allow less current through the primary resulting in less kV output. To summarize, a (VCNT) 0f 4.99v is min current command, should have min inverter current, should have min kV.

(VCNT) is an composite signal generated from the difference between kV command and kV feedback. This error signal is also an input into (VCNT).

Compare these three readings (cathode kV, Cathode inverter current and (VCNT)) and troubleshoot. Nominal values are attached.

9. Cathode Inverter Duty Cycle Explanation: 100% – 100%

This value comes from the kV Control Bd. 46-321198G1-F TP23, through the backplane and Gentry I/O bd. The system uses duty cycle to regulate at the lower mAs more than it uses frequency. At the higher mAs the system uses frequency to regulate more than it uses duty cycle. Compare the cathode duty cycle to the anode duty cycle.

10. Anode Inverter Duty Cycle Explanation:	**83%**	**–**	**83%**

This value comes from the kV Control Bd. 46-321198G1-F TP22, through the backplane and Gentry I/O bd. The system uses duty cycle to regulate at the lower mAs more than it uses frequency. At the higher mAs the system uses frequency to regulate more than it uses duty cycle. Compare the cathode duty cycle to the anode duty cycle.

Note: The following statement is only true for the older KV board 46-321064G1 and inverters tuned to 19.1 Khz and 18.6 Khz. The anode duty cycle should never reach 100% and rarely gets past 95%. At 95% and at a max (VCNT) command, the system is out of energy, therefore you should only see these percentages at 140kv, 340ma. When the system is out of energy, the kv will start caving in. Also at mAs higher than 100ma, the anode duty cycle should never exceed the cathode duty cycle.

IF THIS SCENARIO HAPPENS, the system is running out of energy. Most likely due to an IGBT not firing.

FOR KV BOARDS OTHER THAN 46-321064G1: The duty cycle can achieve 100% on either the cathode or anode inverter. This should be considered normal operation for the new inverters.

Exposure Duration, Number, and Status Register Explanation:			
Exposure duration:	–	10000mS	10001mS
Exposure number:	–	1	1
Status register (Address = FFCFF9H):		–	8FH

2.1.5 Tube Spit Explanation

2.1.5.1 How does the system determine when a tube spit happens?

When a fast fall time is detected on the kV waveshape.

Tubes spit all of the time. A pessimist might even say that if a tube doesn't spit, there is something wrong with it. The question is, "When do we stop scanning because of tube spits?" The answer is, "when spits affect image quality or could cause equipment damage."

The kV Control Bd. monitors the kV via the kV feedback test points. A tube spit will cause the kV drop at a very fast rate. An integrator circuit on the kV Control Bd. monitors the kV feedback, whenever this integrator detects this fast fall time (an integrator has little impedance to fast frequencies), it is considered a tube spit. The kV Control Bd. will then turn off x-rays for approximately 100ms to allow the x-ray tube to recover.

2.1.5.2 Why is scanning stopped after 32 spits have been detected?

The answer is image quality.

It has been determined that more than 32 spits per scan second may affect image quality, therefore the system will stop scanning when the system has counted more than 32 spits per scan second.

On the older style kV Control Bd. (46-321064), scanning will abort when 32 spits occur in a rolling 1 second window, for a net rate of 27.1 to 40.7 spits/sec.

On the newer style kV Control Bd. (2143147), scanning will abort when 9 spits occur in a rolling 0.26 second window for a net rate of 34.3 spits/sec.

Overcurrents and Shoot-Thrus protect the system against damage. Spit detection is not used to protect the system against damage.

2.1.6 Bleeder Ripple/Oscilloscope Aliasing

The current bleeder in use today was designed for line frequency type generators and has a band width of 720hz. The high voltage subsystem operates at approximately 19.khz to 31khz. The problem is, if you connect a scope probe directly to the bleeder, it has a tendency to amplify high frequency ripple. The bleeder requires the cable capacitance to roll off the high end properly. Also, there are actually a couple different bleeders out there under the same model #. They were never

intended to deal with signals above 720 Hz (for line frequency machines). As a result the high frequency response is unreliable.

This is not to say avoid using the present bleeder for measuring high voltage. The Bleeder is what GE Healthcare uses for measuring high volt. HOWEVER when using the bleeder it is very difficult determine what is real ripple and what is aliasing.

Refer to the waveshape in Section 2.1.7, on page 688 for examples of normal bleeder waveshapes.

2.1.7 kV Reference Material

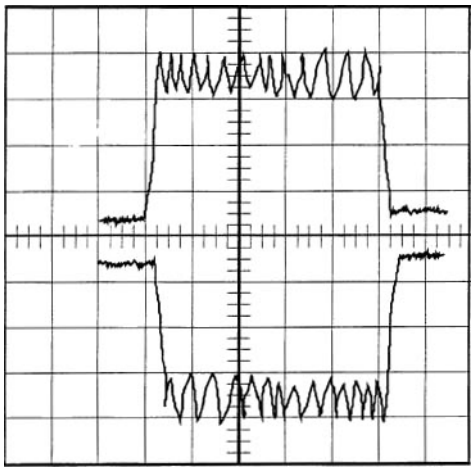

Figure 9-2 kV Ripple @ 0.2 second scope trace

- A:20V=0.2S B:20V=0.2S
- 140KV 340ma Bleeder (slow sweep)
- This is a normal picture.

This is a good example of the scope aliasing the inverter ripple. NOTE: that the ripple can be as high as 20kV per side. Although aliasing will indicate something at higher frequencies, it is not a true waveform.

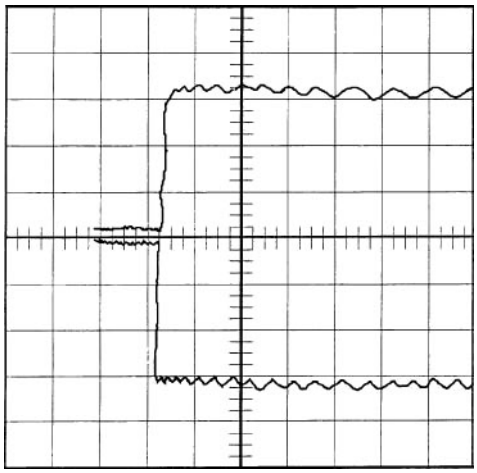

Figure 9-3 kV Ripple @ 0.1 second scope trace

- A:20V=0.1S B:20V=0.1S
- 140KV 340ma Bleeder (slow sweep)
- This is a normal picture.

This is a good example of the scope aliasing the inverter ripple. This picture is the same picture as is in the previous section, the only difference is the scope time base. NOTE: that the ripple can be as high as 20kV per side. Although aliasing will indicate some thing at higher frequencies, it is not a true waveform.

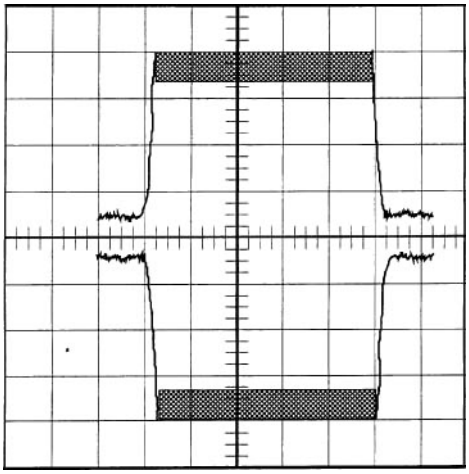

Figure 9-4 kV Ripple @ 0.2 sec. scope trace w/scope in “peak or “envelope” mode

- A:20V=0.2S B:20V=0.2S
- 140KV 340ma Bleeder (slow sweep)
- This is a normal picture, w/scope in “peak” or “envelope” mode.

This is a good example of the scope aliasing the inverter ripple. NOTE: that the ripple can be as high as 20kV per side. Although aliasing will indicate something at higher frequencies, it is not a true waveform.

RESULTS SCREEN VALUES FOR:

kV Control Bd. (2143147)

- with a Compact PDU (unregulated HVDC)
- with an PERFORMIX tube
- at Nominal Line Voltage

MA	TOTAL KV	CATHODE KV	ANODE KV	ANODE MA	CATHODE INV I	ANODE INV I	VCNT V	CATHODE % DUTY	ANODE % DUTY	HVDC
10	79.8	40	39.9	9.4	2.25	2.075	4.16	20	18	669
20	79.9	39.9	39.9	18.8	3.85	3.675	3.83	32	29	665
40	79.8	39.9	39.9	37.8	6.95	6.6	3.58	40	37	661
100	79.8	39.9	39.9	94.2	16.05	15.075	3.3	50	47	651
200	79.9	39.7	39.8	188.1	31.8	29.85	2.73	73	65	644
300	79.7	39.9	39.8	282.3	47.625	44.625	2.02	100	90	637
350	80.1	40	40.1	328.4	55.5	55.2	1.69	100	86	633
400	80.3	39.4	40.5	373.8	63.075	59.4	1.48	100	90	630

Table 9-3 kV Control Board (2143147) Values w/Nominal Line Voltage @ 80kV

MA	TOTAL KV	CATHODE KV	ANODE KV	ANODE MA	CATHODE INV I	ANODE INV I	VCNT V	CATHODE % DUTY	ANODE % DUTY	HVDC
10	99.8	49.9	49.8	9.4	2.325	2.2	4.06	24	21	671
20	99.8	49.9	49.9	18.7	4.025	3.85	3.68	37	33	666
40	99.7	49.9	49.9	37.7	7.075	6.725	3.44	45	42	659
100	99.8	49.8	49.9	94	16.125	15.074	3.08	58	56	650
200	99.6	49.6	50	187.5	31.8	29.925	2.55	78	70	642
300	99.7	49.5	50.2	281.2	47.675	44.7	1.84	100	86	634
350	99.5	50	50.2	327.1	55.675	51.95	1.55	100	90	630
400	99.5	49.8	50	373.2	63.3	59.35	1.35	100	93	624

Table 9-4 kV Control Board (2143147) Values w/Nominal Line Voltage @ 100kV

MA	TOTAL KV	CATHODE KV	ANODE KV	ANODE MA	CATHODE INV I	ANODE INV I	VCNT V	CATHODE % DUTY	ANODE % DUTY	HVDC
10	119.8	59.9	59.8	9.3	2.45	2.325	3.93	28	25	668
20	119.7	59.8	59.9	18.5	4.275	3.975	3.54	44	37	664
40	119.7	59.9	59.8	37.6	7.275	6.85	3.25	52	49	655
100	119.7	59.8	59.7	93.7	16.25	15.15	2.85	66	64	646
200	119.7	59.6	59.8	187.2	32	29.85	2.35	86	78	638
300	119.7	59.3	60.3	280.6	47.8	44.8	1.56	100	90	629
350	119.7	59.9	60.5	327.6	55.8	52.025	1.32	100	97	623
400	118.8	60.2	60.1	372.3	63.175	59.35	1.16	100	99	619

Table 9-5 kV Control Board (2143147) Values w/Nominal Line Voltage @ 120kV

MA	TOTAL KV	CATHODE KV	ANODE KV	ANODE MA	CATHODE INV I	ANODE INV I	VCNT V	CATHODE % DUTY	ANODE % DUTY	HVDC
10	139.6	69.9	69.7	9	2.575	2.325	3.82	32	30	667
20	139.5	69.8	69.6	18.2	4.325	3.975	3.37	53	42	662
40	139.6	69.9	69.7	37.5	7.45	6.9	3.04	59	57	651
100	139.7	70	69.7	93.5	16.3	15.075	2.58	74	73	644
200	139.6	69.7	69.8	186.5	32	28.925	2.01	97	88	635
300	139.6	69.1	69.6	280.2	47.8	44.75	1.27	100	96	623
340	139.6	69.6	70.1	316.5	54.1	50.3	1.1	100	100	620
XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Table 9-6 kV Control Board (2143147) Values w/Nominal Line Voltage @ 140kV

2.2 mA Troubleshooting Theory

2.2.1 mA Loop Theory

2.2.2 mA Meter Verification Theory

The purpose of mA Meter Verification is to ensure that the mA Measurement Electronics has a gain of one between actual tube current and reporting to the firmware. This firmware value would then be reported to the console.

The method outlined in various GE Healthcare documents is to install an ISO compliant, calibrated ammeter across two test points. This meter effectively shorts out a 680ohm resistor. The next step is to install a 62ohm resistor from one side of the ammeter to the mA test point (TP5) on the measurement Bd.

TP5 is a voltage representation of tube current. This voltage is fed to the mA Control Bd. in the OBC and the resultant mA is fed to the firmware and can be read from a mA test point. This is where the gain of one is needed, between the Measurement Bd. TP5 and the mA Control Bd. mA Test Point.

When ACCEPT is touched on the console screen and after a time delay Q1 is turned on (+)15vdc (0r -15vdc) is applied through the ammeter (not the shorted out 680ohm resistor), through the 68ohm resistor to TP5. 15vdc over 62ohm comes out to 242mA, add in the other resistances in the measurement circuit an it comes out to be about 140mA to 200mA.

It really doesn't matter what the actual mA is, all that matters is that the console reading (firmware value from the mA Test Points) MATCHES what the ISO compliant, calibrated ammeter says.

2.2.3 SW and HW Tools Available for Troubleshooting

2.2.3.1 Schematics

Direction 2243317

- mA/Filament Control Bd. Schematics 2154834SCH
- OBC Backplane list
- Gantry Rotating Member Block Diagram
- Gantry_Rotating_Interconnect
- X-Ray Tube 120 Vac

2.2.3.2 Equipment

- Multi-meter
- Oscilloscope

2.2.4 Explanation of Cathode & Anode mA Results Screen

Cathode mA:	**193.7mA**	**200.0mA**	**193.7mA**

This value comes from the mA Control Bd. 2154834 TP4, through the backplane and Gentry I/O bd. Since the cathode is in series with the anode, TP4 should be the same value as the TP10 (anode mA, they are in series). The scale is 1v/100mA.

In closed loop mode TP4 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP4 is actually the cathode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Cathode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance

(3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

If cathode and anode mA are different, suspect mA measurement electronics (use mA Meter Test), or suspect a shattered x-ray tube insert shorting out the filament (cathode) or the anode.

Anode mA:	**193.7mA**	**200.0mA**	**193.7mA**

This value comes from the mA Control Bd. 2154834 TP10, through the backplane and Gentry I/O bd. Since the cathode is in series with the anode, TP10 should be the same value as the TP4 (cathode mA, they are in series). The scale is 1v/100mA.

In closed loop mode TP10 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP10 is actually the anode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Anode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

If cathode and anode mA are different, suspect mA measurement electronics (use mA Meter Test), or suspect a shattered x-ray tube insert shorting out the filament (cathode) or the anode.

2.2.5 Reference Material

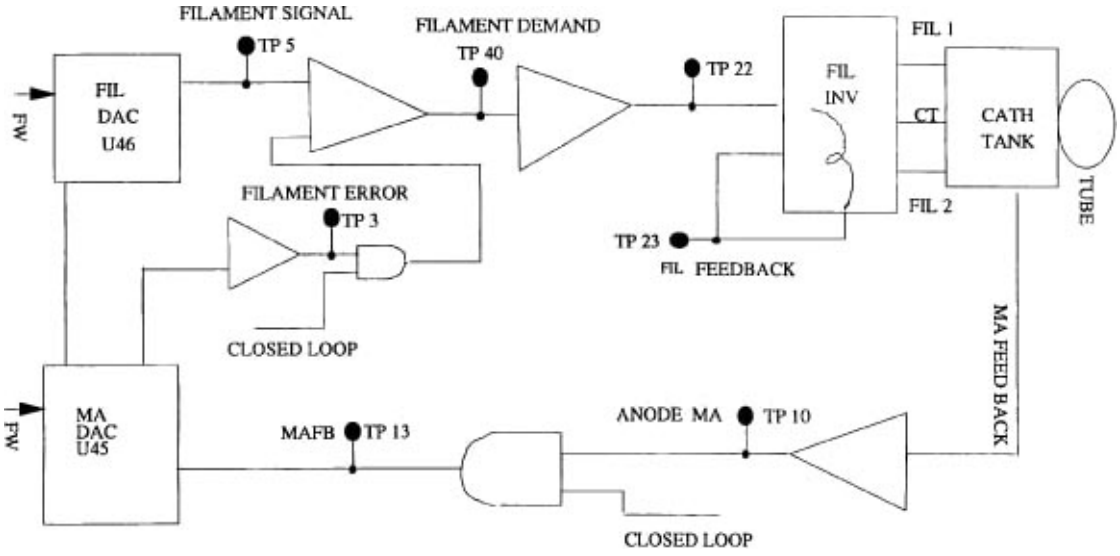

Figure 9-5 Simplified schematic

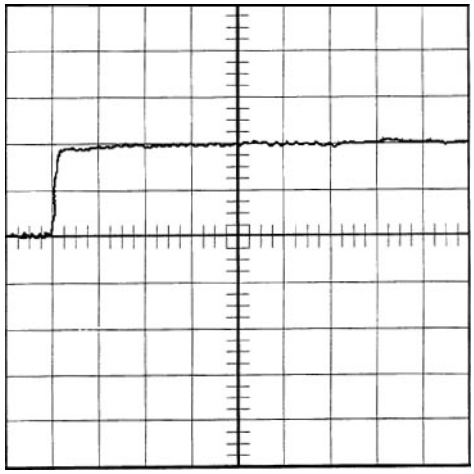

Figure 9-6 Normal mA waveshape for 80kV, 100mA.

- Channel A:0.5 v Board: mA Control 2154834 scope: TEK 224
- Vert: 0.5v Horz:5mS TP 10 to TP 2
- 80KV 100mA CLOSED LOOP mA TP10 (anma) to TP2 (sgnd)

This is a picture of the mA feedback read off of the mA Control Bd, with **CLOSED LOOP** mA selected. There should not be a great difference between CLOSED LOOP mA and OPEN LOOP mA. IF there is, it indicates that CLOSED LOOP is trying to make up for a problem, investigate for root cause.

Anode and cathode mAs are in series. Therefore anode and cathode mA waveshapes are duplicates.

Comment: *If not, either Ohm's law has been redefined for series circuits, or there is a problem. Verify for a measurement problem first.*

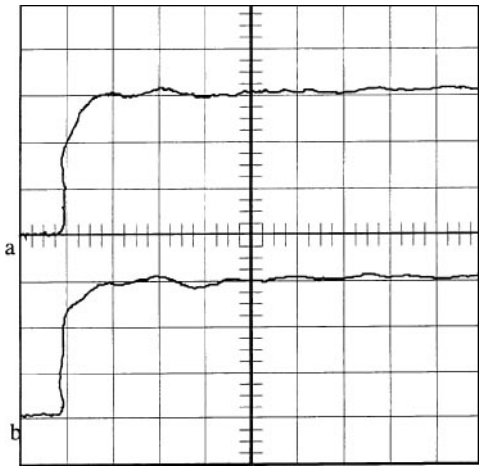

Figure 9-7 Normal mA waveshape for 80kV, 320mA.

- Channel A: 1v=5mS Board: mA control 2154834 scope:TEK 244 B:1v=5mS Vert:1v Horz:5mS.
- Ch 1 (a)= 80KV 320mA CLOSED LOOP mA TP10 (ANMA) to TP2 (sgnd)
- Ch 2 (b)= 80KV 320mA CLOSED LOOP mA TP4 (CAMA) to TP2 (sgnd)

This is a picture of the mA feedback read off of the mA control bd.

There should not be a great difference between CLOSED LOOP mA and Open loop mA. If there is, it indicates that CLOSED LOOP is trying to make up for a problem, investigate for root cause.

Anode and cathode mAs are in series. Therefore anode and cathode mA waveshapes are duplicates. If not, either Ohm's law has been redefined for series circuits, or there is a problem. [I would verify for a measurement problem first.]

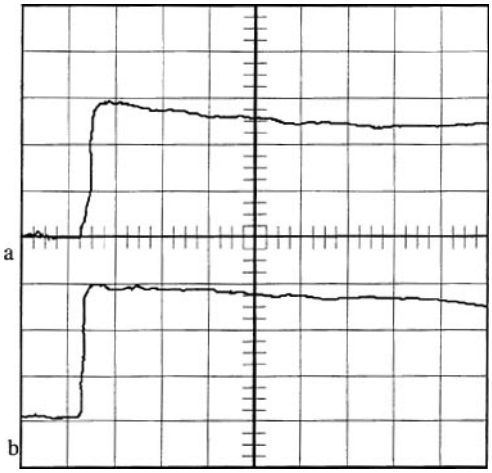

Figure 9-8 Normal mA waveshape for 80kV, 320mA OPEN LOOP MODE

- channel a:1v=50mS Board scpoe:TEK 224
- b:1v=50mS mA control Vert:1v
- 2154834 Horz: 50mS
- ch1 (a) =80KV 320mA OPEN LOOP mA TP10 (anma) to TP2 (sgnd)
- ch2 (b) =80KV 320mA OPEN LOOP mA TP4 (cama) to Tp2 (sgnd)

In Open Loop Mode, there is a possibility of exceeding 400mA. DO NOT run the mA higher than 350mA in Open Loop Mode. EXCEEDING 400mA WILL DAMAGE THE H.V. SUBSYSTEM.

This is a picture of the mA feedback read off of the mA Control Bd, with OPEN LOOP mode selected.

Compare this picture with CLOSED LOOP mA at the same technique. Note that in OPEN LOOP mode the mA is not regulated to a perfect 320 mA.

There should not be a great difference between CLOSED LOOP mA and OPEN LOOP mA. If there is, it indicates that CLOSED LOOP is trying to make up for a problem. Investigate for root cause.

2.3 HEMRC Theory

2.3.1 HEMRC Functions Theory

2.3.1.1 Performix Tube Theory of Operation

The Performix Tube uses a three-phase stator, which requires a HEMRC (High Efficiency Motor Rotor Controller) assembly and HEMRC Control board instead of the CTVRC Control board and assembly.

2.3.1.2 HEMRC Control Board (HCB)

The HEMRC Control board, (2179860) resides in slot A2 of the OBC. The HEMRC Control board performs three main functions. It provides:

- The interface between the OBC and the HEMRC
  Figure 9-11, on page 698, has a Functional Interconnect for the hardwire control signals.
- HVDC Bus voltage monitoring
- A CAN **(Controller Area Network)** interface between the OBC and future subsystems

See Section 2.3.2, on page 696, for HEMRC Control board Theory of Operation.

2.3.1.3 HEMRC Assembly

The HEMRC Assembly contains an Interface Board, AC Drive, Chopper Resistor Assembly, harness and assorted power supplies. The HEMRC Assembly also contains the Detector Heater, Collimator and Filament Power Supplies, which operate in the same manner as their HSA (CTVRC) counterparts.

The HEMRC Assembly replaces the CTVRC Assembly in systems that use the Performix tube.

Figure 9-9 shows a block diagram of the HEMRC assembly.

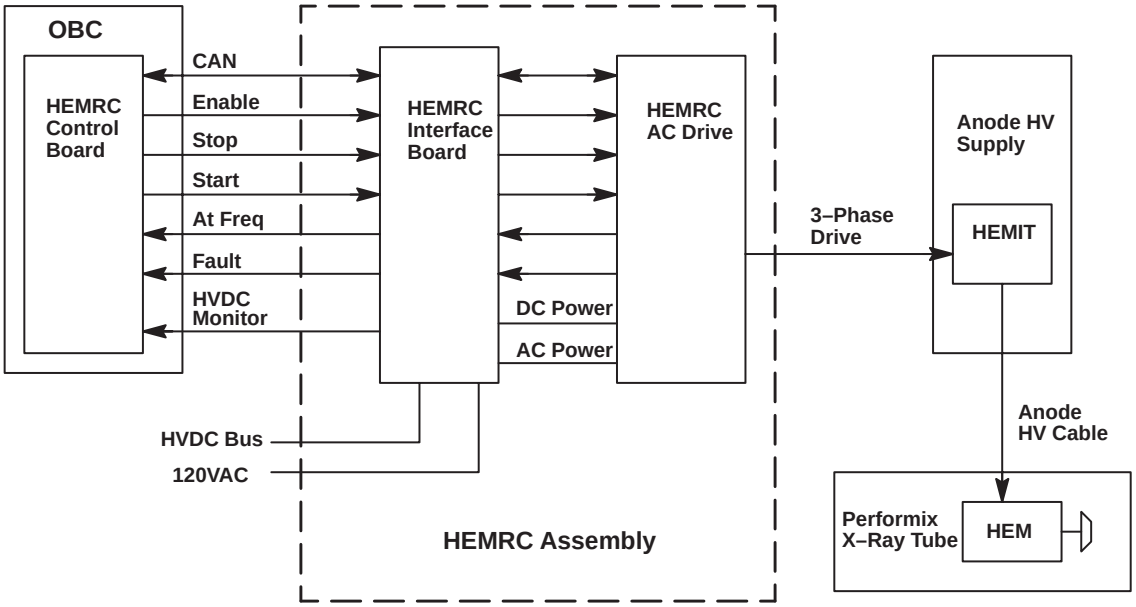

Figure 9-9 HEMRC Hardware Block Diagram

2.3.1.4 General HEMRC Function

The Rotor Control function provides three phase power to the rotating anode of the Performix x-ray tube. In addition to the HEMRC Control board, the Performix tube requires a HEMRC AC Drive, HEMRC Interface board, HEMIT (High Efficiency Motor Isolation Transformer), and controlling firmware. The rotor control firmware controls the acceleration, run, and deceleration cycles of the rotating anode. The rotor control firmware resides on the OBC CPU board and communicates directly with the HEMRC Control board (HCB), in slot A2. The HEMRC Control board communicates with the HEMRC AC Drive through the HEMRC Interface board (HIF), located on the HEMRC assembly. The drive converts input power to three phase anode HEM (High Efficiency Motor Drive). This motor drive power passes through the HEMIT, located in the Anode High Voltage Transformer, before it reaches the HEM in the Performix Tube.

Refer to Figure 9-10. Control signals travel from the HCB to the HEMRC through the gantry harness. The HEMRC Interface Board routes the signals to the HEMRC AC Drive. The HEMRC AC Drive sends Stator power through a low voltage, shielded stator cable to the HEMIT. The HEMIT provides 1:1 HV isolation and couples the stator power to the Performix tube through the Anode High Voltage cable.

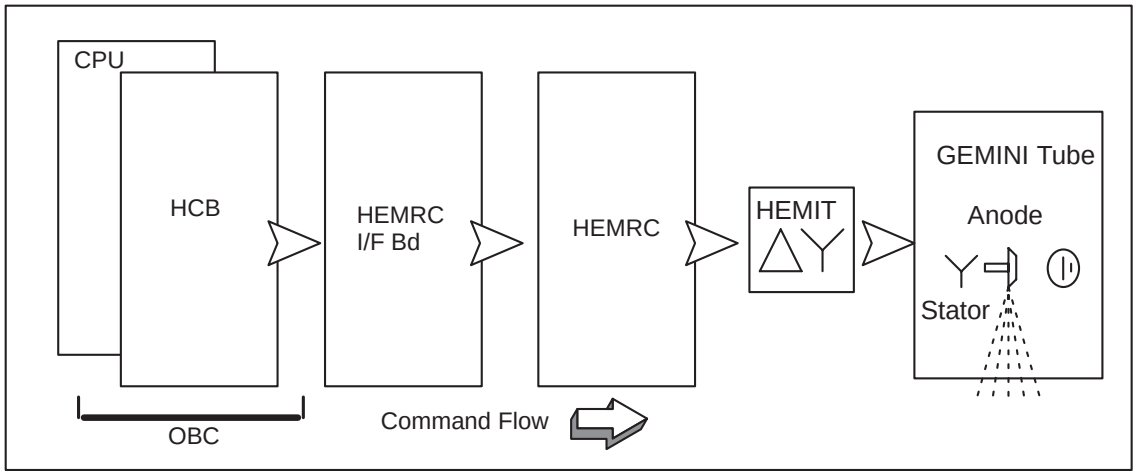

Figure 9-10 HEMRC Functional Command Flow Diagram

2.3.2 HEMRC Control Board – Theory of Operation

The HEMRC Control board (HCB), located in slot A2 of the OBC, uses the VME bus to communicate with the OBC CPU. The HCB uses a CAN (Controller Area Network) serial interface, called the HCAN (HEMRC CAN), and discrete signals to communicate with the HEMRC. Figure 9-11, on page 698 shows the discrete control signals. The CAN interface and discrete control signals enter the HIF (HEMRC Interface) for distribution to the HEMRC. The HIF also provides an analog feedback voltage to the HEMRC Control board in proportion to the voltage on the CT HVDC bus.

The HCB also contains a separate CAN serial interface, called the GCAN (Gantry CAN), and discrete control signals to communicate with other subsystems in the CT gantry subsystem. The HCB communicates with the HIF and gantry subsystems through shielded cables from the J3 connector of the HEMRC Control board.

Both the HEMRC CAN and the Gantry CAN originate in the HCB. The HCB supplies isolated 12V power (1.2A capability) and Fault circuitry to the GCAN, and accommodates up to six (6) CAN nodes (future) on the network.

Fault detectors and fault status feedback from the HEMRC and Gantry CAN based subsystems (if used) monitor hardware operation. The HCB notifies the CPU when it detects a fault, or a monitored value falls out of tolerance.

2.3.2.1 VME Interface

The VME interface contains the logic to perform address and data latching, address decoding, and VME handshaking, according to timing specified in PAL documentation, 2147462PDL. All signals pass through the standard VME connector, J1.

Of the seven interrupts defined for the VME bus, the HCB uses level 1, level 2, and level 4 interrupts. Other boards on the OBC also use the level 1 interrupt, which is wire OR-ed on the backplane.

- **IRQ1**: Interrupt level 1 indicates the presence of a hard failure. A fault signal from the HEMRC or the HIV (High Voltage DC Bus Over voltage signal) generates a level 1 interrupt. Firmware can mask a HEMRC fault with the HEMRC_FLT_EN signal, to prevent HCB tie ups.
- **IRQ2**: The HCB uses Interrupt level 2 during HCAN and GCAN communications.
- **IRQ4**: Interrupt level 4 indicates the occurrence of a transition a state change or the presence of a Gantry CAN fault. Firmware can mask the GCAN fault.

2.3.2.2 Command I/O

In normal operation, the OBC CPU sends state commands through the command registers located at address FFB821H and FFB823H. The OBC CPU also uses the command register located at FFB823H to provide Board Level Diagnostic (BLD) features.

The registers located at FFB829H, FFB82BH, and FFB82DH report Status.

Section 2.3.2.16, on page 704, contains the Command Register assignments.

2.3.2.3 Reset Pushbutton

The HCB contains a manual board reset pushbutton. Pushing the on-board reset does not have the same effect as receiving a RACKRST or SYSRST from the VME. The RACKRST and SYSRST also reset the GCAN.

2.3.2.4 Clocks

U2, U3, and U4 on the HCB generate 244Hz and 15.26Hz clocks from the 16MHz clock. The HVDC Bus monitoring circuit uses the 244Hz clock and the HEMRC CAN Interface circuit uses the 15.26 Hz clock.

2.3.2.5 Voltage Reference

The Voltage Reference circuitry produces a test reference voltage used to test the HVDC Bus monitoring circuit during board level diagnostic (BLD) tests.

2.3.2.6 HEMRC CAN (HCAN)

The HCB uses the 82527 CAN protocol controller (U54) and CAN bus interface circuitry to communicate with the HEMRC Assembly. The HCB communicates with the OBC CPU through the address and data bus, R_W*, and HEMRC_CAN_CS* signals. The 82527 communicates with the HEMRC through the HCAN bus interface, connected to the TX0 and RX0 pins. The 82527 interrupts the OBC CPU with the HEMRC_CAN_IRQ* signal to indicate a status change of the 82527. The HEMRC_CAN_IRQ* generates a level 2 interrupt to the OBC CPU through the status register located at FFB82DH, bit 0.

The 82527 uses the 16MHz clock for timing. The board RESET* signal resets the 82527.

U66 and U67 optically isolate the HEMRC CAN bus from the HEMRC Control board circuitry. U77, the CAN transceiver chip, resides on the isolated side of the CAN interface. The optically isolated side of the HEMRC CAN receives power from an isolated 12 volt, 125 mA supply located on the HEMRC. VR3 regulates this 12 volt supply down to 5 volts. This isolated 5 volt supply provides power to the isolated side of the HEMRC CAN interface. The HEMRC CAN output signals are HCH and HCL. R94 provides the required CAN bus termination for the HEMRC Control board end of the HEMRC CAN bus.

DS8 illuminates whenever the 82C250 receives data over the HEMRC CAN bus.

2.3.2.7 OBC to HEMRC Interface Overview

The communications between the OBC and HEMRC consist of:

- Bi-directional CAN serial communications bus: a 125 Kbaud bidirectional serial link, used to convey commands and status information between the HEMRC and OBC
- Fault signal from the HEMRC to OBC
- At-speed signal from the HEMRC to the OBC
- Enable signal from the OBC to the HEMRC
- Three-wire start-stop signal

The opto-isolated Enable, Start, and Stop signals from the OBC to the HEMRC provide a contact closure as an input to the HEMRC (Figure 9-11). The Enable contacts close electrically to enable the HEMRC, the Start contacts close electrically to start the HEMRC, and the Stop contacts close

electrically to enable the HEMRC to run and open electrically to stop the HEMRC. The Enable, Start, and Stop opto-isolators carry 10mA with less than a 3V drop when closed, and withstand 5V when the contacts open.

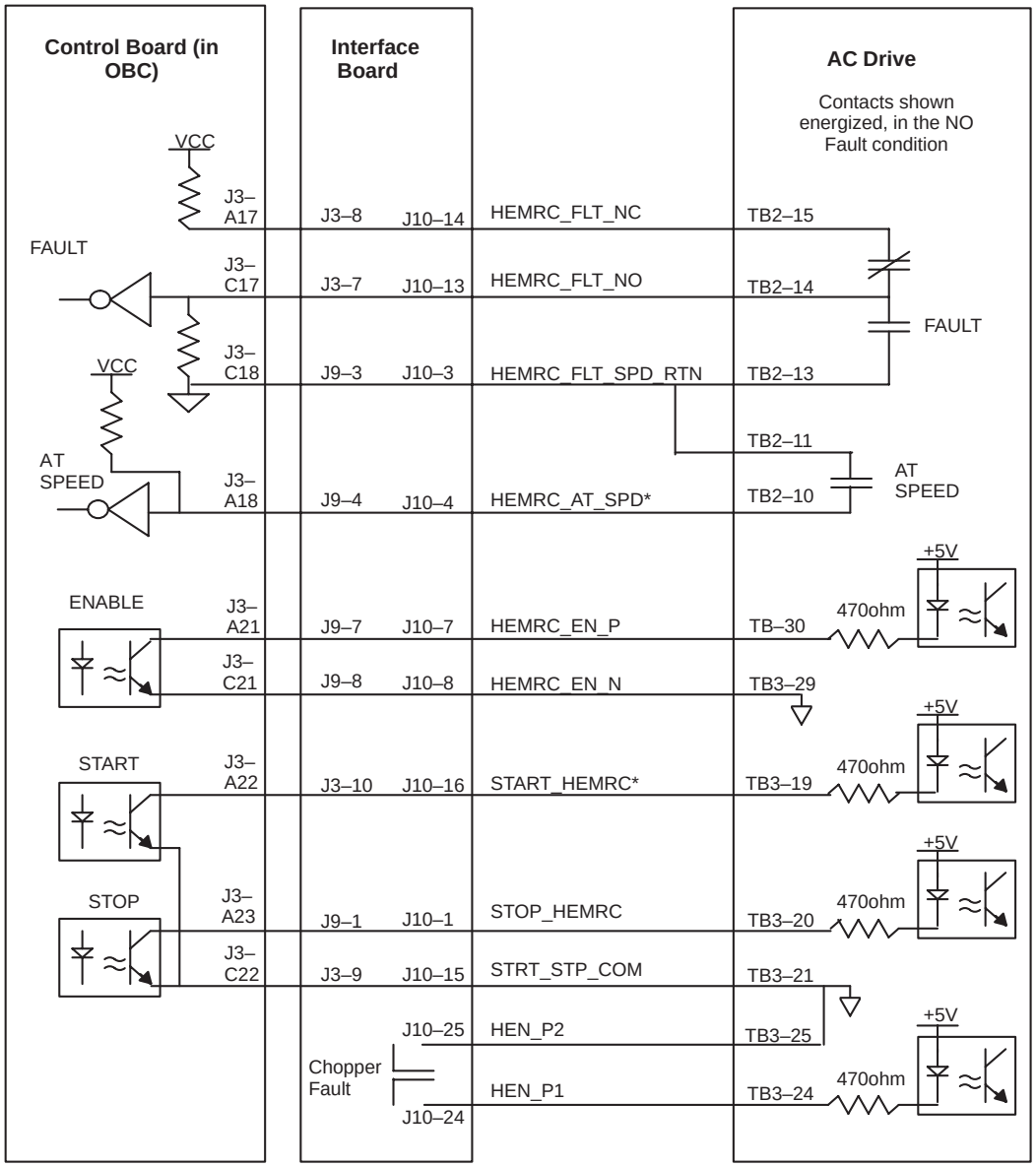

Figure 9-11 Hardwire Control Signals, Functional Interconnect

The fault signal from the HEMRC to the OBC consists of the HEMRC_FLT_NC, HEMRC_FLT_NO, and HEMRC_FLT_SPD_RTN signal wires. Figure 9-11 contains a block diagram of the connections between the HCB and HEMRC. Refer to the schematics for actual component values. Use the components in Figure 9-11 for functional reference only. The circuit uses drives with a normally-open fault contact. If either the HEMRC_FLT_NC signal wires or HEMRC_FLT_NO signal wires open electrically, the HCB generates a fault condition. If the HEMRC_FLT_SPD_RTN signal wires open while the HEMRC_FLT_NC and HEMRC_FLT_NO signal wires are connected, the HCB does NOT sense a HEMRC fault condition. The HEMRC_FLT_SPD_RTN connects to chassis ground to provide a redundant signal return path for the fault signal. In addition, if the HEMRC_FLT_SPD_RTN wire opens, the HCB will not sense an at-speed condition, which indicates the x-ray tube anode failed to reach a safe speed to allow x-ray exposure.

The HEMRC fault feedback circuit uses three signals from the HEMRC (fed back through the HEMRC Interface board), HEMRC_FLT_NC, HEMRC_FLT_NO, and HEMRC_FLT_SPD_RTN.

Under a no-fault operating condition, the HEMRC_FLT_NC and HEMRC_FLT_NO signals connect electrically, and the HEMRC_FLT_NO and HEMRC_FLT_SPD_RTN signals do not connect electrically, which creates a logic high signal to the input of U17 pin 1, that indicates a no-fault condition. During a fault condition, no electrical connection exists between the HEMRC_FLT_NC and HEMRC_FLT_NO signals, and the HEMRC_FLT_NO and HEMRC_FLT_SPD_RTN signals connect electrically to create a logic low to the input of U15 pin 1, which indicates a fault condition.

If the rotor is at or above Frequency for the phase it is currently in, then AT SPEED will be satisfied and closes. AT SPEED will then Open when the Phase changes transition, and waits for the rotor to be at or above Frequency again for this next phase, then will close if the rotor reaches Frequency. This will continue throughout the entire rotor cycle, Accel, Run, and Brake. It is key to know that the A/B drive will try to drive the rotor to the correct speed, and if it can not attain the speed requested, the current will max out at a specific level and not drive any higher, the result will be that the rotor could not make it to the correct frequency in the allotted time for that phase, and the AT SPEED fault will be seen.

2.3.2.8 Fault Circuitry

This feedback uses three signals to allow a broken wire to be detected as a fault condition. If the HEMRC_FLT_NC wire breaks, the input to U15 pin 1 goes low to indicate a fault condition (regardless of the integrity of the two remaining signals). If the HEMRC_FLT_NO wire breaks, the input to U15 pin 1 goes low to indicate a fault condition (regardless of the integrity of the two remaining signals). If the HEMRC_FLT_SPD_RTN signal wire breaks, the drive uses the remaining HEMRC_FLT_NC and HEMRC_FLT_NO signals to indicate a fault condition. With the three signal design, no possible combination of broken wires could prevent the detection of a HEMRC fault condition.

In a fault condition, U17 pin 2 goes to a logic high, which clears the D flip-flop U20 and causes U20 pin 12 to go high and indicate a fault with the signal HEMRC_FLT. During a fault condition, U41 pin 10 goes to a logic low, which combines with the ROT_EN signal to disable the HEMRC.

When the fault clears, the FLTRST signal resets the HEMRC_FLT.

Under a no-fault condition, the HEMRC enables when the ROT_EN signal and the output U41 pin 10 (no fault) go to a logic high, creating a low impedance between the HEMRC_EN_P and HEMRC_EN_N output signals, which turns the opto-isolator U73 “ON”.

The HEMRC_EN_P and HEMRC_EN_N output signals pass through the HEMRC Interface board on route to the HEMRC. The center of schematic sheet eight contains the HEMRC at-speed indication circuit. When the HEMRC reaches its programmed speed, it closes a contact between the HEMRC_AT _SPD* and HEMRC_FLT_SPD_RTN signals, to create a logic high to U17 pin 4. The next clock pulse clocks this signal into D flip-flop U6, which sends the AT_SPEED signal to a logic high to generate a momentary pulse on the STAT_CHG signal, which in turn sends a level 4 interrupt to the OBC CPU.

Because D flip-flop U6 receives a 15.26Hz clock pulse, the OBC CPU has enough time to respond to the level 4 interrupt and read the status of the HEMRC Control board before the status changes again. This clocking scheme also prevents the generation of simultaneous interrupts. The HEMRC_AT_SPD* signal combines with the INTLK* signal to prevent x-ray exposure from occurring before the HEMRC reaches its pre-programmed speed. The EXPEN signal must equal a logic high before x-ray exposure can occur.

2.3.2.9 HEMRC Stop and Start

The discrete start and stop signals to the HEMRC are opto-coupled logic signals. The HEMRC_STOP* signal must equal a logic high for the HEMRC to start acceleration, continue acceleration or run. The logic high HEMRC_STOP* signal creates a low impedance between the STOP_HEMRC and STRT_STP_COM output signals, which permits the HEMRC to accelerate or run.

When the HEMRC_START signal goes to a logic high (causing a low impedance between the START_HEMRC* and STRT_STP_COM outputs) and the HEMRC_STOP* signal equals a logic high, the HEMRC begins to accelerate (if it hasn’t already done so). Once acceleration begins, the HEMRC continue to advance along its acceleration profile, or continues to run, regardless of the

logic condition of the HEMRC_START signal. The HEMRC begins to decelerate (if it is running) whenever the HEMRC_STOP* signal goes to a logic low.

2.3.2.10 Gantry CAN

The HEMRC circuitry supports the use of the 82527 CAN protocol controllers (U53 and U62) and CAN bus interface circuitry to communicate with the CAN based gantry subsystems. The Gantry CAN interface uses two CAN protocol controllers on the CAN bus. The 82527s communicate with the OBC CPU through the address and data bus, R_W*, GCAN1_CAN_CS*, and GCAN2_CAN_CS* signals. The 82527s communicate with the gantry subsystems through the CAN bus interface, connected to the TX0 and RX0 pins. A status change of the 82527 CAN causes the GCAN1_IRQ* and GCAN1_IRQ* signals to generate a level 2 interrupt to the OBC CPU, visible at status register location FFB82DH.

The 82527s use the 16MHz clock for timing. The board RESET* signal resets the 82527s.

U62, U63, U54, and U65 optically isolate the Gantry CAN (GCAN) bus from the HEMRC Control board (HBC) circuitry. The CAN transceiver chips, U74 and U75, on the isolated side of the CAN interface, receive power from an isolated five volt supply produced by DC-DC converter U82 on the HEMRC Control board. The GCAN output signals are GCH and GCL. R103 provides the required CAN bus termination for the HEMRC Control board end of the gantry CAN bus when you connect GCR to GCH with the jumper plug on J4 and J5.

When the HEMRC Control board transmits on the gantry CAN bus, DS5 (G1TX) or DS6 (G2TX) illuminates to indicate transmission activity. During reception, DS7 (GRX) illuminates.

The discrete signals for the Gantry CAN interface are GCAN_RST, GCAN_FLT and FAULT2. When GCAN_RESET goes to a logic high, it uses RS485 transceiver (DS3695) U79 to drive GCAN_RST_P high and GCAN_RST_N low.

The Gantry CAN fault feedback circuitry consists of two parts.

- The primary system uses the 82C250 CAN transceiver U72. When a fault condition exists on one of the gantry CAN subsystems, GCAN_FLT_P goes high relative to GCAN_FLT_N, and Rxd and Txd equal a logic zero. This condition causes a logic high on the GCAN_FLT signal, which in turn generates a level 4 interrupt whenever the GCAN_FLT_EN signal equals a logic high. DS4 (GFLT) illuminates whenever a gantry CAN fault condition exists.
- The second fault uses a loop through signal of the GCAN_+12V_ISO signal through other modules. This signal enters the HCB at J2-A8 (FAULT_SENSE). If this signal goes low for any reason, the FAULT2 and GCAN_FLT signals go to a logic high. The firmware can also break the loop-through line by driving DRV_GCAN_FLT* to a logic zero, which creates a GCAN_FLT and FAULT2 signal that firmware can readback.

The GCAN_FLTRST signal resets both kinds of CAN faults. At 3.0 mS must elapse between the release of a Driven GCAN Fault (DRV_GCAN_FLT*) and the Gantry CAN Fault Reset (GCAN_FLTRST), to allow time for the solid state relay to switch.

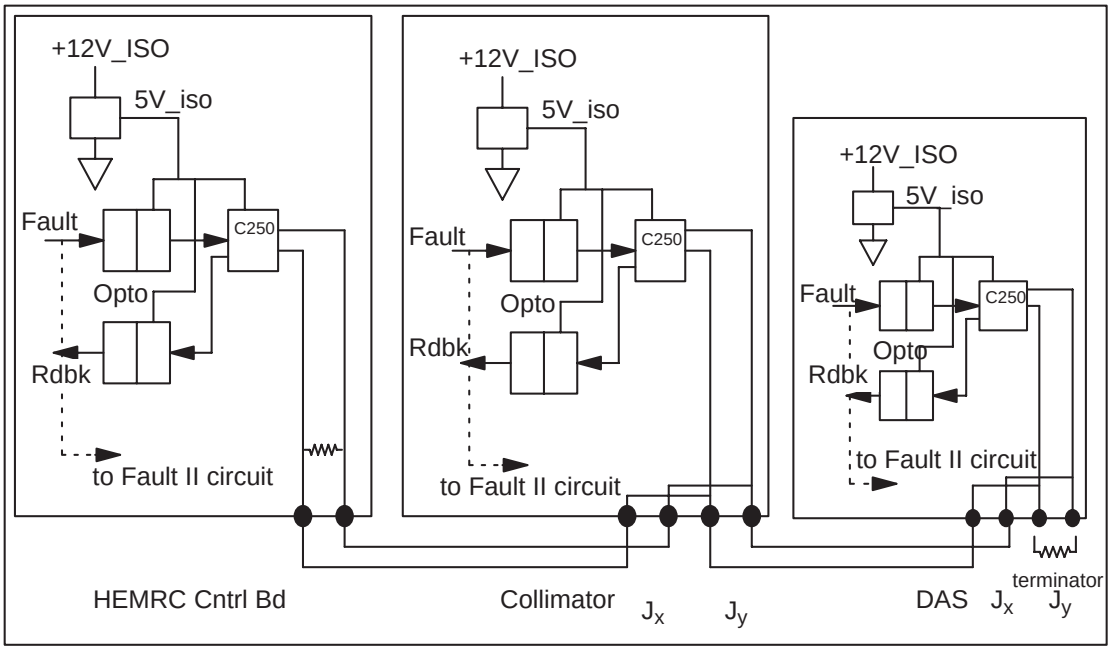

Figure 9-12 GCAN Bus Primary Fault Signal Path

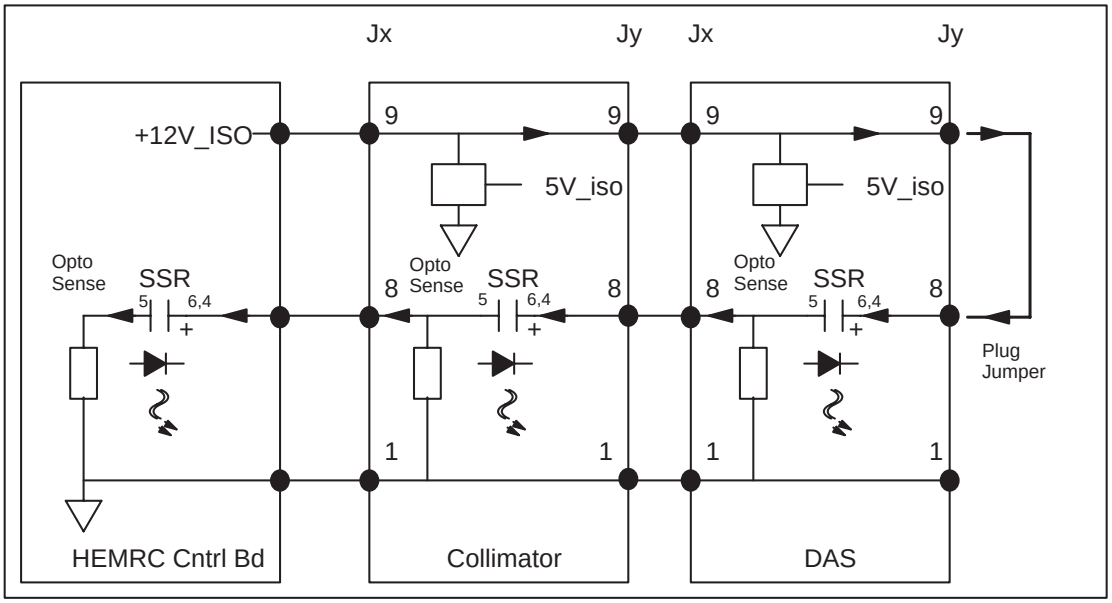

Figure 9-13 GCAN Bus Secondary Fault Signal Path

2.3.2.11 DC Bus Voltage Monitoring

The system uses the HBC to monitor the HVDC Bus that feeds the HEMRC. The HEMRC Interface board provides the HVDC Bus feedback to the HEMRC Control board (HCB).

The differential amplifier AR4 senses the feedback voltage. The HEMRC Interface board contains the one megohm of the input impedance. Resistor networks R147 & R148 and R143 & R144 limit the common mode voltage injected at the op-amp. You can monitor the voltage at “DCV” (TP 9); scaled 100V/V. The MUX periodically sends this value to the CPU for it to read.

The circuit compares this voltage to a fixed ~470V limit, and samples the result at a 244 Hz rate. Whenever the result changes state, it generates a level 4 interrupt to signal the CPU that the bus is responding to commands &/or faults. The CPU can then take appropriate action.

The voltage also passes through a filter with an approximately 20 millisecond time constant, for comparison to an upper limit. Jumper JP1, selects the upper limit. Position “A” selects an upper limit of ~670V for use by systems with a DCRGS PDU. Position “B” sets the upper limit to ~800V, for use by systems with an unregulated HVDC Supply in their PDU. The position of jumper JP1 produces a signal, DCR*, which the CPU reads at address FFB829H.

If a failure of the HVDC Supply occurs, the circuit exceeds the upper voltage limit, and generates an abort. This condition produces a level 1 interrupt, described in the following MUX_IRQ section.

2.3.2.12 MUX_IRQ

The MUX_IRQ function consists of an analog multiplexer, used to feed the HVDC Bus voltage feedback signal and test reference voltage back to the OBC through RC_MUX and the IRQ generation circuits.

You can monitor the multiplexer output at test point “MUX” (TP3). VR2 and AR3 generate the +10V and -10V reference voltages. The CPU reads the value of the +10V reference through the multiplexer. The CPU detects scaling errors in the system by comparing its value to an external reference.

Two fault conditions, High DC Bus Voltage and HEMRC Fault, generate a level 1 interrupt. Firmware can use the HEMRC_FLT_EN signal to mask the HEMRC_FLT signal. The firmware masks the interrupt during powerup reset conditions.

A High DC Bus Voltage fault generates a “KILLBC*” signal that immediately disables the back-up contactor supplying the inverter power. This fault may indicate a loss of control in the DC bus regulator, and the existence of a potential hazard.

When it receives a level 1 interrupt, the CPU interrogates the board status registers to determine what fault occurred, then it disables the HEMRC and resets the interrupt and fault latches while it posts error messages.

Three state transition conditions generate a level 4 interrupt:

- STAT_CHG
- VCHG
- GCAN Fault Firmware can use GCAN_FLT_EN to mask GCAN_FLT

When it receives a level 4 interrupt, the CPU interrogates the board status registers to determine the appropriate action.

A status change in one of the CAN protocol controller devices generates a level 2 interrupt. The HEMRC_CAN_IRQ*, GCAN1_IRQ*, and GCAN2_IRQ* signals indicate a status change in the corresponding CAN protocol control device.

When it receives a level 2 interrupt, the CPU interrogates the register at location FFB82DH to determine the appropriate action.

2.3.2.13 CAN Loopback

When you place the four position shorting plug in the J5 position, it connects the HEMRC CAN to the external HEMRC CAN bus and the Gantry CAN to the external GCAN bus. When you install the connector, the NORMAL signal equals a logic “1”. Register location 0FFB829 contains the status information.

Move the connector to the J4 position to place the HEMRC Control board in diagnostic CAN mode. This mode connects HEMRC CAN bus output to the GCAN bus on the HERMC Control board, and disconnects the external HERMC CAN bus from the circuit board while leaving the GCAN externally connected. This mode permits the readback of the HERMC CAN bus output by the Gantry CAN bus and the readback of the Gantry CAN bus output by the HEMRC CAN. The NOT_NORMAL signal equals a logic “1” when you place the connector in the J4 position. Register location 0FFB829 contains the status information.

The opto-coupler across the HEMRC_ISO_+12V provides readback to the firmware to assist in troubleshooting an error in the CAN readback circuitry. The firmware only senses the presence or absence of the voltage; it tell whether the voltage falls inside or outside the tolerance.

2.3.2.14 CAN Error Detection

CAN implements five error detection mechanisms; three at the message level, and two at the bit level.

Note: CAN will retry up to 128 times before logging an error.

The following mechanisms are at the message level:

- **Cyclic Redundancy Checks (CRC) -** Every transmitted message contains a 15 bit Cyclic Redundancy Check (CRC) code. The CRC is computed by the transmitter and is based on the message content. All receivers that accept the message perform a similar calculation and flag any errors.
- **Frame Checks -** There are certain predefined bit values that must be transmitted at certain points within any CAN Message Frame. if a receiver detects an invalid bit in one of these positions a Form Error (sometimes also known as For at Error) will be flagged.
- **Acknowledgement Error Checks -** If a transmitter determines that a message has not been acknowledged, then an ACK Error is flagged.

The following mechanisms are at the bit level:

- **Bit Monitoring -** Any transmitter automatically monitors and compares the actual bit level on the bus with the level that it transmitted. If the two are not the same, then a bit error is flagged.
- **Bit Stuffing -** CAN uses a technique known as bit stuffing as a check on communication integrity. After five consecutive identical bit levels have been transmitted, the transmitter will automatically inject 9stuff) a bit of the opposite polarity into the bit stream. Receivers of the message will automatically delete (de-stuff) such bits before processing the message in any way. Because of the bit stuffing rule, if any receiving node detects six consecutive bits of the same level, a stuff error is flagged.

2.3.2.15 Control Area Networks

There are two very different and unique CAN networks on the Current LightSpeed Systems.

- **RCIB** GCAN: Network between the OBC and the Collimator Control Bd and DAS Control Bd. GCAN is a 1 MegaBaud bus with point to point protocol, and transfers 8 Bytes at a time.
- **HEMRC** HCAN: Network between the OBC and the Allen Bradley HEMRC AC Drive. HCAN is a 125KBaud bus with Master/Slave protocol and transfers 8 Bytes at a time. (Currently used HCAN protocol is Allen Bradley proprietary.)

The RCIB is the umbilical cord that links the LightSped Controllers to the System. This link consists of the signals listed below. Each signal is a differential pair for noise immunity.

RCIB BLOCK

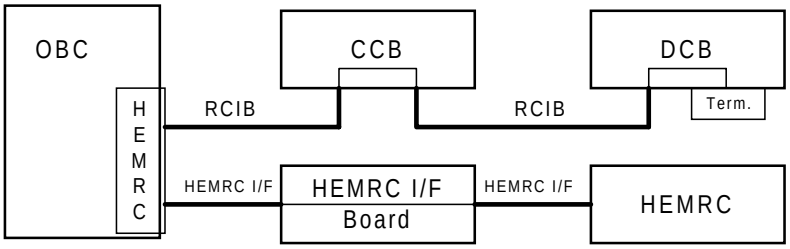

Figure 9-14 Controller Hardware Interface

- Isolated 12VDC is generated by the HEMRC Control Board, which powers the Controller Area Network **GCAN Drivers only**.
- Isolated 12VDC for HCAN is generated by the HEMRC AC DRIVE, which powers the Controller Area Network **HCAN Drivers only**.
- Exposure Command is available to the controllers to determine when x-ray generation begins and ends.

- Triggers are used as the system clock by the controllers. The DAS Control Board (DCB) triggers the data collection each time this line is asserted.
- CAN Serial Line is used for the transmission of control signals. It must be terminated by a 120 Ohm resister at the beginning and end of the cable. This particular CAN line is referenced as the Gantry CAN (GCAN) bus to distinguish it from the HEMRC (HCAN) bus.
- Fault Line is the primary means to inform the OBC of a fault. The fault line is asserted by the Controllers under the following conditions:
  - The Controller is reset.
  - A Fault is detected by the controller.
- Reset Line is asserted by the OBC when it becomes desirable to reset the Controllers. No other controller has the capability to assert this line except for the OBC that is not affected by this signal. The OBC resets this line via a command register or during an OBC reset.
- Interlock line verifies the RCIB cable is connected to all controllers.

2.3.2.16 Memory Maps

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB801	R	All	Insite Info	Board #, character “?” and digit 1 Value = F2H.
FFB803	R	All	Insite Info	Board #, digits 2&3. Value = 17H.
FFB805	R	All	Insite Info	Board #, digits 4&5. Value = 98H.
FFB807	R	All	Insite Info	Board #, digits 6&7. Value = 60H
FFB809	R	All	Insite Info	Board Group #. Value = 01H
FFB80B	R	All	Insite Info	Board Version letter. Example: Value = 42H, ASCII code for “B”. Refer to assembly drawing for specific version information.
FFB80D through FFB81F				Not used.

Table 9-7 Memory Map of Insite Registers

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB821	R/W	7	ROT_EN	A “1” turns the HEMRC control on.
		6	GCAN_RST	Setting this bit to a “1” initiates a reset of the peripherals on the Gantry CAN bus.
		5	INTLK*	Setting this bit to a “1” disables the broken wire interlock to the EXPEN signal. Intended as a diagnostic tool only.
		4	not used	
		3	MUXENA	Analog MUX Selection. MUXENA = “1” selects the analog MUX. MUXENA = “0” is not used but is provided for firm ware compatibility with previous circuit boards and for possible expansion of MUX channels.

Table 9-8 Memory Map of Command Registers

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
		2,1,0	2,1,0	MUXENA concatenated with bits 2,1,0 form the MUX ad dress space. Only the portion of the address space with MUXENA = “1” is used. Bits 2,1,0 select the channel with in the MUX. The four bit concatenated MUX address space and associated signals are listed below. Code — Signal Selected x0H — MUXENA = “0”, not used x1H — MUXENA = “0”, not used x2H — MUXENA = “0”, not used x3H — MUXENA = “0”, not used x4H — MUXENA = “0”, not used x5H — MUXENA = “0”, not used x6H — MUXENA = “0”, not used x7H — MUXENA = “0”, not used x8H — DC rail monitor voltage. Scale: 100 V/V x9H — Signal Ground. 0 V xAH — Signal Ground. 0 V xBH — TESTREF analog voltage. DAC output used to test HVDC bus feedback circuitry. Scale: 1V/V. xCH — Signal Ground. 0 V xDH — Signal Ground. 0 V xEH — Signal Ground. 0 V xFH — +10 V Reference. Scale: 0.5 V/V

Table 9-8 Memory Map of Command Registers (Continued)

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB823	R/W	7	not used	
		6	HVDC_MON_TST	A “1” injects 98.6% of the TESTREF DAC (B825) output into the HVDC bus monitor.
		5	not used	
		4	DRV_GCAN_FLT*	A low creates a GCAN Fault.
		3	HEMRC_FLT_EN	A “0” disables the HEMRC_FLT signal from generating a level 1 interrupt. A “1” allows the HEMRC_FLT to generate a level 1 interrupt. The status of HEMRC_FLT can be read at status register (B829) regardless of the state of HEMRC_FLT_EN.

Table 9-9 Memory Map of Diagnostic Command Register

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
		2	GCAN_FLT_EN	A “0” disables the GCAN_FLT gantry CAN fault signal from generating a level 4 interrupt. A “1” allows the GCAN_FLT to generate a level 4 interrupt. The status of GCAN_FLT can be read at status register (B829) regard less of the state of GCAN_FLT_EN.
		1	HEMRC_STOP*	A “0” commands the HEMRC to decelerate. A “1” is required to allow the drive to accelerate or run.
		0	HEMRC_START	A “1” commands the HEMRC to accelerate. HEMRC_STOP* must be a “1” for acceleration. This bit does not need to be maintained at “1” to keep the HEMRC running.

Table 9-9 Memory Map of Diagnostic Command Register (Continued)

Note: Command Register FFB823 is intended for diagnostic use only. Application code must set all bits to “0” before turning the HEMRC on.

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB825	W	All	DAC “A” Data	TESTREF voltage command. 00H - FFH corresponds to: 0V – +10V.
FFB827	W	All	not used but available for DAC “B” Data expansion	

Table 9-10 Memory Map of DAC Command Registers

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB829	R	7	FAULT 2	A “1” indicates that the loop back signal has been broken somewhere in the system. (See Figure **XREF**.)
		6	AT_SPEED	A “1” indicates the HEMRC is at or above programmed speed.
		5	DCR*	A “1” indicates jumper JP1 is in the Unregulated HVDC Supply selection state. This changes the limits for the HVDC Bus Overvoltage detector.
		4	GCAN_FLT	A “1” indicates a fault on one or more of the gantry CAN based devices.
		3	ROTINT4	A “1” indicates the HEMRC Control board has issued a level 4 interrupt.
		2	LOV	A “1” indicates the DC Rail is less than 450V. This bit is continuously updated every 4 msec. A change of state generates a level 4 interrupt.

Table 9-11 Memory Map of Status Register and GCAN Fault Reset

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
		1	NORMAL	A “1” indicates that the CAN mode connector is in the normal CAN mode location. This is required for CAN communication to the HEMRC and any other CAN based subsystems on the gantry.
		0	NOT_NORMAL	A “1” indicates that the CAN mode connector is in the diagnostic CAN mode location. In this position, CAN communications are looped back between the HEMRC CAN network and the Gantry CAN network.
FFB829	W	N/A	GCAN_FLTRST	A write to this address causes the gantry CAN fault signal to be reset provided a fault condition no longer exists. Any data value can be used for this write.

Table 9-11 Memory Map of Status Register and GCAN Fault Reset (Continued)

ADDRESS	R/W	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB82B	R	7	HIV	A latched “1” indicates an overvoltage was sensed on the HVDC Bus. (if JP1=“A”, DCV > 670 V else if JP1=“B”, DCV > 800V.) This generates a level 1 interrupt and disables the HEMRC and back-up contactor.
		6	not used	
		5	not used	
		4	not used	
		3	not used	
		2	not used	
		1	HEMRC_12V_ FLT	A “0” indicates that the HEMRC_ISO_+12V is non-zero. It does not guarantee that it is at +12V.
		0	HEMRC_FLT	A “1” indicates a fault condition exists on the HEMRC. This is latched on the HEMRC.
FFB82B	W	N/A		A write to this address will clear all the above latched status flags, provided the originating fault has cleared.
FFB82D	W	N/A		A write to this address will clear the level 4 interrupt re quest latch.
FFB82F	W	N/A		A write to this address will clear the level 1 interrupt re quest latch.

Table 9-12 Memory Map of Status Register and Fault Reset

ADDRESS	R/W	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB82D	R	7	not used	
		6	not used	
		5	not used	
		4	not used	
		3	not used	
		2	GCAN2_IRQ*	A “0” indicates the Gantry CAN protocol controller #2 (82527) is requesting interrupt service.
		1	GCAN1_IRQ*	A “0” indicates the Gantry CAN protocol controller #1 (82527) is requesting interrupt service.
		0	HEMRC_CAN_IRQ*	A “0” indicates the HEMRC CAN protocol controller (82527) is requesting interrupt service.
FFB82D	W	N/A		A write to this address will clear the level 4 interrupt re quest latch.

Table 9-13 Memory Map of CAN Interrupt Status Register and IRQ4 Reset

ADDRESS	R/W	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB82F	W	N/A		A write to this address clears the level 1 interrupt request latch.

Table 9-14 Memory Map of IRQ1 Reset

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
1	D00	BBSY*	D08
2	D01	BCLR*	D09
3	D02	ACFAIL*	D10
4	D03	BG0IN*	D11
5	D04	BG0OUT*	D12
6	D05	BG1IN*	D13
7	D06	BG1OUT*	D14
8	D07	BG2IN*	D15
9	LGND	BG2OUT*	LGND
10	SYSCLK	BG3IN*	SYSFAIL*
11	LGND	BG3OUT*	BERR*
12	DS1*	BR0*	SYSRESET*
13	DS0*	BR1*	LWORD*
14	WRITE*	BR2*	AM5

Table 9-15 Pin Assignments J1/P1 Connector – VME Bus Interface

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
15	LGND	BR3*	A23
16	DTACK*	AM0	A22
17	LGND	AM1	A21
18	AS*	AM2	A20
19	LGND	AM3	A19
20	IACK*	LGND	A18
21	IACKIN*	SERCLK	A17
22	IACKOUT*	SERDAT*	A16
23	AM4	LGND	A15
24	A07	IRQ7*	A14
25	A06	IRQ6*	A13
26	A05	IRQ5*	A12
27	A04	IRQ4*	A11
28	A03	IRQ3*	A10
29	A02	IRQ2*	A09
30	A01	IRQ1*	A08
31	-12V	+5VSTDBY	+12V
32	+5V	+5V	+5V

Table 9-15 Pin Assignments J1/P1 Connector – VME Bus Interface (Continued)

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
1	+5LED	+5V	+5V
2	LGND	LGND	LGND
3		<RESERVED>	RACKRST*
4			
5			
6			
7			
8			
9			
10			
11			
12	LGND	LGND	LGND
13	+5V	+5V	+5V
14			
15			
16			
17			

Table 9-16 J2/P2 Connector – Interboard Connections

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
18			RC-MUX
19			KILLBC*
20			EXPEN
21	EXPCMD		
22	LGND	LGND	LGND
23			VREF
24			DCV
25			
26	SGND	SGND	SGND
27	+15V	+15V	+15V
28	SGND	SGND	SGND
29	-15V	-15V	-15V
30	SGND	SGND	SGND
31	LGND	LGND	LGND
32	+5V	+5V	+5V

Table 9-16 J2/P2 Connector – Interboard Connections (Continued)

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
1			
2			
3			
4	GCAN_+12V_ISO		IGND
5	GCAN_H	OPEN	GCAN_L
6	Connected to Pins B and C via backplane	Connected to Pin A via back plane	Connected to Pin A via back plane
7			
8	FAULT_SENSE	Connected to Pin A via back plane	Connected to Pin A via back plane
9	GCAN_FLT_P	OPEN	GCAN_FLT_N
10	OPEN	OPEN	OPEN
11	DAS_TRIG+		DAS_TRIG-
12			
13			
14	GCAN_RST_N		GCAN_RST_P
15	EXP_CMND_N		EXP_CMND_P
16	TRIG_N		TRIG_P
17	HEMRC_FLT_NC		HEMRC_FLT_NO
18	HEMRC_AT_SPD*		HEMRC_FLT_SPD_RTN

Table 9-17 J3/P3 Connector - External Connections

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
19			
20	HEMRC_CAN_H		HEMRC_CAN_L
21	HEMRC_EN_P		HEMRC_EN_N
22	START_HEMRC*		STRT_STP_COM
23	STOP_HEMRC		
24	DCRV-		DCRVM-
25	HEMRC_ISO_+12V		HEMRC_ISO_RTN
26			
27			
28			
29	PGND	PGND	PGND
30	+24V	+24V	+24V
31	+24V	+24V	+24V
32	PGND	PGND	PGND

Table 9-17 J3/P3 Connector - External Connections (Continued)

2.3.3 HEMRC Error Messages

The HEMRC Control function within the OBC may detect certain error conditions, generally related to communication or functional interfaces to the AC Drive. Many of these messages contain variable fields. (In the following listing of possible error messages a*%d* represents a numeric value, *%b* represents a variable text string, and*%xh* represents a data value.)

MESSAGE NUMBER	MESSAGE TEXT
185500	HEMRC CAN chip interrupt can not be cleared. Disabling CAN chip. Interrupt code:*%d* Disable code:*%d*
185501	HEMRC CAN Bus error. HEMRC serial communications are down.
185502	Software error detected while waiting for HEMRC semaphore. HEMRC message not sent.
185503	Software error detected while pending on event flags. CAN message request not processed. VRTX error:*%d*
185504	Software error: Timeout waiting for free HEMRC CAN Buffer. HEMRC message not sent.
185505	Could not send HEMRC message in the allotted time. HEMRC serial link is down. Possible causes: HEMRC CAN jumper, HEMRC fuse, interconnects, CAN devices,... Retries used:*%d*
185506	Invalid response received when sending HEMRC message. HEMRC message not sent. Retries used:*%d*
185507	Software error: Invalid response received from CAN ISR. HEMRC message not sent. ISR response code:*%d*

Table 9-18 HEMRC Error Messages

MESSAGE NUMBER	MESSAGE TEXT
185508	Software error: Invalid packet sent to HEMRC. HEMRC error response code:*%d* Service=*%d* Class=*%d* Instance=*%d* Attribute=*%d* Data=*%d*
185509	Software error: Invalid parameter. HEMRC message not sent.
185510	Software error: Parameter mismatch. The parameter value read from the HEMRC does not match the value written. Parameter number: *%d* Expected value: *%d* Actual value: *%d*
185511	HEMRC fault could not be reset.
185512	The HEMRC CAN communications initialization failed.
185513	The rotor configuration file may be incompatible with the present HEMRC firmware version. Rotor operation may be impaired. HEMRC Firmware version: *%d.%02d*
185514	The rotor configuration file may be incompatible with the present HEMRC drive type. Rotor operation may be impaired. HEMRC drive type: *%d*
185515	*%b* error: Reset state found active.
185516	HEMRC CAN chip
185517	Gantry CAN chip #1
185518	Gantry CAN chip #2
185519	Hardware error: *%b* control line as read from the HEMRC Control Board in unexpected state*%d*, expected state*%d*.
185520	Hardware error:*%b* control line as read from the HEMRC Drive was found in unexpected state*%d*, expected state*%d*.
185521	“Enable”
185522	“Start”
185523	“Run/Stop”
185524	The HEMRC is not running after being enabled. Unknown source of failure. HEMRC status: *0x%06x*
185525	Software error detected while waiting for HEMRC semaphore. CAN loopback test not run. VRTX error:*%d*
185526	HEMRC CAN Bus Error. An abnormal number of errors have occurred on the HEMRC CAN bus. Check diagnostic jumper on HEMRC board and wire connections.
185527	CAN Loopback Test Aborted. Message Transmit Error Message was not transmitted successfully from*%b* to*%b*. TxOk signal did not go high.
185528	CAN Loopback Test Aborted. Message Receive Error Message sent from*%b* was not successfully received by*%b*. New Data signal did not go high.
185529	CAN Loopback Test Aborted.*%b* received message successfully, but did not generate interrupt.
185530	CAN Loopback Test Identifier Error.*%d* of the transmissions from*%b* to*%b* resulted in conflicting message Identifiers.
185531	CAN Loopback Test Data Length Code Error.*%d* of the transmissions from*%b* to*%b* resulted in conflicting values for the data length code segment of the Message Configuration Register.

Table 9-18 HEMRC Error Messages (Continued)

MESSAGE NUMBER	MESSAGE TEXT
185532	CAN Loopback Test Message Lost Error. Lost*%d* of the messages transmitted from*%b* to*%b*.
185533	CAN Loopback Test Error.*%d* of the bytes transmitted from*%b* to*%b* contained an error.
185534	CAN Loopback Test Error. *%d* messages transmitted by *%b*, but *%b* only received *%d* messages.
185535	CAN Loopback Test Error. *%d* packets sent from *%b* to *%b* contained errors.
185536	Firmware Error: Unable to install interrupt handler.
185537	CAN Bus Error. An abnormal number of errors have occurred on the CAN bus. Error detected by *%b*.
185538	Firmware Error: Bus Fault Flag is set, but none of the CAN chips are bus off.
185539	Firmware Error: Unable to post HEMRC message semaphore.
185540	Firmware Error: Bad interrupt code found in interrupt register during loopback test. Interrupt Code: *%d*
185541	Hardware Error: Interrupts are occurring but there are no interrupt codes in any of the CAN chip interrupt registers.
185542	CAN Warning Status. An abnormal number of errors have occurred on the CAN bus. Error detected by *%b*. Status Register Value: *%xh*
185543	Hardware Error: *%b* chip interrupt cannot be cleared. Disabling chip. Interrupt Code: *%d*
185544	Error: The loopback test found the first error while sending a message from *%b* to *%b*. Expected Value: *%d* Actual Value: *%d*
185545	Hardware Error: Message Object 15 generated an interrupt, but Interrupt Pending was not set.
185546	The HEMRC is not running after being disabled. HEMRC status: *0x%06x*
185547	Hardware error: The At Frequency line from the HEMRC is stuck high. HEMRC Control Board latch address: 0xFFB829 Bit: D6 HEMRC status: OFF
185548	The HEMRC operating frequency is below the minimum value. Actual frequency: *%d.%03d* Minimum frequency limit: *%d.%03d* At Frequency signal: *%b* Expected: *%b* Rotor State = *%b*
185549	The At Frequency signal does not agree with the drive output frequency. Possible causes: Interconnection, HEMRC drive, HEMRC control board. Drive freq: *%d.%03d* Minimum freq. limit: *%d.%03d* At Frequency signal: *%b* Expected: *%b* Rotor State = *%b*
185550	Active
185551	Inactive
185552	The CAN test jumper on the HEMRC Control Board is in the wrong position for this test. Place the jumper in the diagnostic position and rerun test. HEMRC address: 0xFFB829 Bit: D0
185553	The HEMRC drive detected a Line Loss. This occurs when the input power to the drive falls below 85% of the nominal Bus voltage. Possible causes: x-ray tube stator, HEM-IT, HEMRC power supply,... Alarm status: *%xH*

Table 9-18 HEMRC Error Messages (Continued)

MESSAGE NUMBER	MESSAGE TEXT
185554	The HEMRC drive is being re-initialized due to the detection of error *F%d*. Status: *%d* (1=OK)
185555	The CAN test jumper on the HEMRC Control Board is in the DIAGNOSTIC position. Place jumper in the NORMAL mode in order to scan.
185556	The CAN test jumper on the HEMRC Control Board is missing. Place jumper in the NORMAL mode in order to scan.
219800	The HEMRC AC Drive reported fault code: Fxx (Where xx equals the number in the following table.)

Table 9-18 HEMRC Error Messages (Continued)

2.3.3.1 Error Messages

The HEMRC AC Drive contains an independent microprocessor controller. When the drive detects a fault, it sends a Fault Code to the HCB/OBC. The OBC, in turn, posts an error message in the log. Unfortunately, the OBC logs all AC Drive error messages as # 219800. However, the body of the message contains the actual Fault Code in the first line, as shown in Table 9-19.

Subsequent lines in the message contain a unique description/interpretation, based on the actual Fault Code.

FXX	FAULT	DESCRIPTION
1	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist, contact the factory for instructions.
2	Auxiliary Fault	The interlock between the Chopper Control circuit on the HEMRC I/F Board and the Drive is open. Possible Chopper Control fault or connections to the I/F board. Also check the fuse on the chopper resistor pan.
3	Power Loss Fault	The Drive internal DC bus remained low for >500mS. Possible low voltage condition on 120 Vac in gantry or power interruption. Also may indicate excessive run or braking power required due to sluggish tube.
4	Undervoltage Fault	The Drive internal DC bus voltage dropped below 325V. Possible low voltage condition on 120 Vac in gantry or power interruption. Also, may indicate excessive run or braking power required due to sluggish tube.
5	Overvoltage Fault	The Drive internal DC bus voltage has exceeded 810V. Possible failure of HEMRC I/F Board Chopper Control or excessive motor regeneration from x-ray tube during braking.
6	Motor Stall Fault	The Drive output current has exceeded 12.6A for > 4 seconds. Possible x-ray tube frozen bearing or shorted stator or Anode HV cable. Also, possible defective HEMIT and/or stator cable.
7	Overload Fault	The Drive output current has exceeded 9.7A for an extended time. Possible x-ray tube sticky bearing or shorted stator or Anode HV cable. Also, possible defective HEMIT and/or stator cable.

Table 9-19 HEMRC Fault Codes for the 219800 Error Message

FXX	FAULT	DESCRIPTION
8	Overtemp Fault	The Drive heatsink temperature has exceeded 90C (195F). Check for blocked or dirty heat sink fins. Also check if the gantry ambient temperature has exceeded 40C (104F).
9	Open Pot Fault	Potentiometer speed control is not used in this system. This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry operation.
10	Serial Fault	This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
11	Op Error Fault	This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
12	Overcurrent Fault	Check for a short circuit at the drive output or excessive load conditions at the motor.
13	Ground Fault	Check the motor and external wiring to the drive output terminals for a grounded condition.
14 to 18	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
19	Precharge Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
20 21	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
22	Drive Fault Reset	Power up has occurred with an open Stop_HEMRC or closed Start_HEMRC* signal. Check Control Board and wiring between Drive and OBC.
23	Loop Overrun Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
24	Motor Mode Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
25	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
26	Power Mode Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
27	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist, contact the factory for instructions.
28	Timeout Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
29	Hertz Error Fault	This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
30	Hertz Select Fault	This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.

Table 9-19 HEMRC Fault Codes for the 219800 Error Message (Continued)

FXX	FAULT	DESCRIPTION
31	Timeout Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
32	EEprom Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
33	Max Retries Fault	The Drive unsuccessfully tried to reset a fault. See message(s) above for original problem.
34	Run Boost Fault	Verify that the [Run Boost] parameter is less than or equal to the [Start Boost] parameter.
35	Negative Slope Fault	This fault code indicates a Volts/Hertz programming error. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
36	Diag C Lim Fault	Check programming of [Cur Lim Trip En] parameter. Check for excess load, im proper DC boost setting, DC brake volts set too high or other causes of excess current.
37	P Jump Error Fault	
38	Phase U Fault	A phase to ground short has been detected in the U phase. Check the wiring between the drive and HEMIT. Check HEMIT for grounded primary winding.
39	Phase V Fault	A phase to ground short has been detected in the V phase. Check the wiring between the drive and HEMIT. Check HEMIT for grounded primary winding.
40	Phase W Fault	A phase to ground short has been detected in the W phase. Check the wiring between the drive and HEMIT. Check HEMIT for grounded primary winding.
41	UV Short Fault	A phase to phase short has been detected between the U & V phases. Check the wiring between the drive and HEMIT. Check HEMIT for shorted primary.
42	UW Short Fault	A phase to phase short has been detected between the U & W phases. Check the wiring between the drive and HEMIT. Check HEMIT for shorted primary.
43	VW Short Fault	A phase to phase short has been detected between the V & W phases. Check the wiring between the drive and HEMIT. Check HEMIT for shorted primary.
44 45	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
46	Power Test Fault	This fault code indicates a possible hardware failure in the Drive. Check all connections to the Power/Driver Board. Retry operation. If problems persist, re place the Drive.
47	Transistor Saturation Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
48	Reprogram Fault	Reset the OBC or cycle power to the drive.
49	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
50	Poles Calc Fault	

Table 9-19 HEMRC Fault Codes for the 219800 Error Message (Continued)

FXX	FAULT	DESCRIPTION
51	Background 10ms Over	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
52	Foreground 10ms Over	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
53	EE Init Read	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
54	EE Init Value	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
55	Temp Sense Open	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
56	Precharge Open	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
57	Ground Warning	Check the HEMIT and external wiring to the drive output terminals for a grounded condition.
58	Blown Fuse Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
59 to 64	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
65	Adapter Frequency Error	This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
66	EEprom Checksum Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
67	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
68	ROM or RAM Loss Fault	Internal power-up tests did not execute properly. Check Language Module. Retry operation. If problems persist, replace the Drive.
69 70	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.

Table 9-19 HEMRC Fault Codes for the 219800 Error Message (Continued)

2.3.3.2 Switches, Test Points, LEDs, Jumpers and Adjustments

SWITCHES

SW #1	LABEL	DESCRIPTION
S1	RESET	(Mom.) Resets all command, fault and interrupt latches on this board and also creates a GCAN_RESET signal, which is sent to downstream controllers via the control interface bus connections.

Table 9-20 HEMRC Switches

TP#	COLOR	LABEL	DESCRIPTION
TP1	Black	LGND	Logic ground
TP2	Red	+5V	+5V supply voltage
TP3	Yellow	MUX	Analog signal as selected by the muxes
TP4	Red	+15V	+15V supply voltage
TP5	White	-15V	-15V supply voltage
TP6	Yellow	+10V	+10V Reference
TP7	Yellow	DCV	DC rail monitor voltage. Scale: 100V/V
TP8	Black	SGND	Signal ground

Table 9-21 HEMRC Test Points

LED	COLOR	LABEL	DESCRIPTION
DS1	Yellow	LORPM	HEMRC output frequency below programmed threshold
DS2	Yellow	LOV	DC Rail less than 470V
DS3	Red	HIV	DC Rail overvoltage (>670V) detected
DS4	Red	GFLT	Fault on GCAN based subsystem
DS5	Green	G1TX	GCAN1 transmitting
DS6	Green	G2TX	GCAN2 transmitting
DS7	Green	GRX	GCAN receiving
DS8	Green	HRX	HEMRC CAN receiving
DS9	Red	HFLT	Fault on the HEMRC
DS10	Green	—	General – Function defined by firmware
DS11	Green	—	General – Function defined by firmware
DS12	Green	—	General – Function defined by firmware
DS13	Green	—	General – Function defined by firmware
DS14	Green	—	General – Function defined by firmware
DS15	Green	—	General – Function defined by firmware
DS16	Green	—	General – Function defined by firmware
DS17	Green	—	General – Function defined by firmware
DS300	Green	G12V	GCAN_+12V_ISO present

Table 9-22 HEMRC LEDs

JUMPERS

JP#	LABEL	DESCRIPTION
JP1	Position A	Selects voltage limits for systems with a DCRGS PDU. (Default shipping position.)
JP1	Position B	Selects voltage limits for systems with an unregulated HVDC Supply

Table 9-23 HEMRC Jumpers

ADJUSTMENTS

None.

2.3.3.3 Precautions

ESD can damage devices on the HEMRC Control board. This damage may not be immediately apparent, but may show up in the future as degraded operational performance. Never handle this board unless you are wearing a properly grounded ESD prevention wrist strap. Pay careful attention to ESD packaging and handling procedures to insure the long term reliability of this assembly.

2.3.3.4 Default Jumper Configuration

The default configuration for shipment: JP1= “A” and jumper plug in J5 (Normal CAN Mode). Secure the jumper plug to the header with a tie-wrap. (See assembly drawing for details).

2.3.4 HEMRC Assembly – Theory of Operation

2.3.4.1 HEMRC AC Drive

The HEMRC AC Drive is a customized version of a commercially available Allen-Bradley Model 1336 variable frequency AC motor drive. It contains its own microprocessor, power supplies and a three phase full bridge inverter. The AC Drive communicates with the OBC CPU through a CAN (Controller Area Network) serial bus.

Note: Through special arrangement with Allen-Bradley, the AC Drive uses a derivative of their PROPRIETARY protocol for maximum communication speed and efficiency.

The OBC/HCB firmware controls all sequence operations of the drive. The drive’s internal CPU controls lower level detail functions and fault protection. In addition to the CAN, the HCB uses discrete signals to control the drive. These signals include Enable, Start, Stop, At Speed, and fault signals. The AC Drive provides an isolated 12V supply to the HCB, to power the opto-isolators.

During normal operation the AC Drive outputs a 3-phase voltage produced by variable pulse width switching of the drive’s IGBT inverter. The peak voltage of this output equals either the HVDC (High Voltage DC) bus voltage or the rectified 380V from transformer T1 (described in Section 2.3.4.5, on page 723), whichever is greater. However, independent of bus voltage, the drive uses PWM switching to maintain the commanded RMS 3 phase output voltage and frequency. The HCB firmware modifies the commands to the drive as required to supply the current needed for acceleration, run and deceleration of the x-ray tube.

JUMPER SETTINGS FOR THE AC DRIVE INSIDE THE HEMRC

When installing the HEMRC AC Drive review the following jumper settings.

JP1	Open
JP2	Installed

There are spare jumpers located near the Allen-Bradley Language Module.

2.3.4.2 HEMRC Interface Board

The following reference information comes from the HEMRC Interface Board Test Specification, 2145832TST. Refer to the 2145832TST document for any updated information, or for more complete discussion of the Interface Board functions.

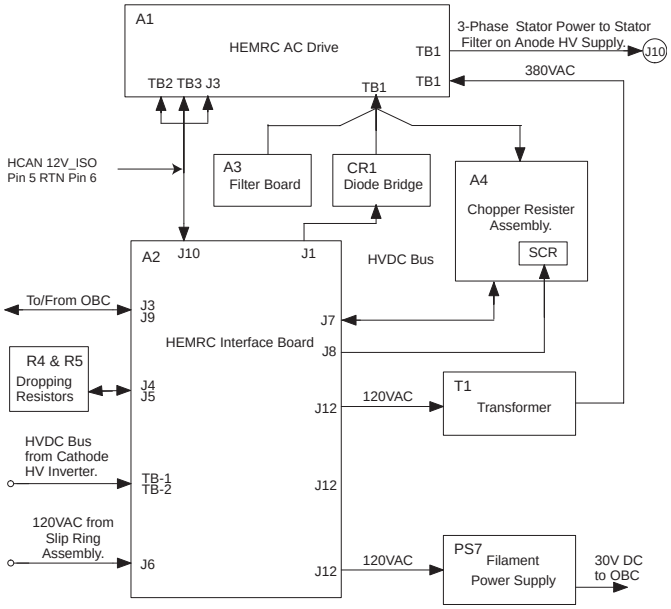

Figure 9-15 HEMRC Assembly Block Diagram

Wiring Harness

These signal lines, originally used for the OBC wire list, have been reassigned in the HEMRC control. Table 9-24 lists signal names corresponding to the OBC wire list and the HEMRC control.

OBC WIRE LIST	PERFORMIX TUBE SYSTEM				
WIRE LIST SIGNAL NAME	HEMRC CONTROL BOARD J3-	NEW SIGNAL NAME	HEMRC I/F BD INPUT CONN.	HEMRC I/F BD OUTPUT CONN.	HEMRC AC DRIVE I/O CONN.
LLEDL	A17	HEMRC_FLT_NC	J3-8	J10-14	TB2-15
ULEDL	C17	HEMRC_FLT_NO	J3-7	J10-13	TB2-14
LLEDR	A18	HEMRC_AT_SPD*	J9-4	J10-4	TB2-10
ULEDR	C18	HEMRC_FLT_SPD_RTN	J9-3	J10-3	TB2-11 & 13
STI1_L	A20	HEMRC_CAN_H	J3-4	J10-12	J3-1
STI2_L	C20	HEMRC_CAN_L	J3-3	J10-11	J3-6
LDI1_L	A22	START_HEMRC*	J3-10	J10-16	TB3-19
LDI2_L	C22	STRT_STP_COM	J3-9	J10-15	TB3-21
STI1_R	A21	HEMRC_EN_P	J9-7	J10-7	TB3-30
STI2_R	C21	HEMRC_EN_N	J9-8	J10-8	TB3-29

Table 9-24 OBC Wire List to HEMRC Control Signal Name Translation

OBC WIRE LIST	PERFORMIX TUBE SYSTEM				
WIRE LIST SIGNAL NAME	HEMRC CONTROL BOARD J3-	NEW SIGNAL NAME	HEMRC I/F BD INPUT CONN.	HEMRC I/F BD OUTPUT CONN.	HEMRC AC DRIVE I/O CONN.
LDI1_R	A23	STOP_HEMRC	J9-1	J10-1	TB3-20
LDI2_R	C23		J9-2	J10-2	
DCRVM+	A25	HEMRC_ISO_+12V	J9-5	J10-5	J3-4
DCRV+	C25	HEMRC_ISO_RTN	J9-6	J10-6	J3-3
DCRV-	A24	DCRV-	J3-6		
DCRVM-	C24	DCRVM-	J3-5		
		HEN_P1		J10-9	TB3-24
		HEN_P2		J10-10	TB3-25

Table 9-24 OBC Wire List to HEMRC Control Signal Name Translation (Continued)

HVDC Sensing

HVDC enters the board at TB1 & TB2, passes through fuses F1 & F2 and outputs to the AC Drive at J1. Fuses F1 & F2 provide isolation between the HVDC bus and the AC Drive in the event of a component failure. LED DS1 illuminates to indicate the presence of voltage.

The HEMRC Interface Board provides the HVDC Bus monitor input. The resistors R1 through R5 form the input network of a differential amplifier circuit, located on the HEMRC Control Board. The output of this network drives a set of fault detectors read by the OBC CPU to monitor bus status.

R6 through R10, along with CR1 & U1, form a threshold detector circuit. U1, an optically coupled, normally closed, solid-state relay enables the chopper regulator when the HVDC bus voltage falls below 500V. U1 switches (nominally) between 500 and 550 volts.

Capacitors C1, C2, & C3 provide common mode and differential mode EMI filtering.

Chopper Control

DANGER

THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE DC–RAIL AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

The Interface board Chopper circuit helps to dissipate excess energy in the AC Drive's internal DC bus. During braking of the x-ray tube rotor, the system HVDC bus turns off, which in turn directs U1 to enable the chopper. As the tube decelerates, its motor acts as a generator, which converts some of the kinetic energy to current. The AC Drive channels this current into its internal DC bus, causing the voltage on the bus to rise. If the bus voltage exceeds 810V the drive disables itself and aborts the braking process. When the braking process aborts, the rotor coasts to a stop. The chopper limits the bus voltage to approximately 750V to prevent the tube from coasting.

The AC Drive's DC voltage powers the circuit at J7. Two 7500 ohm 40W chassis mounted dropping resistors, connected at J4 & J5, limit the power supply current to <50 mA. CR4 regulates the nominal 15V to power the Chopper Control circuit. LED DS3 lights to indicate the presence of circuit power.

When U1 enables the chopper, the open collector of AR1-1 floats, which in turn enables the operation of comparator circuit of AR1-2. The voltage sensed at J7-1 is scaled and compared to a fixed 5V reference provided by VR1. When the bus voltage exceeds 750V, AR1-2 goes high, driving Q3 and turning on IGBT Q1. An external 100 ohm, 1000W shunt resistor, is connected through a fuse (DC+ and J7-5) to the collector of Q1. When Q1 turns on, this shunt resistor is applied to the DC bus and discharges the excess energy. When the voltage falls below 700V, AR1-2 goes low and driver transistor Q2 turns off Q1, which disconnects the shunt resistor.

The AR1-13 circuit detects the on state of Q1. Normally, Q1 stays on for a few milliseconds at a time. If it stays on too long, Q1 can damage the shunt resistor. Therefore, when the collector of Q1 goes low for more than ~1ms, AR1-13 floats high to release the RC timer of R26 & C10. If this condition lasts for more than ~130ms, AR1-14 goes high, which generates a fault condition.

Pins 4 & 5 of J8 are normally jumpered together so the normal low state of AR1-14 turns “on” the normally open solid-state relay U2, and closes its output “contact”. The output of U2 passes through J10-9 & 10 to the AC Drive. When this circuit opens, the drive detects an error condition and aborts all operation. It also notifies the system of the fault.

The detected fault also turns on Q4, to generate a pulse from T1 at J8-1 & 3, which fires the gate of an external SCR. The SCR is connected between an 8 ohm tap on the shunt resistor and the DC-. When the SCR fires, the surge current blows the chopper’s input fuse and isolates the fault from the HVDC bus supply.

AC Distribution

120 Vac enters the board at J6 and illuminates LED DS2. Fuse F3 feeds the collimator power supply through J12-1 and fuse F4 feeds the filament power supply through J12-3. Fuse F5 feeds the isolation transformer, which supplies standby & braking power through J12-5 to the HEMRC AC Drive.

2.3.4.3 Filter Board

The filter board adds differential mode and common mode capacitance to the AC Drive internal DC bus to reduce the electrical noise created by the switching IGBTs. This board is required for EMI/ EMC compatibility.

2.3.4.4 Chopper Resistor Assembly

The chopper resistor assembly provides a high power dissipation load to the AC Drive bus, if required during x-ray rotor braking. The chopper resistor configuration resembles the shunt regulator. The Interface Board contains the actual chopper switching element (an IGBT).

When the x-ray tube induction motor brakes, it can momentarily generate a current. When this happens, the AC Drive converts some of the rotational energy to electrical energy and returns it to the internal DC bus causing a rise in the bus voltage. If the DC bus voltage exceeds ~750V, the chopper IGBT turns on and discharges the excess energy through resistors A4R1 & A4R2. The IGBT turns off when the voltage drops below ~700V. This process continues as long as necessary to keep the bus voltage below ~750V. Normally this action occurs for less than 5 seconds during the brake cycle. At all other times the IGBT remains off and essentially “disconnects” the resistors from the bus. The intermittent duty cycles permits the use of resistors with a much lower power rating than a continuous duty cycle would require.

Because the circuit uses the intermittent duty rated resistors A4R1 & A4R2, it contains fuse A4F1 to isolate the resistors from the bus, in the event of a control failure. If a fault occurs, A4SCR1 fires and crowbars the bus. The anode of A4SCR1 connects to a tap on resistor A4R1, nominally set to 8 ohms from the fused end. When the SCR fires, the high current load it creates causes fuse A4F1 to open and disconnect the resistor assembly from the bus, to isolate the fault.

2.3.4.5 Step-Up Transformer

500VA isolation transformer, T1, is configured as a nominal 115:380 V step-up transformer. T1 provides the 24 hour power to the AC Drive, needed to maintain communication with the HCB/OBC. Diodes inside the AC Drive rectify the ~380Vac create a nominal 500 Vdc bus (no load, with 120 Vac input). DC to DC converters inside the drive develop power for its internal logic from this bus. During extended periods of running the rotor, the system main HVDC bus turns off, and T1 becomes the course of continuing power for the Drive. T1 always provides the power during rotor braking.

2.3.4.6 Bridge Rectifier

Bridge Rectifier CR1 connects in series between the system main HVDC and the AC Drive internal bus to provide an alternate power source for the drive. The drive internal bus voltage always equals the greater of either the main HVDC or the T1 voltage.

Because the drive bus remains energized at all times, but the main HVDC bus only energizes during rotor acceleration, exposures and 1 minute hold-up times, CR1 isolates the main HVDC bus from the drive's internal bus. CR1 prevents the drive bus from feeding back to the main HVDC bus and accidently energizing the gantry slip rings and PDU.

2.3.4.7 Dropping Resistors

Chassis mounted dropping resistors R4 & R5 provide the power supply from the AC Drive internal bus to the Chopper Control on the Interface Board. The Chopper Control supply is referenced to the HVDC bus return, NOT to ground. NEVER reference this voltage to ground.

DANGER **THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE DC – RAIL AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.**

2.3.4.8 Connectors

The HEMRC Assembly has many connections to the LightSpeed system. Unless otherwise indicated, for ease of installation and field upgrade of existing systems, these connections use Mate-N-Lok connectors. Connector designations follow the labelling conventions used in the previous system configurations. Many of the external connections are made directly to sub-components on the assembly and use that sub-component's location identifier in its label.

The following sections group the connections into External Connections and Internal Connections.

External Connections

CATHODE INVERTER

PIN#	SIGNAL	DESCRIPTION
1	HVDC-	HVDC- from Cathode Inverter EMC Filter

Table 9-25 TB1 – From Cathode Inverter (10-32 stud)

PIN#	SIGNAL	DESCRIPTION
1	HVDC+	HVDC+ from Cathode Inverter EMC Filter

Table 9-26 TB2 – From Cathode Inverter (10-32 stud)

HEMRC

PIN#	SIGNAL	DESCRIPTION
1	—	No Connection
2	—	No Connection
3	HEMRC_CAN_L	Bidirectional CAN data line (low)
4	HEMRC_CAN_H	Bidirectional CAN data line (high)
5	DCRVM-	HVDC+ Rail Voltage Monitor to control board
6	DCRV-	HVDC- Rail Voltage Monitor to control board
7	HEMRC_FLT_N O	Normally open fault signal to control board
8	HEMRC_FLT_NC	Normally closed fault signal to control board
9	STRT_STP_CO M	Common return for START_HEMRC* and STOP_HEMRC signals from the control board
10	START_HEMRC*	Start command from the control board

Table 9-27 J3 – To/From HEMRC Control Board in the OBC

SLIP RING

PIN#	SIGNAL	DESCRIPTION
1	120 Vac	120 Vac from the gantry slip ring
2	0VAC	AC Neutral from the gantry slip ring
3	—	No Connection

Table 9-28 J6 – From 120 Vac Slip Rings

HEMRC CONTROL BOARD

PIN#	SIGNAL	DESCRIPTION
1	STOP_HEMRC	Stop command from the control board
2	spare	Unused
3	HEMRC_FLT_SPD_RTN	Common return for _FLT_ and HEMRC_AT_SPD* signals to the control board
4	HEMRC_AT_SPD*	At speed signal to the control board
5	HEMRC_ISO_+12V	AC Drive 12V power supply to the control board
6	HEMRC_ISO_RTN	Return for the 12V power supply to the control board
7	HEMRC_EN_P	High side of enable signal from the control board
8	HEMRC_EN_N	Low side of enable signal from the control board
9	—	No Connection
10	—	No Connection

Table 9-29 J9 – To/From HEMRC Control Board in the OBC

FILAMENT

PIN#	SIGNAL	DESCRIPTION
Push-On	30VDC	30 VDC positive to mA Control Board in the OBC
Ring Term	30VRTN	30 VDC return to mA Control Board in the OBC

Table 9-30 (No Connector) – Output from Filament Power Supply

STATOR

PIN#	SIGNAL	DESCRIPTION
1	BLK	Phase 2 to Stator Filter on Anode HV Supply
2	WHT	Phase 1 to Stator Filter on Anode HV Supply
3	GRN	Phase 3 to Stator Filter on Anode HV Supply
4	SHLD	Cable Shield to Stator Filter on Anode HV Supply

Table 9-31 Stator Cable Output to Stator Filter (& HEMIT)

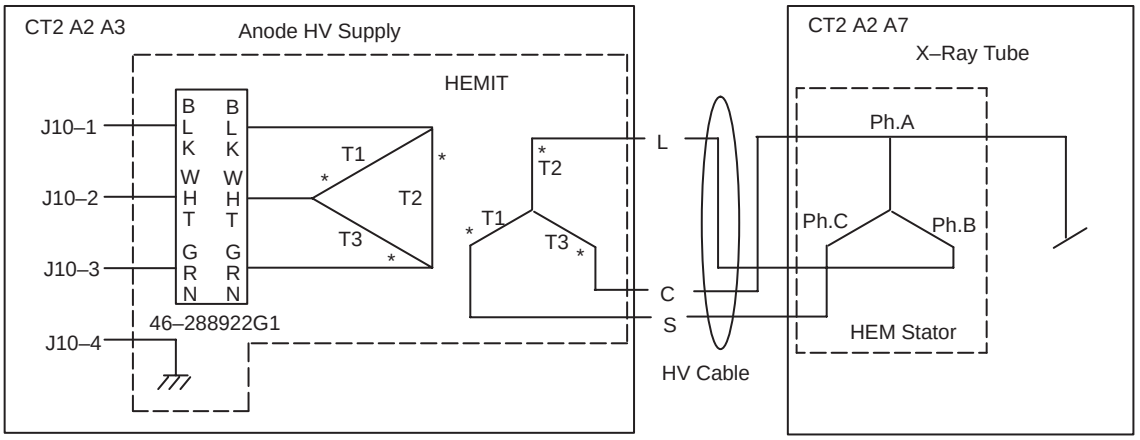

Figure 9-16 HEMIT Wiring Diagram

RESISTANCE READINGS FOR HEMIT

Input
- J10-1 to 2 Approx 1.2 Ohms
- J10-2 to 3 Approx 1.2 Ohms
- J10-1 to 3 Approx 1.2 Ohms

Output
- L to C Approx 1.2 Ohms
- S to C Approx 1.2 Ohms
- L to S Approx 1.3 Ohms

RESISTANCE READING AT THE TUBE WELLS

Cathode
- L to C Approx 0.2 Ohms
- S to C Approx 0.2 Ohms
- L to S Approx 0.3 Ohms

Anode
- L to C Approx 2.3 Ohms
- S to C Approx 2.3 Ohms
- L to S Approx 2.3 Ohms

Note: At no time should you read any continuity to ground. Readings are approximates, variability in meter leads and measurement methods should be taken into consideration.

Internal Connections

HEMRC

TERMINAL	SIGNAL	DESCRIPTION
S	H4	380 Vac input from transformer, T1
T	H1	380 Vac return from transformer, T1
DC+	DC+	Bidirectional DC bus connection from CR1+, Filter Board, and Chopper Resistor Assembly
DC-	DC-	Bidirectional DC bus connection from CR1-, Filter Board, and Chopper Resistor Assembly
U	BLK	Phase 2 to Stator Filter on Anode HV Supply
V	WHT	Phase 1 to Stator Filter on Anode HV Supply
W	GRN	Phase 3 to Stator Filter on Anode HV Supply

Table 9-32 A1 TB1 – HEMRC AC Drive Power Connections, A1

"TO" HEMRC INTERFACE BOARD

TERMINAL	SIGNAL	DESCRIPTION
10	HEMRC_AT_SPD*	At speed signal to the OBC via I/F Board
11	HEMRC_FLT_SPD_RTN	Common return for _FLT_ and HEMRC_AT_SPD*
signals to the OBC via I/F Board	13	HEMRC_FLT_SPD_RTN
Jumper to terminal 11	14	HEMRC_FLT_NO
Normally open fault signal to the OBC via I/F Board	15	HEMRC_FLT_NC
Normally closed fault signal to the OBC via I/F Board		

Table 9-33 A1 TB2 – To HEMRC Interface Board, A2

"FROM" HEMRC INTERFACE BOARD

TERMINAL	SIGNAL	DESCRIPTION
19	START_HEMRC*	Start command from the OBC via I/F Board
20	STOP_HEMRC	Stop command from the OBC via I/F Board
21	STRT_STP_COM	Common return for START_HEMRC* and STOP_HEMRC signals from the OBC via I/F Board
24	HEN_P1	High side of auxiliary enable from the I/F Board
25	HEN_P2	Low side of auxiliary enable from the I/F Board
29	HEMRC_EN_N	Low side of enable signal from the OBC via I/F Board
30	HEMRC_EN_P	High side of enable signal from the OBC via I/F Board

Table 9-34 TB3 – From HEMRC Interface Board

"TO/FROM" HEMRC INTERFACE BOARD

PIN#	SIGNAL	DESCRIPTION
1	HEMRC_CAN_H	Bidirectional CAN data line (high) to the OBC via I/F Board
3	HEMRC_ISO_RTN	Return for the 12V power supply to the OBC via I/F Board
4	HEMRC_ISO_+12V	AC Drive 12V power supply to the OBC via I/F Board
6	HEMRC_CAN_L	Bidirectional CAN data line (low) to the OBC via I/F Board

Table 9-35 J3 –– To/From HEMRC Interface Board

DIODE BRIDGE

PIN#	SIGNAL	DESCRIPTION
1	HVDC	Fused HVDC+ to bridge diode
2	HVDC	Fused HVDC+ to bridge diode
3	—	No connection
4	—	No connection
5	HVDC_RTN	Fused HVDC- to bridge diode
6	HVDC_RTN	Fused HVDC- to bridge diode

Table 9-36 J1 - To chassis mounted Diode Bridge, CR1

RESISTOR R4

PIN#	SIGNAL	DESCRIPTION
1	none	One end of dropping resistor R1
2 to 9	—	No connection
10	none	Other end of dropping resistor R1

Table 9-37 J4 – To Resistor, R4

RESISTOR R5

PIN#	SIGNAL	DESCRIPTION
1	none	One end of dropping resistor R2
2 to 9	—	No connection
10	none	Other end of dropping resistor R2

Table 9-38 J5 – To Resistor, R5

"TO/FROM" CHOPPER RESISTOR ASSEMBLY

PIN#	SIGNAL	DESCRIPTION
1	DCOUT+	AC Drive internal DC+
2	—	No connection
3	DCFUSED	Fused AC Drive internal DC+
4	—	No connection
5	CHOP_R	Chopper power resistor assembly
6	—	No connection
7	—	No connection
8	DCOUT-	AC Drive internal DC-

Table 9-39 J7 - To/From Chopper Resistor Assembly

"TO SCR" CHOPPER RESISTOR ASSEMBLY

PIN#	SIGNAL	DESCRIPTION
1	GATE	To Gate of SCR
2	—	No connection
3	GATE_RTN	To auxiliary Cathode of SCR
4	none	Interlock loopback to J8-5
5	none	Interlock loopback to J8-4

Table 9-40 J8 - To SCR on Chopper Resistor Assembly SCR1

HEMRC AC DRIVE

PIN#	SIGNAL	DESCRIPTION
1	STOP_HEMRC	Stop command to the AC drive
2	spare	Unused
3	HEMRC_FLT_SPD_RTN	Common return for _FLT_ and HEMRC_AT_SPD* signals from the AC drive
4	HEMRC_AT_SPD*	At speed signal from the AC drive
5	HEMRC_ISO_+12V	AC Drive 12V power supply from the AC drive
6	HEMRC_ISO_RTN	Return for the 12V power supply from the AC drive
7	HEMRC_EN_P	High side of enable signal to the AC drive
8	HEMRC_EN_N	Low side of enable signal to the AC drive
9	HEN_P1	High side of auxiliary enable to AC drive
10	HEN_P2	Low side of auxiliary enable to AC drive
11	HEMRC_CAN_L	Bidirectional CAN data line (low)
12	HEMRC_CAN_H	Bidirectional CAN data line (high)
13	HEMRC_FLT_NO	Normally open fault signal from the AC drive
14	HEMRC_FLT_NC	Normally closed fault signal from the AC drive
15	STRT_STP_COM	Common return for START_HEMRC* and STOP_HEMRC signals to the AC drive
16	START_HEMRC*	Start command to the AC drive
17	—	No connection
18	—	No connection
19	—	No connection
20	—	No connection

Table 9-41 J10 – To/From HEMRC AC Drive

POWER SUPPLIES

PIN#	SIGNAL	DESCRIPTION
3	Fil_120	Fused 120 Vac to filament power supply, PS7
4	Fil_0	0Vac to filament power supply
5	Xform_120	(X3) Fused 120 Vac to Isolation Transformer, T1
6	0VAC	(X1) 0Vac to Isolation Transformer

Table 9-42 J12 - To Power Supplies

2.3.4.9 Test Points, LEDs, Fuses & Tap Adjustments

DANGER

VARIOUS COMPONENTS, INCLUDING THE CHOPPER RESISTOR ASSEMBLY AND HEMRC INTERFACE BOARD, ARE REFERENCED TO THE HEMRC AC DRIVE DC BUS AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

THE HEMRC INTERFACE BOARD CONTAINS NO TEST POINTS. ALL ACTIVE CIRCUITRY IS HIGH IMPEDANCE AND TIED TO HAZARDOUS VOLTAGES. DO NOT PROBE.

HERMC LEDS

LED	COLOR	DESCRIPTION
A1 A1 DS1	Red	Fault condition detected by AC Drive
DS1	Yellow	Power applied to AC Drive
DS1	Yellow	HVDC bus energized
DS2	Green	120 Vac applied to the Interface board
DS3	Yellow	AC Drive DC+ and DC- energized
DS4	Red	Fault detected in the Chopper Control

Table 9-43 HERMC LEDs

HEMRC FUSES

FUSE#	VALUE	DESCRIPTION
F1	20A, 700Vdc	HVDC- to HEMRC AC Drive
F2	20A, 700Vdc	HVDC+ to HEMRC AC Drive
F3	3A, 250Vdc	Not used
F4	8A, 350Vac Slo-Blo	120 Vac to Filament power supply
F5	8A, 350Vac Slo-Blo	120 Vac to HEMRC AC Drive Isolation Transformer
A4 F1	10A, 700Vdc	DCIN+ to Chopper Resistor Assembly
PS5 F1	10A, 32V	Not Used
PS7 F1	15A, 250V	Fused DC to mA Board in the OBC

Table 9-44 HERMC Fuses

A4R1 & A4R2 TAP ADJUSTMENTS

Verify/Align the connection tabs and hardware of the chopper resistors A4R1 and A4R2 so they clear any sheet metal by at least 0.5in.

Adjust the tap band on chopper resistor A4R1 to 8 ohms, ± 0.5 ohms, with respect to the end connected to fuse A4F1.

The tap band on chopper resistor A4R2 is not used, but you still must secure the band in place to prevent dielectric failure to the adjacent sheet metal. To minimize confusion, adjust the tap band to 8 ohms, ± 0.5 ohms, with respect to the end connected to A2J7-5.

2.4 mA Control Board

The 2154834 mA Board is managed by the Cathode mA. This change is required for compatibility with the Performix X-Ray Tube.

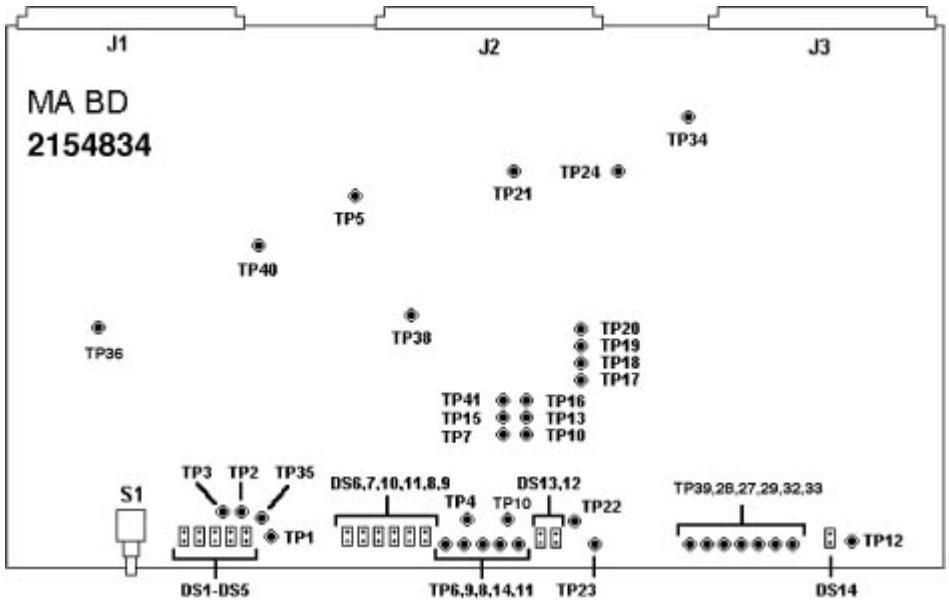

Figure 9-17 2154834, HEMRC mA Board

2.4.1 mA Board LEDs

DS1: (GRN) CLOOP	mA Loop is Closed
DS2: (GRN) INVEN	Inverter is Enabled
DS3: (RED) ANO	Anode OverCurrent Fault Detected in mA Monitoring
DS5: (RED) CAO	Cathode OverCurrent Fault Detected in mA Monitoring
DS6: (RED) FIL FLT	Filament Inverter Fault Detected (includes Inverter Fault Filament Undercurrent, Filament Overcurrent Open Filament and Shorted Filament)
DS7: (RED) INV FLT	Inverter Fault Detected
DS8: (RED) FIL UC	Filament Undercurrent Fault Detected
DS9: (RED) OFIL	Open Filament Fault Detected
DS10: (RED) SH FIL	Shorted Filament Fault Detected
DS11: (RED) FIL OC	Filament Overcurrent Fault Detected
DS12: (RED) IFLT	Filament Inverter Fault Detected (same as DS5 except on Inverter section of board)
DS13: (GRN) SMSP	Small Focal Spot is Selected
DS14: (GRN) INV ON	Inverter is On

2.4.2 mA Board Test Points

TP1: +5 V	+5 V Reference Supply
TP2: SGND	Signal ground
TP3: FERR	Filament Error output from AR3, P7 (0.5 Volt/Amp)
TP4: CAMA	Cathode HV supply mA feedback (1 Volt/100mA)
TP5: FSIG	Filament Demand output from AR7, P1 (1 Volt/Amp)
TP6: LGND	Logic Ground

TP7: -10REF	-10 V Reference Supply
TP8: ACAL1	Put an Ammeter between ACAL1 and CCAL2 as part of anode meter cals (200 mA scale)
TP9: CCAL1	Put an Ammeter between CCAL1 and CCAL2 as part of cathode meter cals (200 mA scale)
TP10: ANMA	Anode HV supply mA feedback (1 Volt/100mA)
TP11: ACAL2	Put an Ammeter between ACAL1 and ACAL2 as part of anode meter cals (200 mA scale)
TP12: FSHG	
TP13: MAFB	mA feedback into multiplying DAC U44, P17
TP14: CCAL2	Put an Ammeter between CCAL1 and CCAL2 as part of cathode meter cals (200 mA scale)
TP16: +24 V	+24 V Supply
TP20: FILSH	Filament Short Signal
TP21: +30 V	+30 V Reference Supply
TP22: FCMD	Filament Command output from AR12, P1 (1 Volt/Amp)
TP23: FCUR	Filament Feedback into PWM U67, P1 (1 Volt/Amp)
TP24: +15 V	+15 V Reference Supply
TP27: FIL CT	Filament Waveform into the Center Tap of the Filament Transformer
TP28: PD	Switching Interval Waveform from the PWM
TP29: FIL2	Filament Inverter Q12 drain Voltage
TP31: FGND	GND Tied to End of Guard Band
TP32: FIL1	Filament Inverter Q14 Drain Voltage
TP33: FSH	Filament Current – DC Level
TP35: +5LED	+5 V LED Chassis Supply
TP36: +5 V	+5 V Chassis Supply
TP37: -15V	-15 V Reference Supply
TP38: +15AV	+15 V Reference Supply
TP39: FD	Tie this Test Point high to disable fault generation
TP40: FDMD	Filament Demand
TP41: MAMUX	mA MUX Selection Output
TP42: FGND	GND Tied to End of Guard Band

2.4.3 mA Board Switch Settings

S1: RESET - Manual reset for the board

2.5 HEMRC Control Board

The HEMRC Control Board (High Efficiency Motor Rotor Control), performs three main functions. It provides an interface between the OBC and the HEMRC, HVDC Bus voltage monitoring, and a

CAN interface between the OBC and future subsystems.

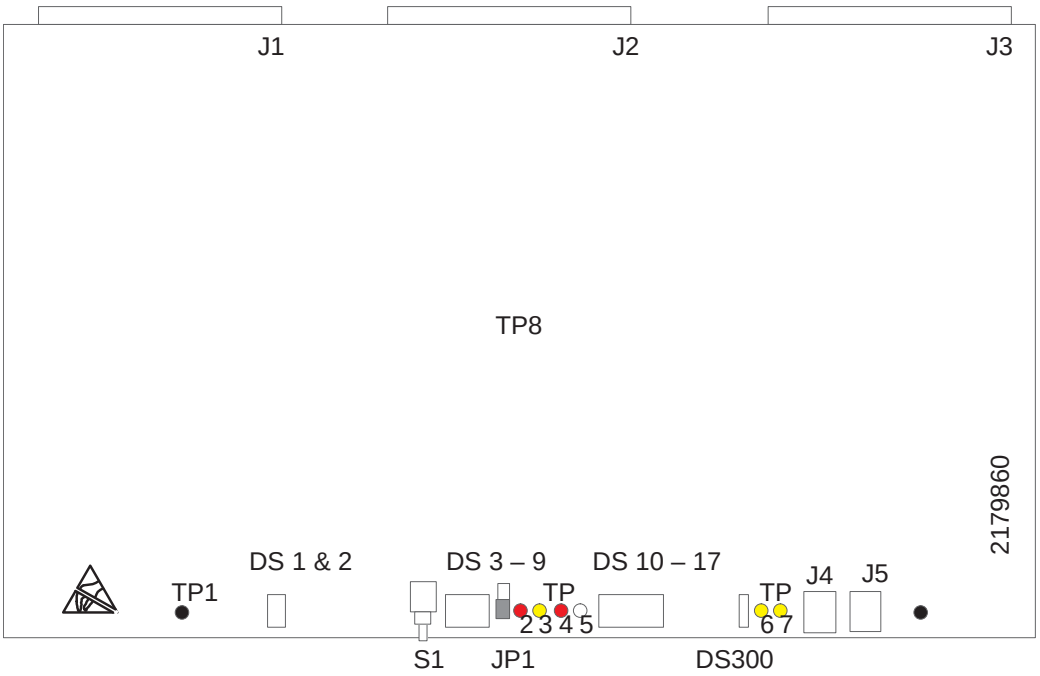

Figure 9-18 2179860 HEMRC Board

2.5.1 HEMRC Board Test Points

TP1: (BLK) LGND	Logic ground
TP2: (RED) +5V	+5 V supply voltage
TP3: (YEL) MUX	Analog signal as selected by the muxes
TP4: (RED) +15V	+15 V supply voltage
TP5: (WHT) -15V	-15 V supply voltage
TP6: (YEL) +10V	+10 V Reference
TP7: (YEL) DCV	DC rail monitor voltage. Scale: 100 V/V
TP8: (BLK) SGND	Signal ground

2.5.2 HEMRC Board LEDs

DS1: (YEL) LORPM	Indicates HEMRC output frequency is below programmed threshold
DS2: (YEL) LOV	Indicates the DC Rail is less than 470 V.
DS3: (RED) HIV	Indicates a DC Rail overvoltage (> 670 V) detected.
DS4: (RED) GFLT	Indicates a fault on a Gantry CAN based subsystem.
DS5: (GRN) G1TX	Indicates Gantry CAN 1 is transmitting.
DS6: (GRN) G2TX	Indicates Gantry CAN 2 is transmitting.
DS7: (GRN) GRX	Indicates GCAN is receiving.
DS8: (GRN) HRX	Indicates HEMRC CAN is receiving.
DS9: (RED) HFLT	General. Function defined by firmware.
DS10: (GRN)	General. Function defined by firmware.

DS11: (GRN)	General. Function defined by firmware.
DS12: (GRN)	General. Function defined by firmware.
DS13: (GRN)	General. Function defined by firmware.
DS14: (GRN)	General. Function defined by firmware.
DS15: (GRN)	General. Function defined by firmware.
DS16: (GRN)	General. Function defined by firmware.
DS17: (GRN)	General. Function defined by firmware.
DS300: (GRN) G12V	Indicates that GCAN_+12V_ISO is present.

2.5.3 HEMRC Board Jumper Setting (JP1)

The maximum output of the PDU can be determined by the OBC by reading the location of this jumper. This jumper location indicates whether or not the PDU has a DCRGS.

JUMPER POSITION

A = Selects voltage limits for systems with a DCRGS. (This is the default shipping position).

B = Selects voltage limits for systems with an Unregulated HVDC Supply. This is the LightSpeed Plus position.

2.5.4 HEMRC Board Jumper Plug

The jumper plug is a four position “shorting” plug that is installed in either the J4 or J5 CAN loopback connector. This jumper plug location selects whether the unit is in the normal or diagnostic CAN mode.

JUMPER PLUG

J5 = (Normal) Selects normal CAN operation where the HEMRC CAN and Gantry CAN are connected to their respective CAN networks. (This is the default shipping position).

J4 = (Loopback) Selects diagnostic CAN mode where the HEMRC CAN and Gantry CAN networks are connected together.

2.5.5 HEMRC Board Switch Function

S1: RESET	Resets all command, fault and interrupt latches on this board, and also creates a GCAN_RESET signal that is sent to downstream controllers via the control interface bus connections.

2.6 HEMRC Interface Board

The HEMRC (High Efficiency Motor Rotor Control) Interface Board provides a transition point for terminating existing gantry harness connections at J3 and J9. The board also provides the input means for the system to monitor the HVDC Bus and AC distribution.

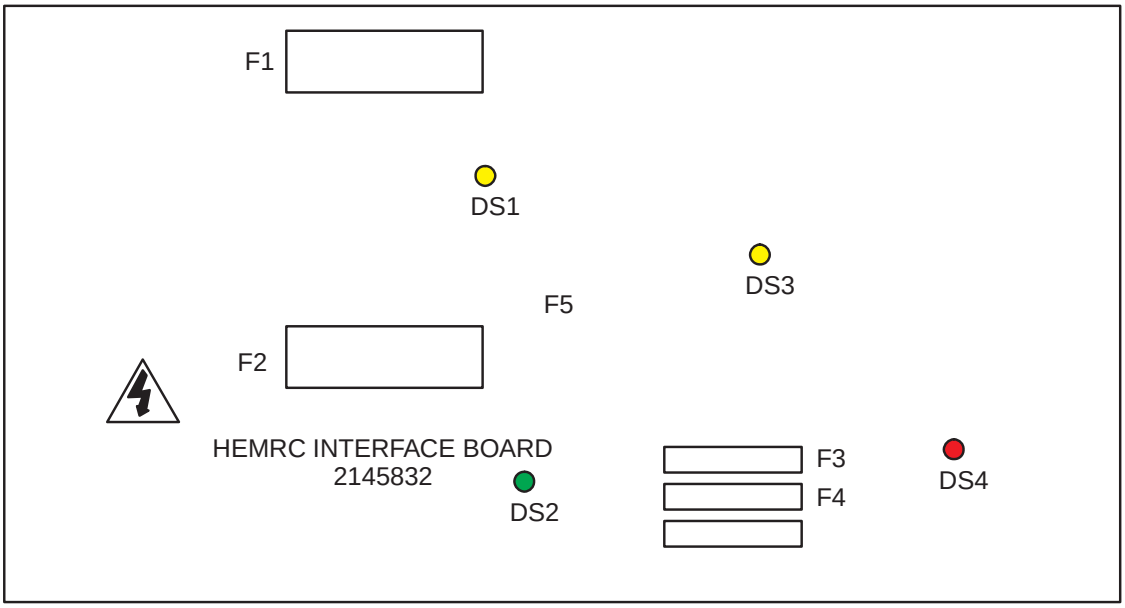

Figure 9-19 2145832 HEMRC Interface Board

2.6.1 HEMRC Interface Board Test Points

CAUTION
Potential for Electrical Shock

There are no test points on this board. All active circuitry is high impedance and tied to hazardous voltages. It must not be probed.

The Chopper Control circuit is referenced to the DC- rail at all times. This is a potentially lethal voltage source. DO NOT connect to ground.

2.6.2 HEMRC Interface Board LEDs

DS1: (YEL)	Indicates the HVDC- to HEMRC AC Drive.
DS2: (GRN)	Indicates 120 Vac is applied to the board.
DS3: (YEL)	Indicates the AC Drive DC+ and DC- are energized.
DS4: (RED)	Indicates a fault was detected in the Chopper Control.

2.6.3 HEMRC Interface Board Fuses

F1: (20A, 700 Vdc)	HVDC- to HEMRC AC Drive.
F2: (20A, 700 Vdc)	HVDC+ to HEMRC AC Drive.
F3: (3A, 250 Vac)	Not Used.
F4: (8A, 250 Vac slo-blo)	120 Vac to Filament power supply.
F5: (8A, 250 Vac slo-blo)	120 Vac to HEMRC AC Drive Isolation Transformer.

2.7 kV Control Board

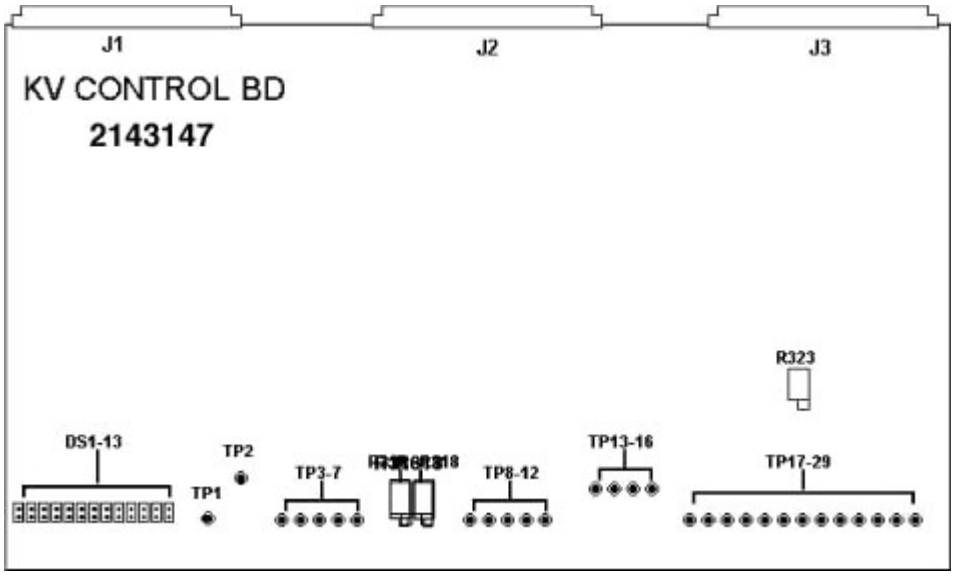

Figure 9-20 2143147 kV Control Board

2.7.1 kV Control Board Test Points

TP1 HVON	Indicates the kV feedback equals or exceeds 75% of command.
TP2 +5V	+5V (VCC) logic power.
TP3 LGND	Logic ground.
TP4 TRIG	A “1” indicates the selected inverter(s) is (are) turned on.
TP5 EXCM	Indicates an exposure command is being received from RCOMM bd.
TP6 EXEN	Indicates exposures are not disabled by the CTVRC, I/O or mA bds.
TP7 SPIT	Indicates a spit has been detected and recovery is in process.
TP8 KVCM	kV command. Scale: 15kV/V.
TP9 ANKV	Anode kV feedback. Scale: 10 kV/V.
TP10 CAKV	Cathode kV feedback. Scale 10kV/V.
TP11 KVTB	Total kV feedback. Scale 20 kV/V.
TP12 SGND	Signal ground
TP13 MUX	Analog MUX output as selected by firmware.
TP14 +10V	+10V reference.
TP15 -15V	-15V supply voltage.
TP16 +15V	+15V supply voltage.
TP17 KVERR	Integrated kV error signal.
TP18 PCNT	Average inverter duty cycle. Scale: 12%/V - 10%.
TP19 SGND	Signal ground.
TP20 ANOC	Anode inverter current. Scale: 25 A/V.
TP21 CAOC	Cathode inverter current. Scale: 25 A/V.
TP22 APH	Anode inverter duty cycle. Scale: 20%/V - 100%.

TP23 CPH	Cathode inverter duty cycle. Scale: 200% - 20%/V.
TP24 VCNT	Frequency control voltage. Scale: 19.5 kHz + 2.2kHz/V.
TP25 LGND	Logic ground.
TP26 SAW	Sawtooth (5 to 10V) at double the inverter frequency, nominally 39 to 61 kHz.
TP27 FREQ	5V square wave at double the inverter frequency.
TP28 APLSA	“1” indicates an “ON” pulse of the anode inverter.
TP2 CPLSA	“1” indicates an “ON” pulse of the cathode inverter.

2.7.2 kV Control Board LEDs

DS1 SPRT	Indicates the maximum spit rate has been exceeded.
DS2 GFLT	Indicates a “GO” fault has occurred.
DS3 ANST	Indicates an anode shoot-through has occurred.
DS4 CAST	Indicates a cathode shoot-through has occurred.
DS5 ANOC	Indicates an anode overcurrent has occurred.
DS6 CAOC	Indicates a cathode overcurrent has occurred.
DS7 ANOV	Indicates an anode overvoltage has occurred.
DS8 CAOV	Indicates a cathode overvoltage has occurred.
DS9 AINT	Indicates the anode inverter interlock is open.
DS10 CINT	Indicates the cathode inverter interlock is open.
DS11 OVRV	Indicates the kV feedback has exceeded the upper limit of the load regulator. May be ignored if on after power up or hardware reset.
DS12 HVND	Indicates anode and/or cathode kV feedback signals exceed 10 kV.
DS13 INON	Indicates the selected inverter(s) is (are) turned on.

2.7.3 kV Control Board Switch Settings

S1: InSite readable dip switch set for the ASCII equivalent of the board assembly version.

2.7.4 kV Control Board Adjustments

R316 CAKV	Adjusts the gain of the cathode kV feedback. Factory adjusted for unity gain. Field adjusted during HV PS cal procedure. Range: approximately ±20%.
R318 ANKV	Adjusts the gain of the anode kV feedback. Factory adjusted for unity gain. Field adjusted during HV PS cal procedure. Range: approximately ±20%.
R323 (FREQ)	Factory adjusted for minimum frequency of 39.0 kHz ±1.0 kHz at TP27 (FREQ) with TP24 (VCNT) set to 0V. Should not require field adjustment.

2.8 Gentry I/O Board

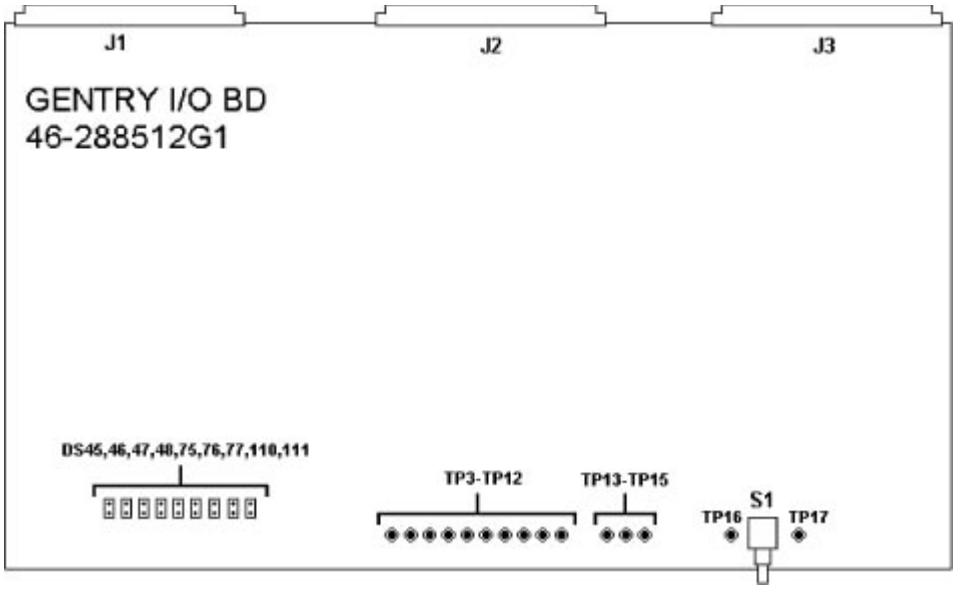

Figure 9-21 46-288512G1 Gentry I/O Board

2.8.1 Gentry I/O Board Test Points

TP3: +5V	TP8: +12V	TP13: SOUT
TP4: LGND	TP9: -12V	TP14: -SIN
TP5: SGND	TP10: +10V	TP15: SRTN
TP6: +15V	TP11: +24V	TP16: +SIN
TP7: -15V	TP12: A/DIN	TP17: PGND

2.8.2 Gentry I/O Board LEDs

DS45: ECMD INTR	DS76: ADC CMPLT
DS46: BCTR INTR	DS77: BTMR EXP
DS47: DTHTR INTR	DS110: TPRLY ON
DS48: BCTR CLS	DS111: INTR CLS
DS75: AXLTS ON	

2.8.3 Gentry I/O Board Switch Settings

S1: Reset

2.9 Interface Measurement Board

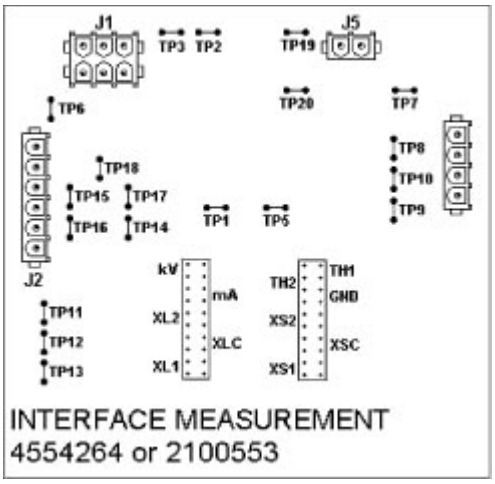

Figure 9-22 Interface Measurement Board

INTERFACE MEASUREMENT BOARD TEST POINTS

TP1 KV	Sensed kV signal - Scale 10 kV/V
TP2 KV	kV signal to OBC
TP3 KV GND	kV return signal to OBC
TP4	
TP5 MA	Sensed kV signal - Scale 100 kV/V
TP6 MA GND	mA return signal to OBC
TP7 PS1	Pressure Switch 1
TP8 PS2	Pressure Switch 2
TP9 TH1	Thermistor 1 (not used)
TP10 TH2	Thermistor 2 (not used)
TP11 XS2	Small Filament 2
TP12 XSC	Small Filament Common
TP13 XS1	Small Filament 1
TP14 XL2	Large Filament 2
TP15 XLC	Large Filament Common
TP16 XL1	Large Filament 1
TP17 MAout	mA signal to OBC
TP18 GND	Tank ground
TP19 kV	Sensed kV signal - Scale 10 kV/V
TP20 GND	Tank ground

See “X-Ray Generation,” on page 681.

Section 3.0
Procedures and Adjustments

3.1 Collimator/Detector Heater Power Supply

TEST POINTS	SPECIFICATIONS
Across output lugs on power supply	24 vdc ± 1 vdc

Table 9-45 Detector Heater Power Supply

ADJUSTMENT PROCEDURE

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Remove gantry side covers and top covers.
2.) Turn **OFF** Axial Drive and HVDC on the STC backplane.
3.) Rotate gantry until Collimator/Detector Power assembly reaches the 2 o'clock position.
4.) Engage gantry rotational lock.
5.) Remove four (4) nuts on Filament Power assembly safety cover and remove cover.
6.) Collimator P.S. output checks:
   - Connect positive voltmeter lead to +OUT terminal on power supply.
   - Connect negative voltmeter lead to -OUT terminal on power supply.
   - Turn voltage adjustment pot to adjust the output voltage to 24 ± 1 VDC.
7.) Reassemble Gantry.

Reference "DAS Power Supply – Left/Right Side," on page 796, for replacement procedures.

3.2 Collimator Fuse 6 Amp

Located on the Fuse box assembly. Use good service procedures.

3.3 Filament Power Supply

TEST POINTS	SPECIFICATIONS
Across Fuse and chassis on HEMRC Assembly	+28 vdc to +37 vdc

Table 9-46 Filament Power Supply

There are no adjustments for this power supply.

CHECK PROCEDURE

CAUTION
Potential for Electrical Shock

When Gantry 120 Vac is energized, 440 VAC is present in the HEMRC assembly. All active circuitry is high impedance and tied to hazardous voltages.

The Chopper Control circuit is referenced to the DC- rail at all times. This is a potentially lethal voltage source. DO NOT connect to ground.

1.) Remove gantry side covers and top covers.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC 120 Vac) on the STC backplane.
3.) Rotate gantry until HEMRC assembly reaches the 2 o'clock position.
4.) Engage gantry rotational lock.
5.) Remove HEMRC cover.
6.) Connect DVM + plus lead to fuse terminal located at HEMRC 2nd tier left rear next to T1 transformer. Connect DVM - minus lead to HEMRC chassis.
7.) Turn 120 Vac switch **ON** at the STC backplane.
8.) Verify voltage.
9.) Turn 120 Vac switch **OFF** at the STC backplane.
10.) Remove DVM connections and reassemble gantry.

3.4 A4R1 & A4R2 Tap Adjustments

CAUTION
Potential for Electrical Shock

When Gantry 120 Vac is energized there is 440 VOLTS present in the HEMRC assembly. All active circuitry is high impedance and tied to hazardous voltages.

The Chopper Control circuit is referenced to the DC- rail at all times. This is a potentially lethal voltage source. DO NOT connect to ground.

Perform All Adjustments using proper Lockout/Tagout Procedures.

1.) Remove gantry side covers and top covers.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC 120 Vac) on the STC backplane.
3.) Rotate gantry until HEMRC assembly reaches the 2 o'clock position.
4.) Engage gantry rotational lock.
5.) Remove HEMRC Resistor cover.
6.) Verify/Align the connection tabs and hardware of the chopper resistors A4R1 and A4R2 so they clear any sheet metal by at least 0.5in.
7.) Adjust the tap band on chopper resistor A4R1 to 8 ohms, ± 0.5 ohms, with respect to the end connected to fuse A4F1.
8.) The tap band on chopper resistor A4R2 is not used, but you still must secure the band in place to prevent dielectric failure to the adjacent sheet metal. To minimize confusion, adjust the tap band to 8 ohms, ± 0.5 ohms, with respect to the end connected to A2J7-5.
9.) Replace cover and reassemble gantry.

3.5 Access HV Maintenance through Service Desktop

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.

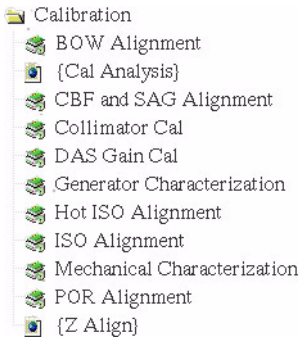

Figure 9-23 Calibration Menu Screen

3.6 Generator Characterization

Use the Generator Characterization Program to update the “small spot” and “large spot” characterization files, to provide a starting point for the closed loop mode of the generator. This iterative process requires several scans at a different KV/MA/spot size. It calculates corrections, repeats the scan until the results fall within tolerance, then updates the characterization file.

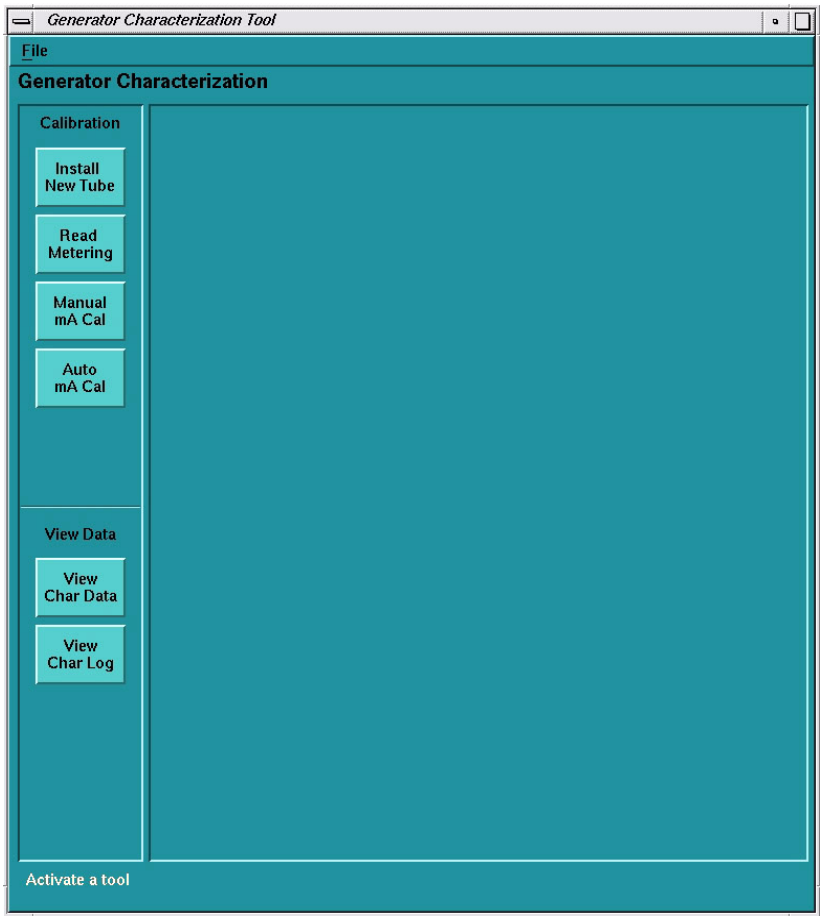

Figure 9-24 Generator Characterization Menu Screen

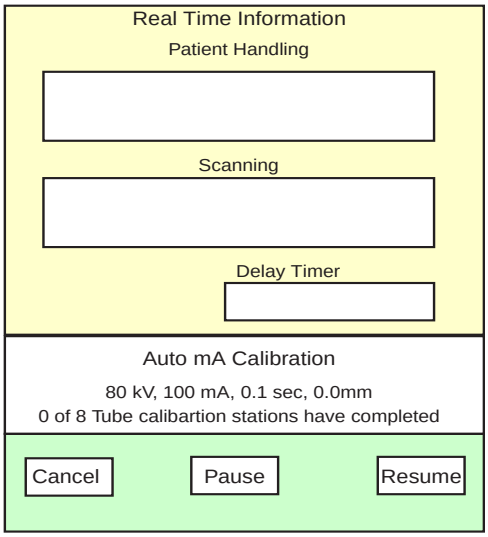

Figure 9-25 Auto mA Calibration Status Screen

3.7 X-Ray Generation / Collimation and Filtration

3.7.1 CAM A/B Amplifier Checkout Procedure

OBJECTIVE

Verify that the CAM A/B Amplifier is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

PROCEDURE SUMMARY

1.) Check the power supply to AMP.
2.) Swap cables with the other AMP.
3.) Select SERVICE DESKTOP.
4.) Select DIAGNOSTICS.
5.) Select COLLIMATOR AND FILTRATION.

6.) Exercise the CAM A/B and verify no test failures. Reference Figure 9-26.

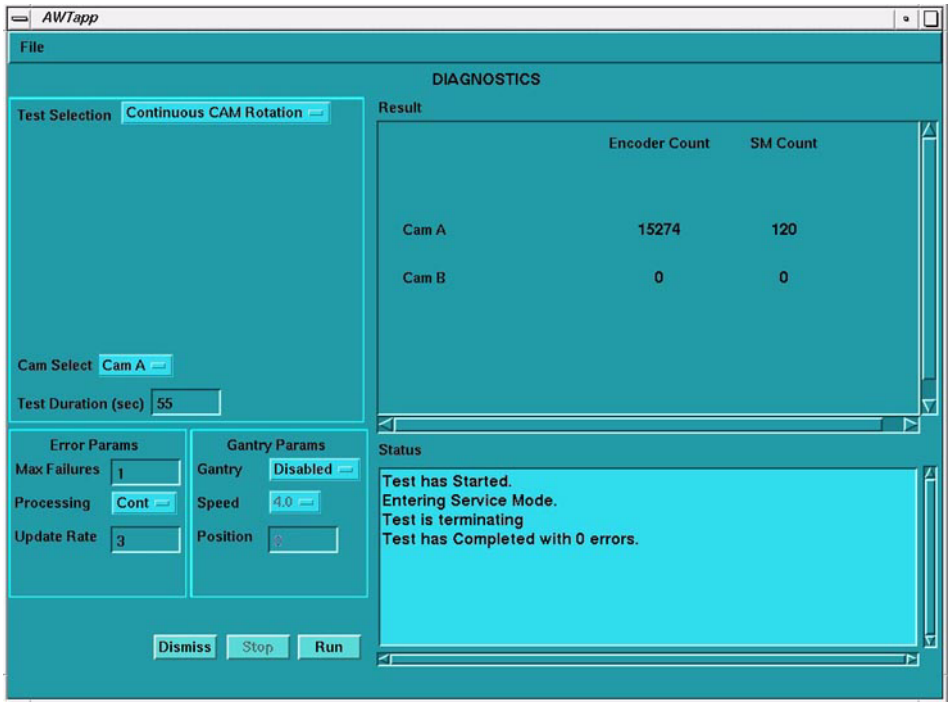

Figure 9-26 Collimator CAM Continuous Rotation Test

3.7.2 CAM A/B Encoder Checkout Procedure

OBJECTIVE

Verify that the CAM A/B Encoder is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

PROCEDURE SUMMARY

1.) Select SERVICE DESKTOP.
2.) Select DIAGNOSTICS.
3.) Select COLLIMATOR AND FILTRATION.
4.) Turn **OFF** the Axial Enable switch on the STC backplane.
5.) Engage gantry rotational lock.

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES TO PREVENT UNEXPECTED GANTRY MOTION.**

6.) Exercise the CAM A/B encoders and verify no test failures. Reference Figure 9-27.

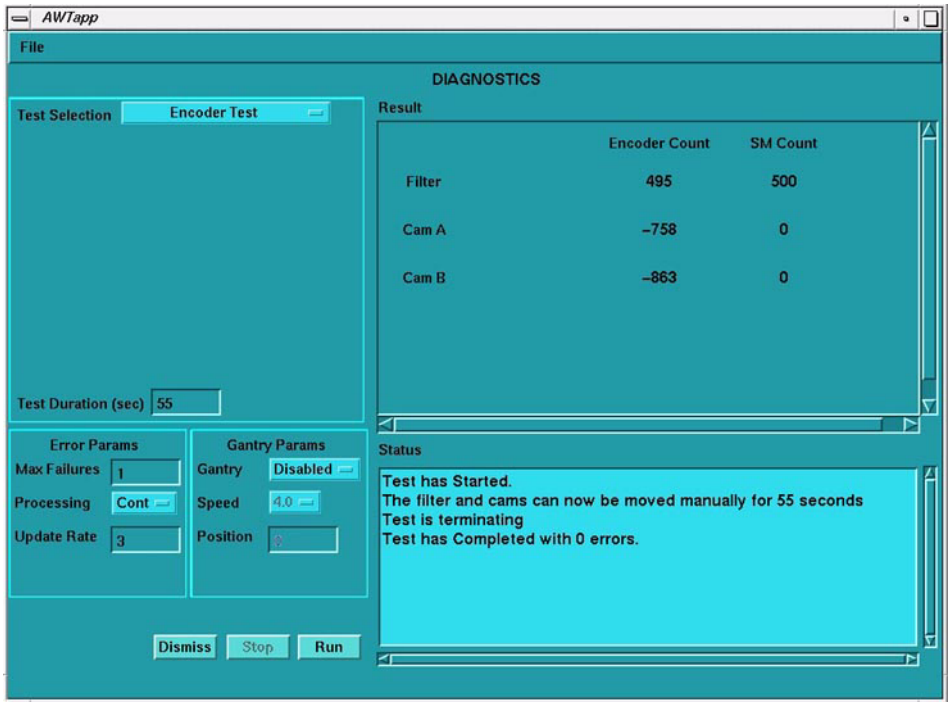

Figure 9-27 Collimator CAM A/B Manual Encoder Test

3.7.3 CAM A/B Motor Checkout Procedure

OBJECTIVE

Verify that the CAM A/B Motor is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

PROCEDURE SUMMARY

1.) Ohm CAM A (or CAM B) motor windings.
2.) Swap CAM drive harness with other CAM.
3.) Perform "CAM A/B Encoder Checkout Procedure," on page 744.

3.7.4 Collimator Control Board Checkout Procedure

OBJECTIVE

Verify that the Collimator Control (CCB) is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

PROCEDURE SUMMARY

1.) Verify correct "Flash" firmware is downloaded.
2.) Select SERVICE DESKTOP.
3.) Select DIAGNOSTICS.
4.) Select COLLIMATOR AND FILTRATION.
5.) Exercise the Application Position Test and verify no test failures. Reference Figure 9-28.

Figure 9-28 Collimator Applications Position Test

3.7.5 Characterization Software Procedure

OBJECTIVE

1.) Verify that the Characterization Software is functional.
2.) FRU's Involved - MOD / CD containing the most recent "System State".
3.) Perform Flash Download if necessary.

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

PROCEDURE SUMMARY

1.) Select SERVICE DESKTOP.
2.) Select UTILITIES.
3.) Select INSTALL.
4.) Select FLASH DOWNLOAD TOOL.
5.) Select QUERY.
6.) Select UPDATE if necessary. Reference Figure 9-29.

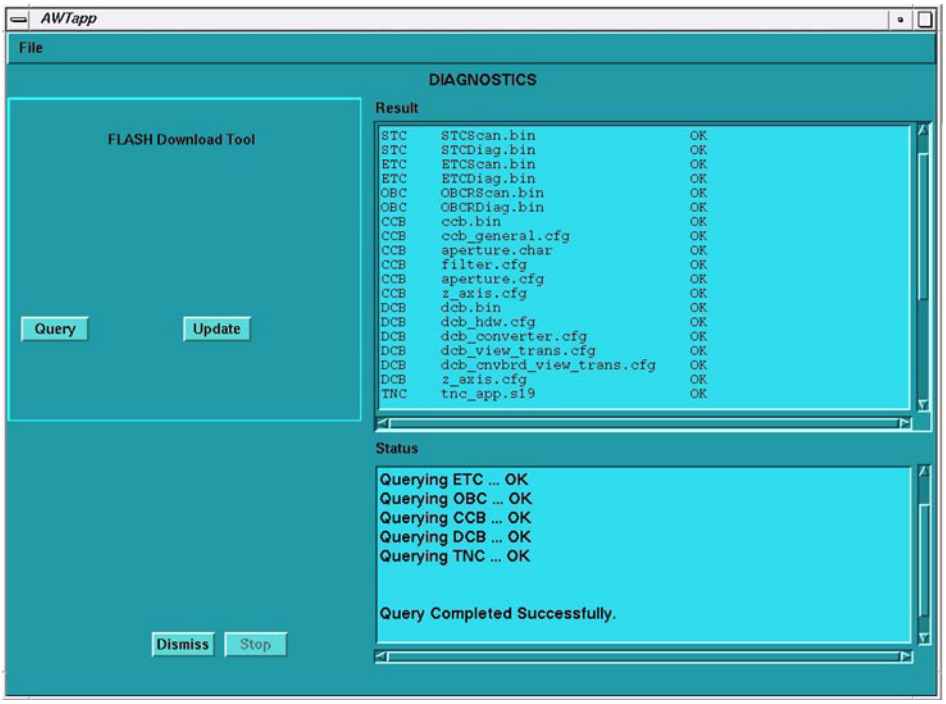

Figure 9-29 Flash Download Tool

3.7.6 Filter Amplifier Checkout Procedure

OBJECTIVE

Verify that the Filter Amplifier is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

PROCEDURE SUMMARY

Reference “Collimator Control Board Checkout Procedure,” on page 746, for diagnostics details.

3.7.7 Filter Encoder Checkout Procedure

OBJECTIVE

Verify that the Filter Encoder is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

PROCEDURE SUMMARY

Reference “Collimator Control Board Checkout Procedure,” on page 746, for diagnostics details.

3.7.8 Filter Home Switch Checkout Procedure

OBJECTIVE

Verify that the Filter Home Switch is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

PROCEDURE SUMMARY

Reference “Collimator Control Board Checkout Procedure,” on page 746, for diagnostics details.

3.7.9 Filter Drive/Motor Checkout Procedure

OBJECTIVE

Verify that the Filter Drive/Motor is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

PROCEDURE SUMMARY

Reference "Collimator Control Board Checkout Procedure," on page 746, for diagnostics details.

3.7.10 Procedure for Determining State of Rotor Operation

OBJECTIVE

1.) Determine the phase of Rotor operation during which an error is generated.

2.) Reference Document:

2145832SCH Schematic - HEMRC_IF, HVDC_Sense, Chopper_Cntl, AC_Dist, HCB

3.) The HEMRC Rotor has 9 phases of operation. There are 3 accel phases, 2 Run phases, 3 Brake phases, and idle. The 3 accel phases and the 1st run phase use HVDC. The rest of the phases use 120 Vac stepped up to 380VAC by T1. A graphical interpretation of the 9 Phases is shown in Figure 9-30.

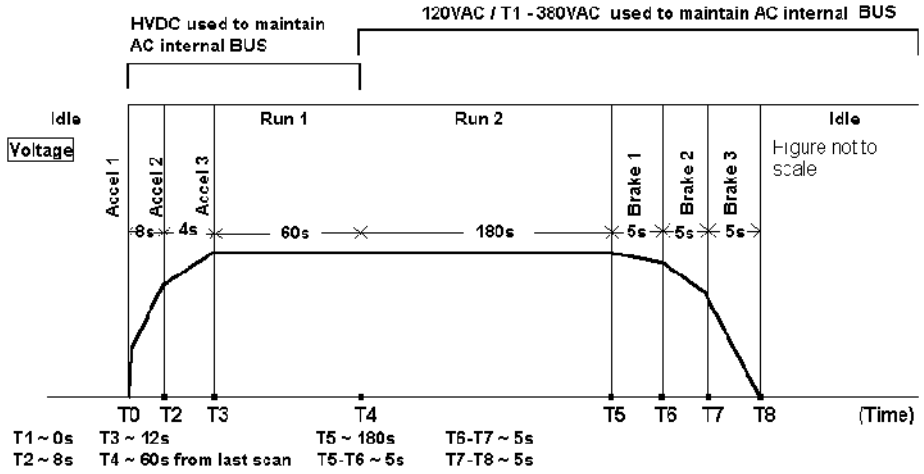

Figure 9-30 9 Phases of Rotor Operation

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

PROCEDURE SUMMARY

The best way to determine the phase is to understand which part of the scan cycle the rotor is in. This can be done by listening to tube accel, run and Brake noises coming from the tube:

- Tube will accelerate when commanded by diagnostics.(A.K.A. "Rotor Prep")
- Tube will accelerate when "Accept Rx" is checked.(A.K.A. "Rotor Prep")
- Tube will brake ≈ 180s after last slice or after last diag request.

3.7.11 HEMRC Rotor Functional Results for Normally Operating System

OBJECTIVE

1.) Give the user examples of Normal Operating Results for the Rotor Control.

2.) Reference Documents: Schematic - HEMRC_IF, HVDC_Sense, Chopper_Cntl, AC_Dist, HCB.

3.) Select DIAGNOSTICS.

4.) Select ROTOR CONTROL.

5.) FRUs Involved:

- HEMRC Interface Board - HIF (All phases)
- HEMRC AC DRIVE (All phases)
- Fuses F1, F2 on interface Bd (would produce a Primary Error of “NO HVDC”)
- HVDC BUS (1st 4 Phases)
- 120 Vac from Slip Ring Assembly (last 4 Phases)
- T1 transformer (last 4 Phases)
- Bridge rectifier - CR1 (1st 4 Phases)

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

PROCEDURE SUMMARY (THEORY/BACKGROUND)

1.) The HEMRC rotor has 9 phases of operation. 3 Accel phases, 2 Run phases, 3 Brake Phases, and idle. The 3 Accel and the 1st run phase use HVDC, the rest of the phases use 120 Vac stepped up to 380VAC by T1.

2.) Run the XRAY Generation / Rotor control Diags with “Test Selection: HEMRC Manual”.

3.) You should be able to observe the following Parameters in the “Test Window”:

- Rotor Op Mode
- Drive Output Current
- Drive Flux Current
- Drive Torque Current
- Drive Temperature
- HVDC Bus Voltage
- Drive Input Voltage
- Drive Output Voltage
- Drive Output Frequency
- Rotor Ref Voltage
- Drive Status Bit Map
- Drive Fault Code
- Status Register
- Fault Register

NORMAL RESULTS WITH UNREGULATED HVDC

Mode	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Run	Run	Run	Run	Run	Brake	Brake	Brake	Brake	Brake	Brake
Output Current	0	8.478	10.86	11.96	12.24	11.59	12	11.71	11.6	7.483	2.31	2.17	2.07	2.3	2.24	2.19	4.214	5.268	6.033	7.516	7.446	7.412	6.193
Flux Current	0	0.818	2.963	4.616	5.732	6.298	6.304	6.394	5.732	3.933	2.59	2.11	1.74	1.49	1.3	0.9	1.157	2.211	3.521	4.819	5.605	7.049	6.015
Torque Current	0	1.576	4.811	6.987	8.334	8.927	9.483	9.635	9.969	9.719	6.2	4.2	2.98	2.37	2.1	2.01	2.34	2.967	2.75	2.951	3.302	2.976	4.112
DriveTemp	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
HVDC Bus	540	541	541	540	540	542	540	541	540	542	541	541	541	541	542	542	273	85	29	11	4	1	1
Input Volt	544	538	535	537	537	537	538	537	539	543	550	566	545	545	546	542	487	601	639	634	553	481	473
Output Volt	0	56	87	112	126	142	185	232	319	106	100	99	99	99	99	99	200	200	200	236	208	100	22
Output Freq	0	50	77	99	111	126	155	194	274	297	280	280	280	280	280	280	274	258	24	221	195	100	21
Ref Volt	9.998	10	9.998	9.998	9.998	9.998	9.998	9.998	9.998	9.998	10	10	10	10	10	10	9.998	9.998	9.998	9.998	9.998	9.998	9.998
Status Bit	0E0C H	0E1F H	0E5F H	0E5F H	0E5F H	0E5F H	0E5F H	0E5F H	0E5F H	0E2F H	0F0F H	0F0F H	0F0F H	0F0F H	0F0F H	0F0F H	0E2F H	0E2F H	0E2F H	0E2F H	02EF H	0E2F H	0E2F H
Drive Fault	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Status Reg	02H	02H	02H	02H	02H	02H	02H	02H	02H	42H	42H	42H	42H	42H	42H	42H	46H	46H	46H	46H	46H	46H	46H
Fault Reg	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H

Figure 9-31 Results with CRPDU Unregulated HVDC

3.8 Frequency Sweeps – Tanks

3.8.1 Errors

Artifacts, CT Number Drifts, Shoot-through, Overcurrents, and mA problems.

3.8.2 Theory

By supplying a sine wave to the primary of the tank and varying the frequency, the impedance of the primary can be observed by measuring the RMS voltage dropped across the primary.

Note: This test only checks the tuned portion of the tanks. If this test reveals a bad tank, the tank is most likely the problem. However, if this test doesn't reveal a bad tank it doesn't absolve the tank, it only reduces the probability of the tank being the problem.

GENERAL GUIDELINES

- A good tank should show a linear rise with frequency with a peak between 40K to 100K HZ.
- A tank with shorted HV rectifiers or capacitors will show a peak between 2K to 20K HZ.
- A tank with a resistive failure such as carbonized insulation will show very low voltage with no well defined peak.

TOOLS

1.) BK 3001 Audio Generator, or equivalent.
2.) Meter to measure RMS voltage to 150 kHz.

FRU'S INVOLVED

Anode and Cathode Tank.

3.8.3 Summary

1.) Set up testing devices.
2.) Remove P1 and P2 wires from tank.
3.) Connect testing devices to tank.
4.) Frequency Sweep the tank using the Audio Generator.
5.) Determine disposition of tank.

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

3.8.4 Procedure Details

1.) Setup meter and Audio Generator
   - Set volt meter to AC Volts.
   - Set up Audio Generator (BK3001): Leads in output jack, Range to X100, waveform to sinewave, attenuation to 0.
   - Connect leads of Audio Generator to meter and adjust amplitude knob to achieve voltage between 1 to 5 volts.
2.) Remove P1 and P2 leads from the High Voltage Tank.
3.) Connect both the BK 3001 and the RMS Meter from P1 to P2 studs.
4.) Sweep the frequency from 2KHz to 150KHz, while monitoring the RMS voltage. Write down each value for reference.
5.) For a good High Voltage Tank, a peak measurement should occur between 40KHz to 100KHz (see Table 9-47). The absence of a peak, or the occurrence of a peak at a frequency other

than 40KHz to 100KHz indicates a High Voltage Supply failure. If the RMS measurements fluctuate at the higher frequencies (i.e., 2-10 volt drift), this tank is also bad. This should be noticeable on the High Voltage waveform at high techniques or it will show as artifacts on patient scans. Replace Tank if it fails to peak within 40kHz to 100kHz,or if the voltage across the RMS meter fluctuates while frequency is stable.

6.) End of procedure.

FREQUENCY SETTINGS ON AUDIO GENERATOR (KHZ)	TANK (MV) SAMPLE VALUES FOR BAD TANK	TANK (MV) SAMPLE VALUES FOR BAD TANK	TANK (MV) SAMPLE VALUES FOR GOOD TANK
2.0	100	55	55
2.8	150	66	66
3.2	175	70	70
4.2	250	81	81
5.0	350	89	89
6.4	750	101	101
7.5	1000	110	110
8	1000	113	113
10	600	129	129
12	340	138	138
15	220	154	154
18	160	159	159
20	130	201	201
28	80	174	174
32	60	167	167
42	30	225	225
50	20	324	324
64	30	578	578
75	50	517	517
80	60	Unstable Voltage	476
100	80	Unstable Voltage	260
120	100	Unstable Voltage	174
150	140	Unstable Voltage	124

Table 9-47 Frequency / Voltage Tank Settings

3.9 Verify kV Meter

This section describes the calibration check of system internal kV metering circuits.

1.) Select READ METERING.

2.) Select RUN to start the test. During the test, the firmware reads the metering circuits in the OFF state, then reads the metering circuits in the ON state, and finally reports the readings to the display.

3.) Compare the data in the “Delta” column on the Read Meter screen (Figure 9-4) to the data in the “Limit” column.

Note: “Delta” = DVM - A/D

CIRCUIT “OFF”	CIRCUIT “ON”
Anode kV = 0 ± 0.5	Anode kV = 50 ± 7.5
Cathode kV = 0 ± 0.5	Cathode kV = 50 ± 7.5
Total kV = 0 ± 0.5	Total kV = 100 ± 15.0

Table 9-48 Generator Characterization Test Specifications

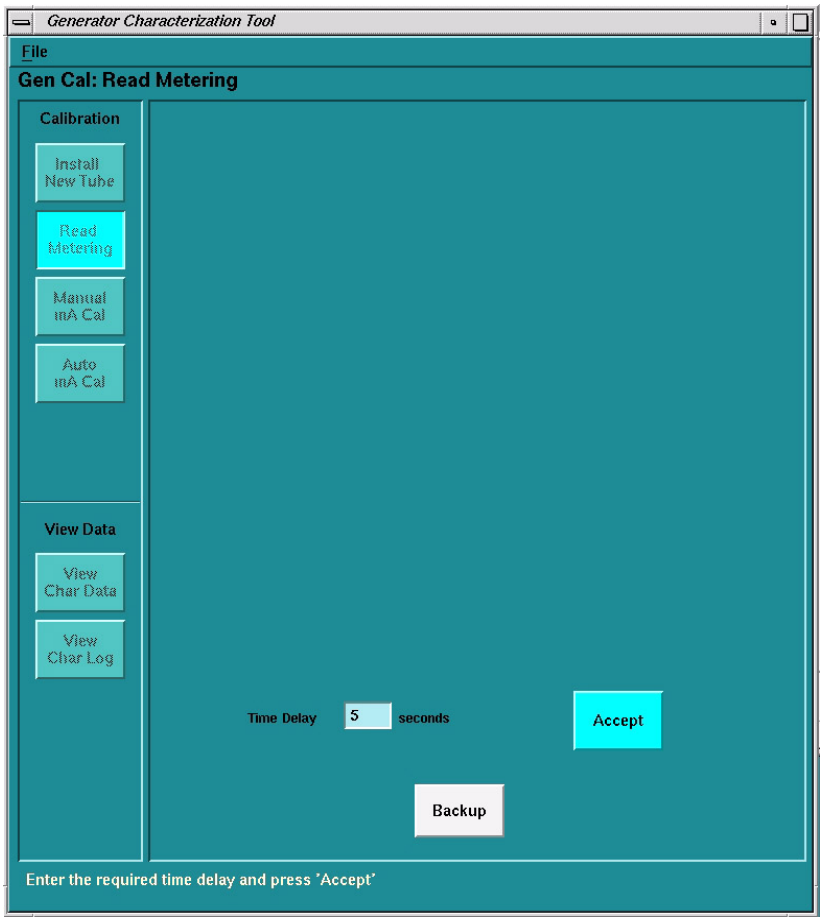

Figure 9-32 Read Metering Screen

3.10 Verify mA Meter

3.10.1 Summary

This section describes the calibration and checks system internal mA metering circuits.

1.) Launch Diagnostics.

2.) Set-up test equipment

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

3.10.2 Procedure Details

1.) Inside the Gantry:
   a.) Switch OFF the **HVDC ENABLE** on STC backplane.
   b.) Switch OFF the **AXIAL DRIVE ENABLE** on STC backplane.
   c.) Rotate the Anode tank to the 2 o'clock position.
   d.) Engage gantry rotational lock.

2.) Select SERVICE DESKTOP.

3.) Select CALIBRATION.

4.) Select GENERATOR CHARACTERIZATION.

5.) Select READ METERING.

Note: On the display, enter a time delay in seconds, to provide enough time for you to walk from the console to the DVM, and record the reading. The test will not begin until this time delay expires. Once it begins, the test enables the meter circuit for only 4 seconds.

6.) Use a DVM as an mA meter; connect it to the hardware on the anode side:
   a.) Connect the black lead to TP8 (ACAL1) on the mA board.
   b.) Connect the red lead to TP11 (ACAL2) on the mA board.

7.) On the Display, select the ACCEPT button.

8.) Record the displayed, and measured, Anode mA values for "Circuit OFF" and "Circuit ON".

Note: The Cathode side should read approximately 19 mA during "Circuit On".

9.) Disconnect the test equipment from the Anode side, if used.

Note: When you exit Generator Characterization, this test may generate kV board tube spit counter = x error messages.

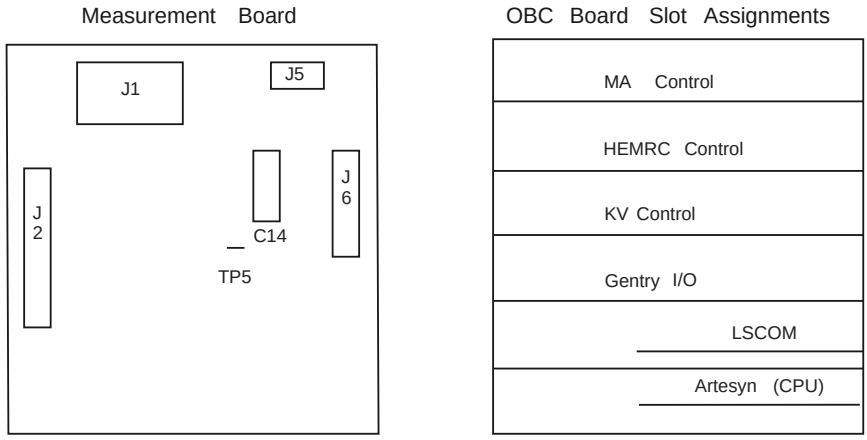

Figure 9-33 Tank Measurement Board

10.) Use a DVM as an mA meter:

a.) Connect the black lead to TP9 (CCAL1) on the mA board.

b.) Connect the red lead to TP14 (CCAL2) on the mA board.

11.) On the Display, Select the ACCEPT button.

12.) Record the displayed and measured Cathode mA values for “Circuit OFF” and “Circuit ON”.

Note: The Anode side should read approximately 20mA during “Circuit On”.

13.) Disconnect the test equipment from the Cathode side if used.

Note: When you exit Generator Characterization, this test may generate kV board tube spit counter = x error messages.

3.11 Set Calseed Values

3.11.1 Summary

This procedure creates the slope intercept relationship. The software needs to determine the power demands to achieve desired mA versus the loading effect of the tube.

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

3.11.2 Procedure Details

Use the following sequence to run a partial Install New Tube. Use this procedure to set the calseed values on a new system.

1.) Select UTIITIES.

2.) Select DIAGNOSTICS.

3.) Select INSTALL NEW TUBE.

4.) The system prompts you to verify the tube type.

5.) Verify the number corresponds to your tube type, answer **Y** (yes) or **N** (no):

SOFTWARE TOKEN	HOUSING #	INSERT #
12-MX_135CT	46-274800G1	46-274600G1
13-MX_165CT	46-309500G2	46-309300G1
14-MX_165CT_I	46-309500G2	46-309300G2
15-MX_200CT	2137130-2	2120785

Table 9-49 Software Tokens for Various Tube Housings & Inserts (CalSeed)

6.) Press START SCAN when it illuminates.

The system automatically runs the program and updates the display:
- seed filament current shift scans -

Note: ABORT the program after the seed filament current shift scans and before the ductility warm-up.

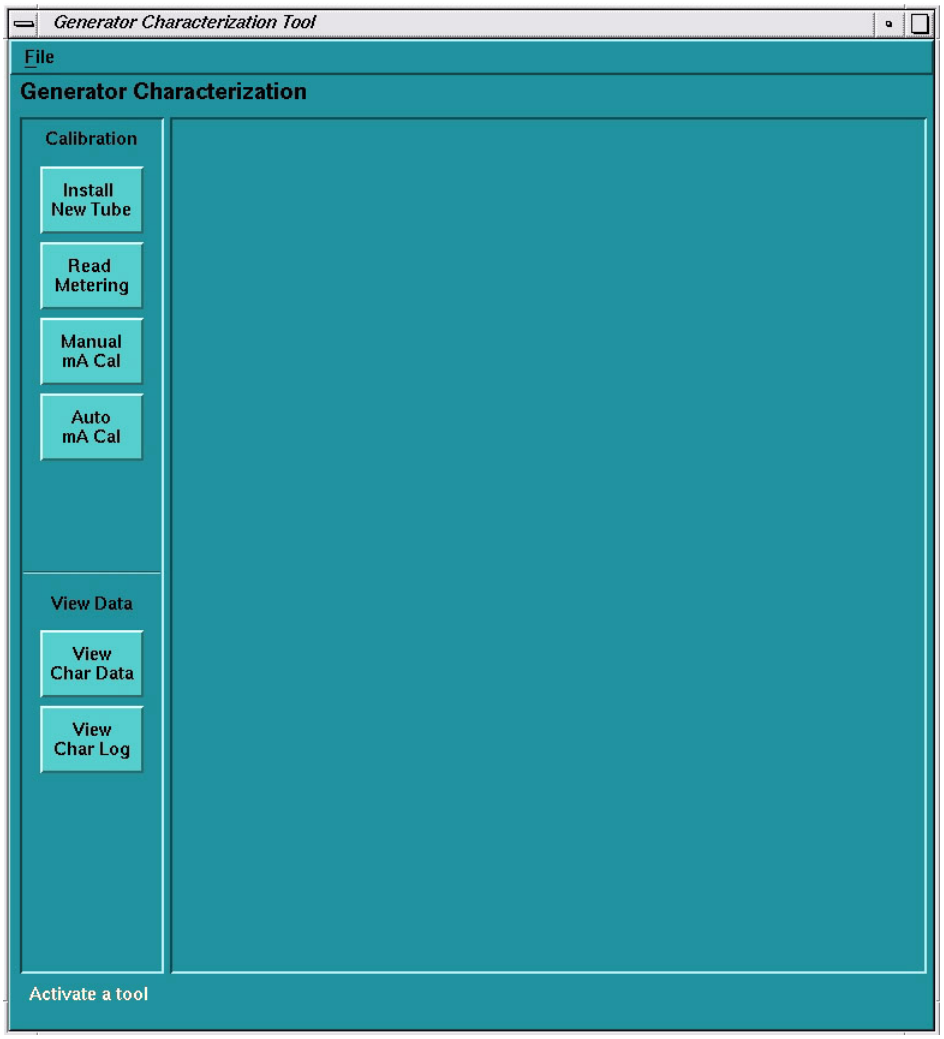

Figure 9-34 Generator Characterization Screen

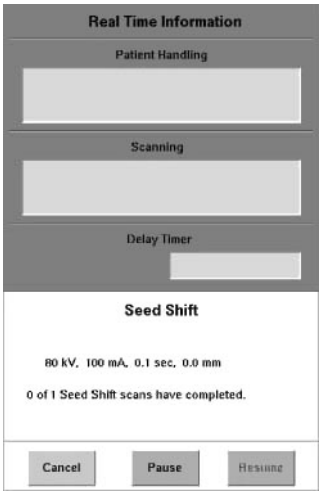

Figure 9-35 Seed Shift Real TIme Information Screen

3.12 KV Gain Pots Adjustment

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

3.12.1 Install HV Divider

1.) Inside the Gantry on the STC backplane:

a.) Switch OFF the **HVDC ENABLE**.

b.) Switch OFF the **AXIAL DRIVE ENABLE**.

c.) Rotate the Tube to the 3 o'clock position

d.) Engage gantry rotational lock.

e.) Switch OFF the **120 VAC GANTRY POWER**.

f.) Install the HV Divider between Tube and Tanks.

Note: Place the HV Divider on a table or tube hoist, so the cables reach the tube.

2.) Add a ground wire (minimum size of AWG 12) from Tube ground to bleeder ground. Refer to Figure 9-36.

CAUTION Potential Electrical Hazard

Performix tube unit MUST be grounded to the gantry during testing.

3.) Switch ON the **120 VAC GANTRY POWER**.

4.) Switch ON the **HVDC ENABLE**.

5.) Press the button, on the gantry control panel, turning ON the drives power.

Note: If the gantry covers are removed press the **RESET BUTTON** on the STC backplane to turn ON Drives power.

6.) Reset the hardware.

NOTICE Potential for tube damage

Incorrect installation of anode and cathode HV cables can destroy the Performix tube unit.

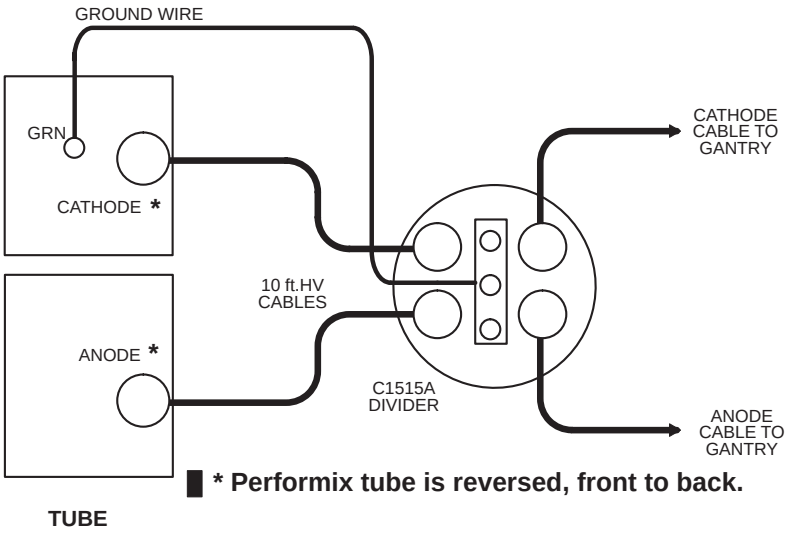

Figure 9-36 HV Divider Installation

3.12.2 Set Up Instrumentation

Use an oscilloscope with 10X probes

1.) Use the Gantry Service Outlet to provide 120 Vac power for the scope. This will reduce noise on the scope waveform.

2.) Connect **channel one** to the **anode** output of the divider. Connect the scope ground to bleeder ground.

3.) Connect **channel two** to the **cathode** output of the divider. Connect the scope ground to bleeder ground.

Note: In order to minimize bleeder-induced ripple on the kV waveform, connect a 30 foot Belden shielded twisted pair cable between the scope probes and the bleeder.

4.) Trigger channel one, positive, DC couple, trigger mode normal.

5.) Channel one and two, 10v/div, time base 200ms.

6.) Invert Channel two.

3.12.3 Calibrate the Cathode

1.) Select SERVICE DESKTOP.

2.) Select REPLACEMENT.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select BLEEDER SETUP and LOAD.

6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON
- **1 SECOND**
- **1 SCAN**
- FOCAL SPOT LARGE
- **100 KV**
- **50 MA**
- MONITOR ENABLE

Interscan Delay **2.00**
DAS Gain **31**
Gantry Tilt **0.0**
Trigger Rate 984
Filter BLOCKED
Calibration Vector NONE

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV equals 50 ± 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Cathode pot on the kV board, until the scope reading for the Cathode kV, and the displayed reading for the Cathode kV in the message log, fall within ±0.5kV of each other.

9.) Use the pot, labeled CAKV, R316, on the kV board, to adjust the scope reading.

- CCW decreases the scope kV.
- CW increases the scope kV.
- 1/2 turn equals approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

3.12.4 Calibrate the Anode

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	DAS Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV is 50 +/– 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Anode pot on the kV board, until the scope reading for the Anode kV, and the displayed reading for the Anode kV in the message log, fall within ±0.5kV of each other.
9.) Use the pot, labeled ANKV, R318, on the kV board, to adjust the scope reading.
- CCW decreases the scope kV.
- CW increases the scope kV
- 1/2 turn is approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

3.12.5 Measure Total kV

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	DAS Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Change the oscilloscope to add ch.1 and ch.2, to read total kV from the HV divider.
8.) Channel one and two, 20v/div, time base 200ms, trigger channel. one, positive.
9.) Select ACCEPT RX.
10.) Record the scope reading, and the Average. kV displayed in the message log, in **FORM 4879**.

11.) Display the Generator Characterization menu.

12.) Toggle the soft-key MONITOR ENABLE **OFF**, so the message log no longer displays kV and mA readings.

3.12.6 Install New Tube Program

Use this program to complete Auto mA Cal on a new tube. *Run this program only on a new tube.*

Refer to Figure 9-5

1.) Select SERVICE DESKTOP.

2.) Select CALIBRATION.

3.) Select GENERATOR CHARACTERIZATION.

4.) Select the INSTALL NEW TUBE.

Note: The system automatically warms up the tube.

5.) The system prompts you with the tube type. Verify the number corresponds to your tube type; answer **Y** or **N**.

SOFTWARE TOKEN	HOUSING NUMBER	INSERT NUMBER
12-MX_135CT	46-274800G1	46-274600G1
13-MX_165CT	46-309500G2	46-309300G1
14-MX_165CT_I	46-309500G2	46-309300G2
15-MX_200CT	2137130-2	2120785

Table 9-50 Tube Type Table (SW tokens for various Housings and Inserts)

6.) Press **START SCAN** when it flashes, to automatically run the program and update the display:

seed filament current shift scans

3.12.7 Auto mA Calibration

Run this program when you replace the X-Ray tube, or the system requires re-calibration.

1.) Select SERVICE DESKTOP.

2.) Select CALIBRATION.

3.) Select GENERATOR CHARACTERIZATION.

4.) Select AUTO MA CAL.

Note: The software automatically warms up the tube.

5.) Press **START SCAN** when it flashes, to automatically run the program and update the display:

– Ductility warm-up -

– Auto mA Cal -

6.) The system displays the final filament currents on the screen.

3.12.8 KV Rise and Fall Times

1.) In the OBC, connect a scope to the KV board.
- Channel 1: Exposure Command EXCM, TP5. Scope ground to LGND, TP3, 2v/div
- Channel 2: Total kV KVTB, TP11. (At this test point KV = 20KV per volt.) Scope ground to AGND SGND, TP12, 1v/div

2.) Set the Scope Time base to 200 usec.
Positive or Negative trigger as required.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select RISEFALL and LOAD.

TECHNIQUE		RISE		FALL	
kV	mA	**Record** Delay ms	Limit	**Record** Delay ms	Limit
80	400		0 +1.9 ms	Test not required.	N/A
140	40	Test not required.	N/A		-0 +0.5 ms

Table 9-51 kV Rise and Fall Time Record Table

Note: See Figure 9-37, on page 763, and Figure 9-38, on page 763, for measurement clarification.

3.12.8.1 Measure Rise Time

1.) Verify/Set-up the following DDC parameters:
- STATIC X-RAY ON — Interscan Delay **2.00**
- **1 SECOND** — DAS Gain **31**
- **1 SCAN** — Gantry Tilt **0.0**
- FOCAL SPOT LARGE — Trigger Rate 984
- **80 KV** — Filter BLOCKED
- **400 MA** — Calibration Vector NONE

Note: Measure rise time only on the 80kV/400mA scan.

2.) Select ACCEPT RX.

3.) Select PAUSE after the start of scan, to prevent the scope from displaying the fall time.

4.) After you record the rise time, select the RESUME to initiate the fall time scan.

5.) Record the delay between the rise of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).
- Do not include the waveform overshoot.
- The 75% point for 80kV equals 60kV

Note: Refer to Figure 9-37 for measurement clarification.

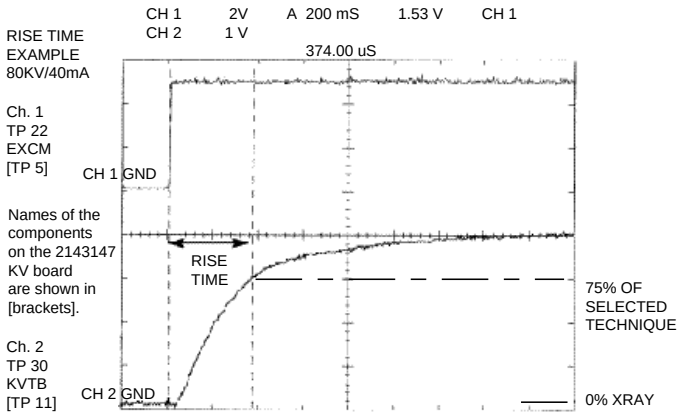

Figure 9-37 Rise Time Measurement

Note: The 75% point for:

- 80kV equals 60kV
- 100kV equals 75kV
- 120kV equals 90kV
- 140kV equals 105kV

3.12.8.2 Measure Fall Time

1.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	DAS Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **140 KV**	Filter BLOCKED
- **40 MA**	Calibration Vector NONE

Note: Measure fall time only on the 140kV/40mA scan.

2.) Record the delay between the fall of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).

- Do not include the waveform overshoot.
- The 75% point for 140kV equals 105kV

Leave the scope connected for the next test.

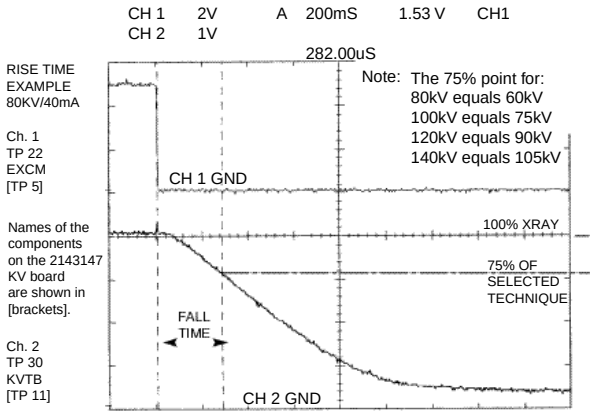

Figure 9-38 Fall Time Measurement

3.12.9 Verify Internal Scan Timer

1.) Select DIAGNOSTIC DATA COLLECTION (DDC).
2.) Select PROTOCOL NAME.
3.) Select SCANTIMER and LOAD.
4.) Toggle the softkey MONITOR ENABLE to **ON**, to display the scan time in the message log.
5.) In the OBC, connect a scope to the kV board, as follows:
   a.) Channel 1, Exposure Command (EXCM, TP22). Scope ground to TP3, 2v/div
   b.) Channel 2, Total kV, TP11. Scope ground to SIG, TP12, 1v/div
   c.) Set the Scope Time base to 200msec, positive trigger.
6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	DAS Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **40 MA**	Calibration Vector NONE

7.) Record the measured scan time from the oscilloscope and the displayed scan time from the message log. Spec limits are as follows:

Note: Scope Exposure Duration = 0.96 to 1.04 s.
Displayed Exposure Duration = 0.99 to 1.02 s.

8.) Toggle the softkey MONITOR ENABLE **OFF**, to stop the scan time display in the message log.
Failure to turn the MONITOR ENABLE **OFF** results in the system message log filling with exposure information.
9.) Disconnect the scope from the kV board.
10.) Replace the OBC cover**.**

3.13 Tube Usage Statistics

The System Browser is used to display information about the currently installed tube as well as previously installed tubes. The Tube Usage viewer provides three different levels of information viewing for Tube Usage: Summary, Details, and Cumulative.

Note: For Tube Warranty purposes ‘Warranty Effective Slices’ is the correct number to report upon tube unit failure.

Figure 9-39 shows an example of the tube Usage Screen. This screen allows you to select Summary, Details or Cumulative Statistics. If previous tubes had been installed on this example system, the other tubes would be listed in the Option: window by descending install date.

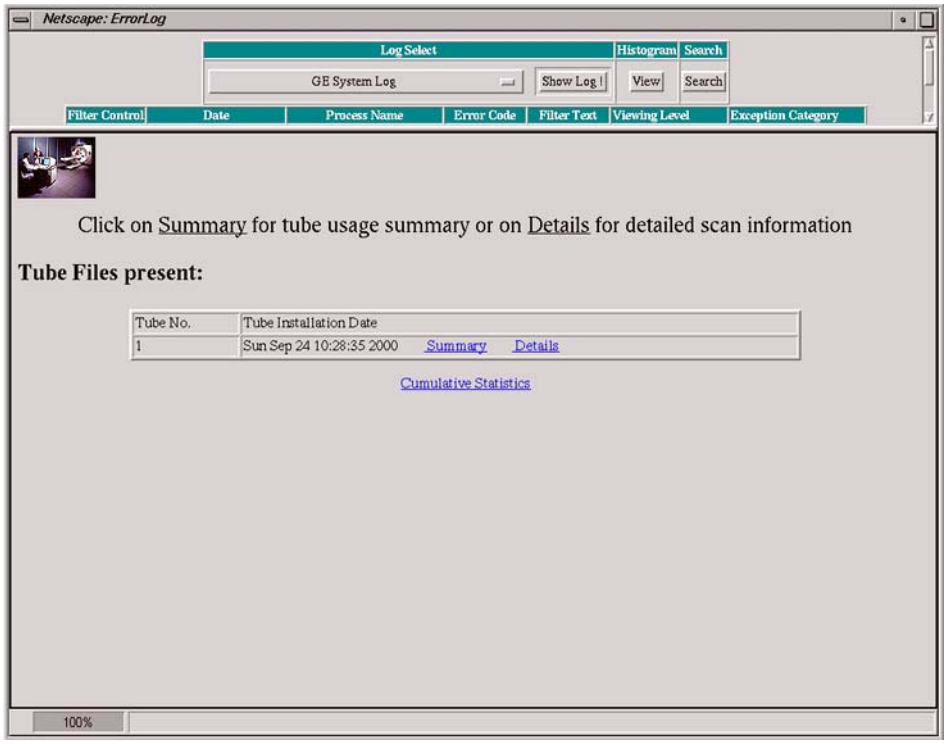

Figure 9-39 Tube Usage Screen.

3.13.1 Tube Usage Details Information

The Tube Usage Details information identifies the selected Tube Unit and Site Information plus details on the types and number of scans taken on that tube unit. Refer to Figures 9-40 and 9-41 for examples of the display.

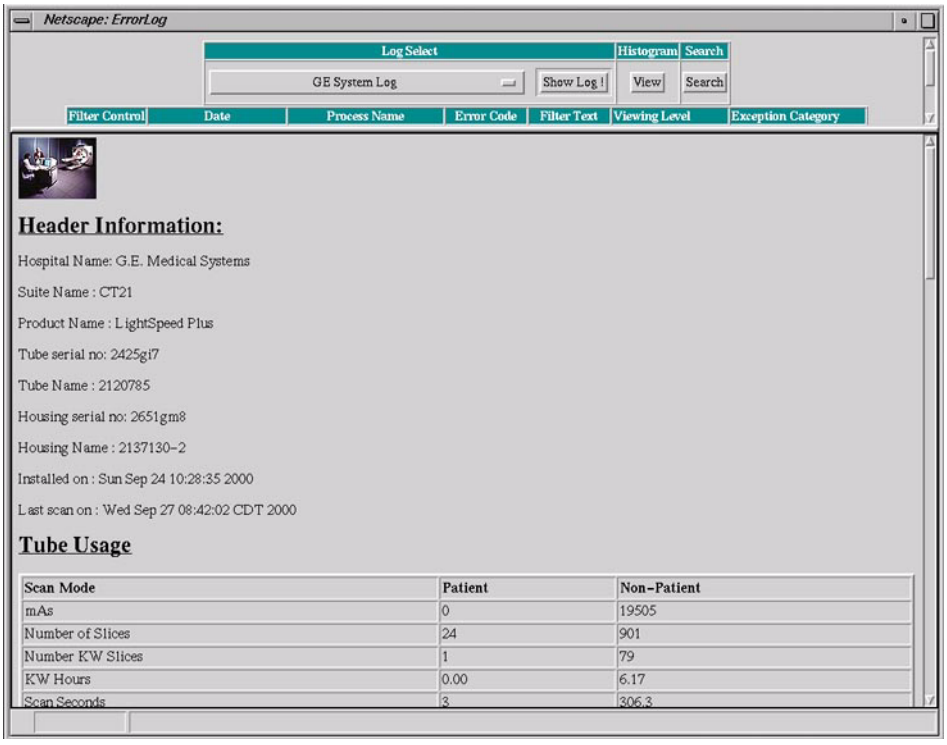

Figure 9-40 Tube Usage Detail Example

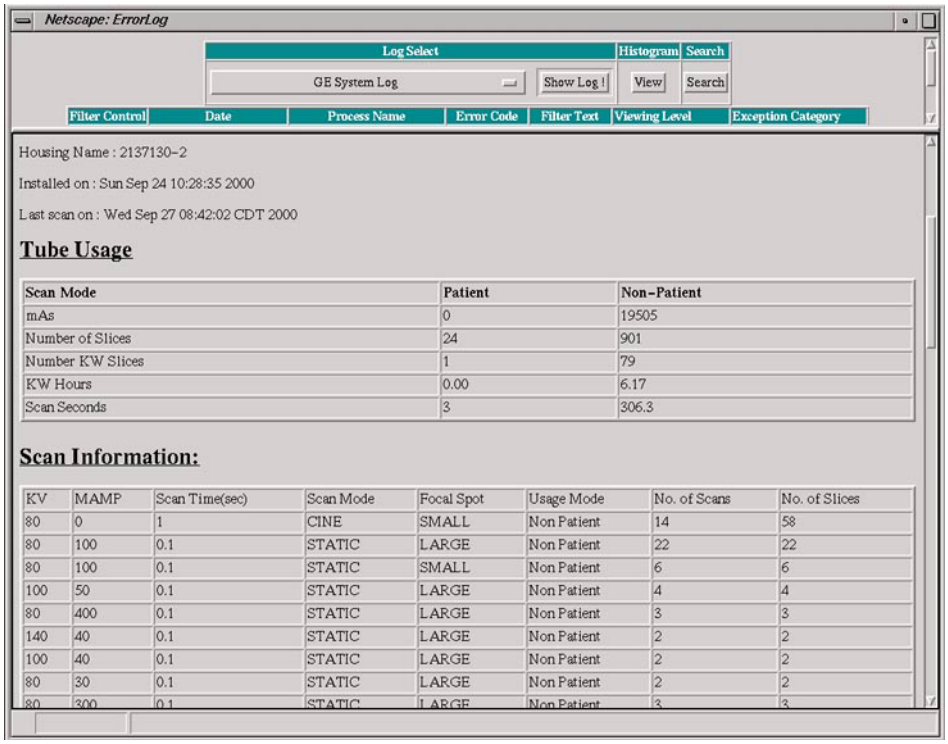

Figure 9-41 Tube Usage Details Screen showing partial Scan Information

3.13.2 Tube Usage Cumulative Information

The Tube Usage Cumulative Information displays the totaled tube usage information for all tubes that have been installed on the system. Refer to Figure 9-42 for an example of the display.

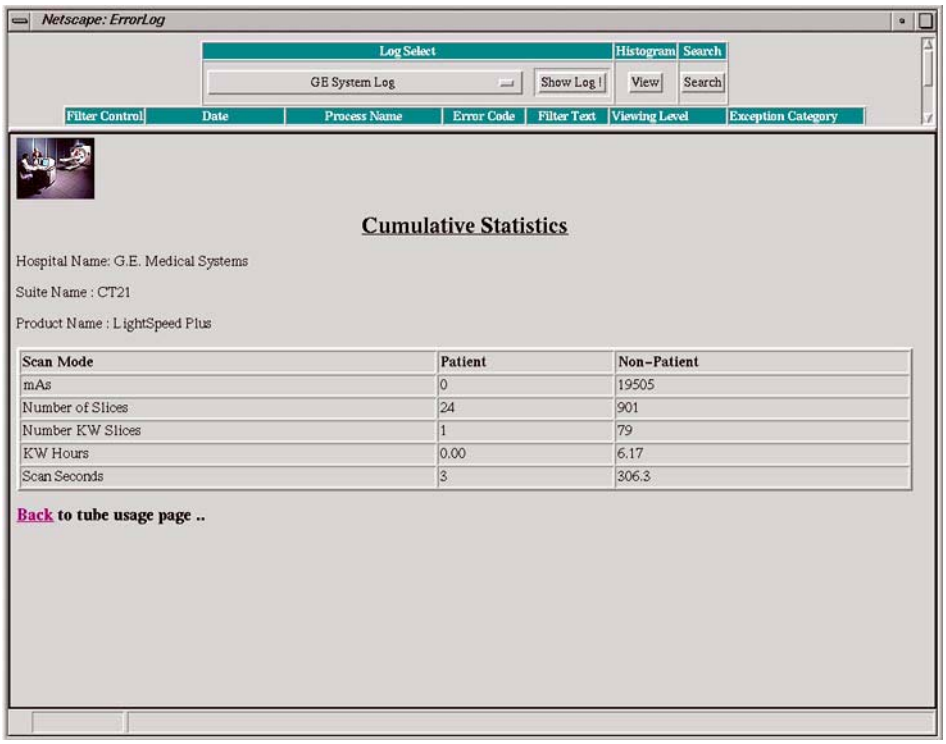

Figure 9-42 Tube Usage Cumulative Example.

3.14 Change Tube (New Tube) Program

New Tube prepares the system to store tube usage statistics, for trend analysis and tube warranty purposes.

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

1.) Select REPLACEMENT.

2.) Select CHANGETUBE.

3.) Refer to the list in Table 9-52, and type/enter the failure code for the defective tube in the "Tube Unit Failure Code" field on the screen.

failcode **ENTER**

FAILURE CODE	FAILURE CODE
AI: Image Artifact	OH: Other-Housing Related
BG: Broken Glass	OL: Generator Overload
CA: Casing Arcing	OR: Other-Rotor Related
CB: Casing Bubbles/Particles Seen	PF: Overheat/Pump Failure
CL: Casing Oil Leak	PT: Pulled Tube (No Failure)
GS: Grid Short	RF: Frozen Rotor
OC: Other-Cathode Related	RN: Noisy Rotor
OE: Tube Loss Due to Failure Elsewhere	SD: Shipping Damage/Error
OF: Open Filament	SS: Stator Open/Stator Short
OG: Arcing	XL: Low X-Ray Output

Table 9-52 Tube Failure Codes

4.) Refer to the Tube Housing; type/enter the new Tube's Insert Serial Number in the appropriate field on the screen.

Insert Serial Number

5.) Refer to the Tube Housing; type/enter the new Tube's Housing Serial Number in the appropriate field on the screen.

Housing Serial Number

6.) Click OK to accept these changes. (Refer to Figure 9-43.)

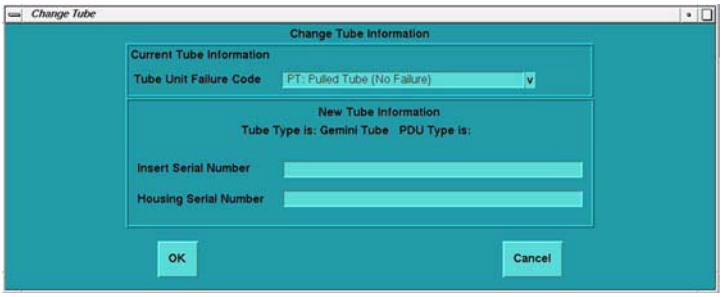

Figure 9-43 Change Tube Screen

3.15 X-Ray Tube Heat Soak and Seasoning

3.15.1 Heat Soak and Seasoning Overview

The Heat Soak and Seasoning program drives the scanner to perform a set of scans, which when taken in the proper sequence and with the correct time intervals between scans can extend the life of CT tubes. This program is run by service personnel whenever deemed necessary by observing the number of tubespits during actual scan operations. The entire protocol consists of three phases that will be executed in sequence.

This program seasons a new tube by first performing a tube heat soak. This process is done to remove any undissolved gases in order to minimize the occurrence of mA overloads.

After the heat soak, a high voltage stability test (Seasoning) is performed to verify that the tube is stable. Real time feedback of high voltage stability is provided to the user in order to determine if the current technique scans must be repeated. Because some of the scans used in this procedure are not used in normal patient scanning, special calibration scans are needed to determine the parameters needed to make these scans.

The Heat Soak and Seasoning procedure can be thought of as a series of alternating calibrations and scans. The particular sequence and parameters differ with the tube's type. In some cases, tube cooling delays need to be determined so that scans can be completed without need for extra cooling delays.

3.15.2 Tube Warmup

The Tube warmup phase of the Tube Heat Soak and Seasoning procedure raises the temperature of the tube slowly in order to prepare it for the high power scans that will follow. This phase is very important to minimize target damage when it is suddenly subjected to high energy input.

3.15.3 Heat Soak

New tubes may have undissolved gases that could render the tube unusable due to excessive arcing. The purpose of the heat soak phase is to redissolve gases in the tube at high temperatures in order to minimize the occurrence of current overloads. (i.e. tube spits).

The Heat Soak procedure consists of three sub-phases, which are: Heat input, Anode Soak and casing Soak. The Heat input and Anode Soak scans are performed in a dynamic series so that additional tube cooling is not necessary during the two sub-phases.

- Heat Input

  This phase heats the target up to maximum heat storage. This heats the target and other parts of the tube to maximum temperature for proper de-gassing. At the same time, the tube "getter", a chemical that absorbs gases, is heated up to its activation temperature to absorb the gases in the tube.

- Anode Soak

  This phase maintains the target at maximum heat storage and maximum temperature to continue the de-gassing and absorption of gases by the getter.

- Casing Soak

  In this phase, the tube unit is heated up to the casing heat storage limit. This heats the oil to a point where gases can be reabsorbed by the oil.

3.15.4 High Voltage Seasoning

High Voltage seasoning eradicates any small micron sized particles that may be in the tube insert. Left in the tube, these particles can become charged and thus, cause arcing. In addition, this segment can be used as troubleshooting tool by the service person to verify that tube operation is stable prior to customer use.

Interruptions during the automated scans are allowed only during the Seasoning phase. if interrupted, scanning can be resumed from the previous scanning station till completion. The state entered on an interruption is called the manual mode.

3.15.5 Heat Soak and Seasoning Procedure

1.) Select REPLACEMENT.
2.) Select DDC.
3.) Select LOAD PROTOCOL.
4.) Refer to Table 9-53, and load each protocol individually.

Tube Heat Soak and Seasoning Protocols

The Tube Heat Soak and Seasoning protocol for the HSA MX_165_CT_I tube is given below. Refer to Performix tube and other x-ray tube replacement procedures. All scans are done with the tube's large focal spot. The scan time and interscan delays specified in the protocols listed must be rigidly enforced. The protocol for the Performix tube is similar.

The execution of the scans listed must follow certain rules. The tube warm up stage is optional depending on the temperature of the tube. The next five scan groups (Heat Input to Casing Soak 2) must be executed without interruptions (if possible). If the protocol is stopped during this period, it is recommended that this entire group of protocols be executed again. During Seasoning, execution may be stopped at the operator's discretion and can be either resumed or started once again from the previous scan group.

MX_165_CT_I Scan Group	kV	mA	# of Scans	ISD (sec.)	Scan Time (sec.)	Pre Group Delay (sec.)	Static / Rotate (4.0sec)
Warm Up	80	100	15	2	2	2	S
Heat Input	80	300	24	2	3	2	R
Anode Soak 1	80	300	25	5	3	3	R
Anode Soak 2	80	300	9	1	1	2	R
Casing Soak 1	80	300	90	12	2	60	R
Casing Soak 2	80	300	10	7	1	7	R
Seasoning 1	90	50	5	5	0.1	5	R
Seasoning 2	100	50	5	5	0.1	5	R
Seasoning 3	110	50	5	5	0.1	5	R
Seasoning 4	120	50	5	5	0.1	5	R
Seasoning 5	130	50	5	5	0.1	5	R
Seasoning 6	135	50	5	5	0.1	5	R
Seasoning 7	140	50	10	5	0.1	5	R
Seasoning 8	145	50	10	5	0.1	5	R
Seasoning 9	150	50	15	5	0.1	5	R

Table 9-53 MX 165 CT HEAT SOAK AND SEASONING PROTOCOL

3.15.6 Hot ISO

Hot ISO is a software procedure that does not require any physical adjustment. It is a set of calculations used to improve image quality due to focal spot movement as the tube is heated.

Hot ISO requires that the tube be heated to near maximum capacity so that the total drift of the focal spot can be measured. Heat Soak and Seasoning (HSS) heats up the new tube to near maximum

storage for tube Seasoning. ISO scans are added between the heating scans and the season scans of the HSS feature with minimal impact on both tube change time and HSS.

The ISO values that result from Hot ISO requires four new fields in ScanHardware.cfg (two to store the drift values of each of the spots (small & large) and two to store the ISO values of the cold spots (small & large). These values will also have to be stored in the INFO file for Save/Restore of system state.

3.16 Exposure Backup Timer Functional Test

Use this test to verify the backup timer operation (i.e., timer activates, timer counts down to zero and backup contactor de-energizes).

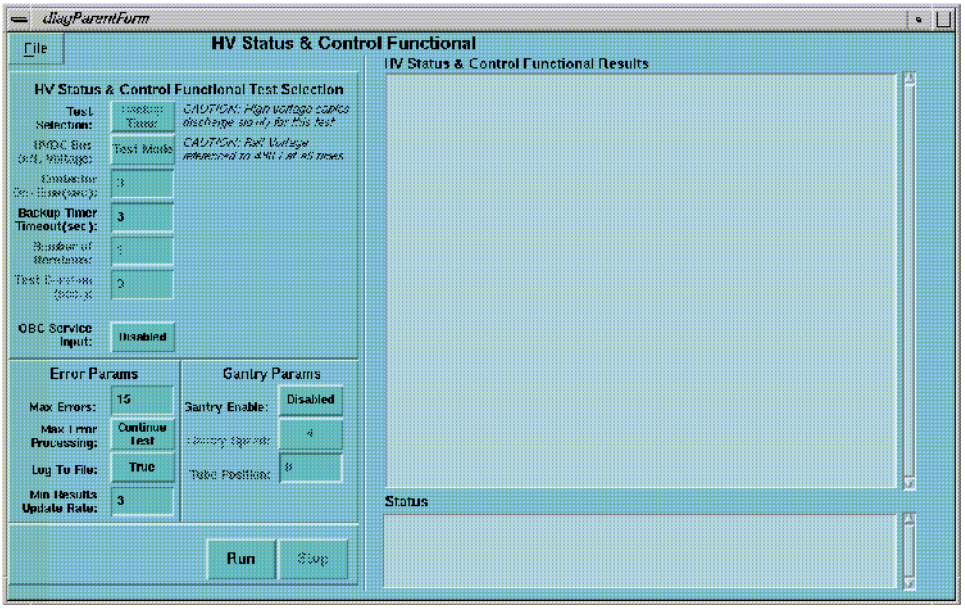

Figure 9-44 Backup Timer Diagnostic Screen

The Gentry I/O Board contains the backup timer. The software loads the scan time +5% into the backup counter before the start of exposure. The extra 5% gives the backup contactor time to energize. The backup timer begins counting down when the system detects the HV ON or Exposure Command. If either of these conditions persist after the timer counts down to zero, it sends a level 1 interrupt to the CPU and disables the backup contactor.

The read and write verification requires the operation of the clock and clock select circuits. This diagnostic tests both the 488.28 Hz and 1953 Hz clocks. The diagnostic simulates an exposure, and verifies that the circuit generates a backup timer interrupt.

The system posts a test status message to the screen while it runs the corresponding test.

The Backup Timer Timeout defaults to three seconds, which should provide enough time to verify operation of the backup timer.

1.) Select DIAGNOSTICS.
2.) Select BACK-UP TIMER GENERATOR.
3.) Select RUN.

- The results window indicates the progress of the test, and not the state of the hardware.
- The screen information updates one line at a time, as each step completes.
- If a failure occurs, the system posts an inverted video error message indicating a test abort after the failing step.

3.17 X-Ray Interlock Functional Test

This function tests the ability of the X-Ray interlock to disable an exposure. The test opens and closes the STC and DIP Board interlock relays and verifies the state of the Gentry I/O interlock sensor. In the event of a fault, the test allows the user to loop on this condition indefinitely, for troubleshooting purposes.

1.) Select DIAGNOSTICS.

2.) Select X-RAY INTERLOCK.

Note: When making selections:

- You may select other tests from this screen by clicking mousebutton one on the test selection softkey, or by clicking mousebutton three over the test selection softkey to display the following pop-up selection menu.
- When you select Run, the system checks the scan subsystem for resident firmware. If the system does not detect the firmware, it posts a message to inform you that it needs to download firmware. It prompts you to select YES to download the firmware.

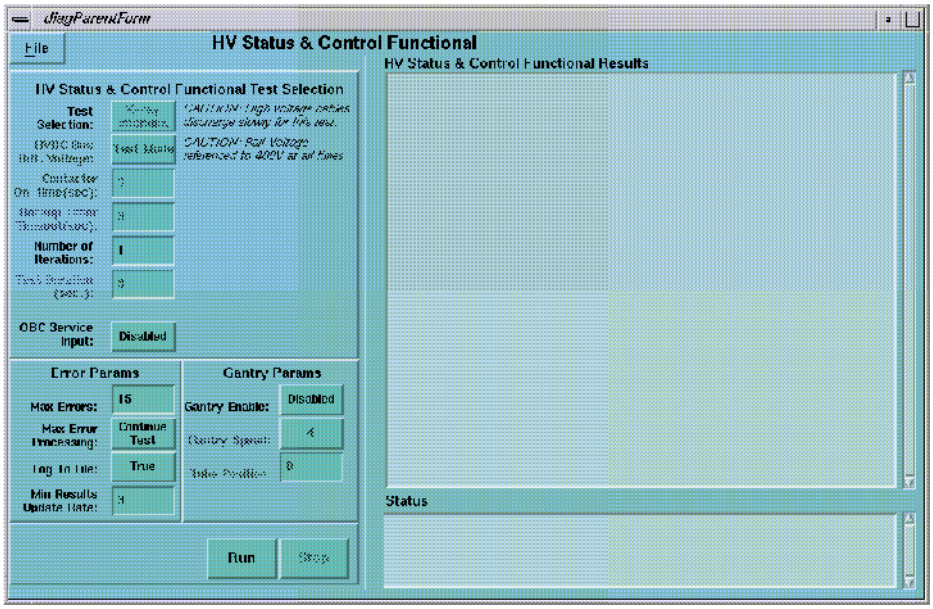

Figure 9-45 X-Ray Interlock Functional Test results example

3.18 X-Ray Exposure Manual Test

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

1.) Select DIAGNOSTICS .

2.) Select KV & MA (X-RAY).

It assumes your baseline is accurate. Test this baseline with a bleeder at least once a year.

Figure 9-46 shows the **X-Ray Functional Test screen**. Input ranges are:

- **KV:** 60 to 140KV in 1KV steps
- **mA:** 40 to 400mA in 1mA steps (10 to 440 mA with Performix tube and CRPDU)
- **Duration:** 1.0 to 10 Seconds in 0.1 second steps
- **Iterations:** 1 to 100
- **ISD:** 1 to 60 Seconds in 1 second steps

Select RUN and wait for the Scan Start button on the console keypad to illuminate. Press the Scan Start button, when lit, to initiate the scan.

The X-Ray Functional Test Results screen output consists of HV statistics. The data displayed was taken 1007ms into the exposure and was posted to the screen. ("_" indicates an unknown value.)

- *Average:* the average value taken over the duration of the exposure.
- *Selected:* the value prescribed by the user.
- *Last Sample:* the last value read before the screen updated. The Last Sample exposure duration displays the data collection time, **in milliseconds, from the start of exposure**.

Data displayed in the Last Sample column represents the last sample of HV statistics taken on or before 1007 milliseconds after the start of the exposure.

Figure 9-46 represents the screen at the end of the exposure. You can tell the exposure has ended because the Last Sample exposure duration equals or exceeds the Selected exposure duration value.

Note: Backup timer determines exposure duration

The backup timer determines the exposure duration. This timer stops counting after the system removes the Exposure Command and HV ON status, which means the last exposure could have occurred later than indicated.

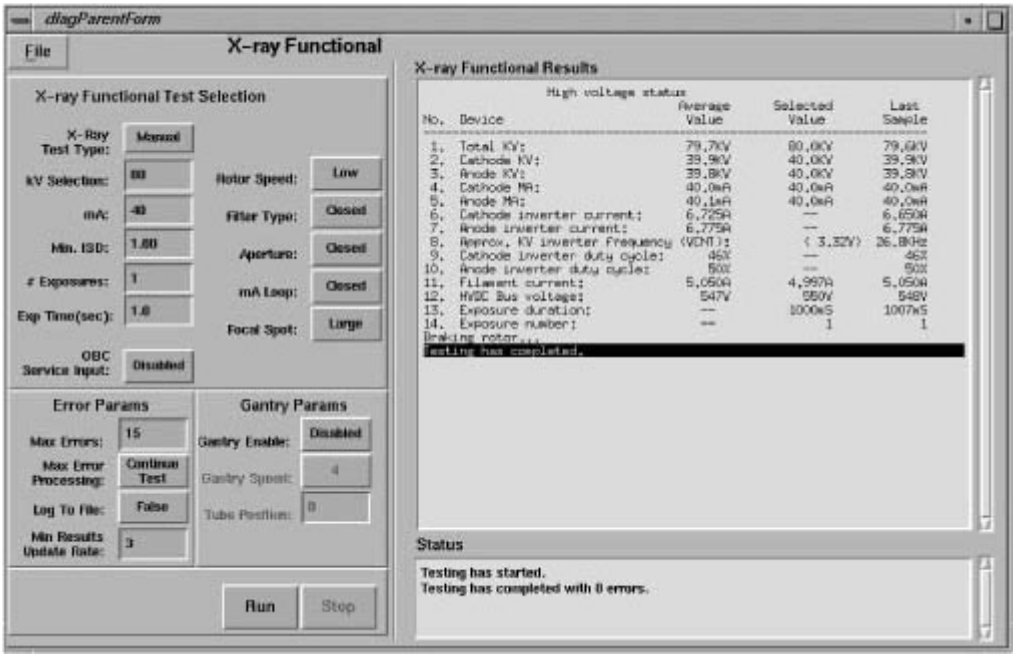

Figure 9-46 X-Ray Functional Test Results Example

3.19 OBC CPU (Artesyn III) - GE Specific Settings

For STC CPU see Chapter 8, Section 2.15, on page 596, and for ETC CPU see Chapter 6, Section 2.4, on page 441.

3.19.1 OBC CPU (Artesyn III) Board Layout

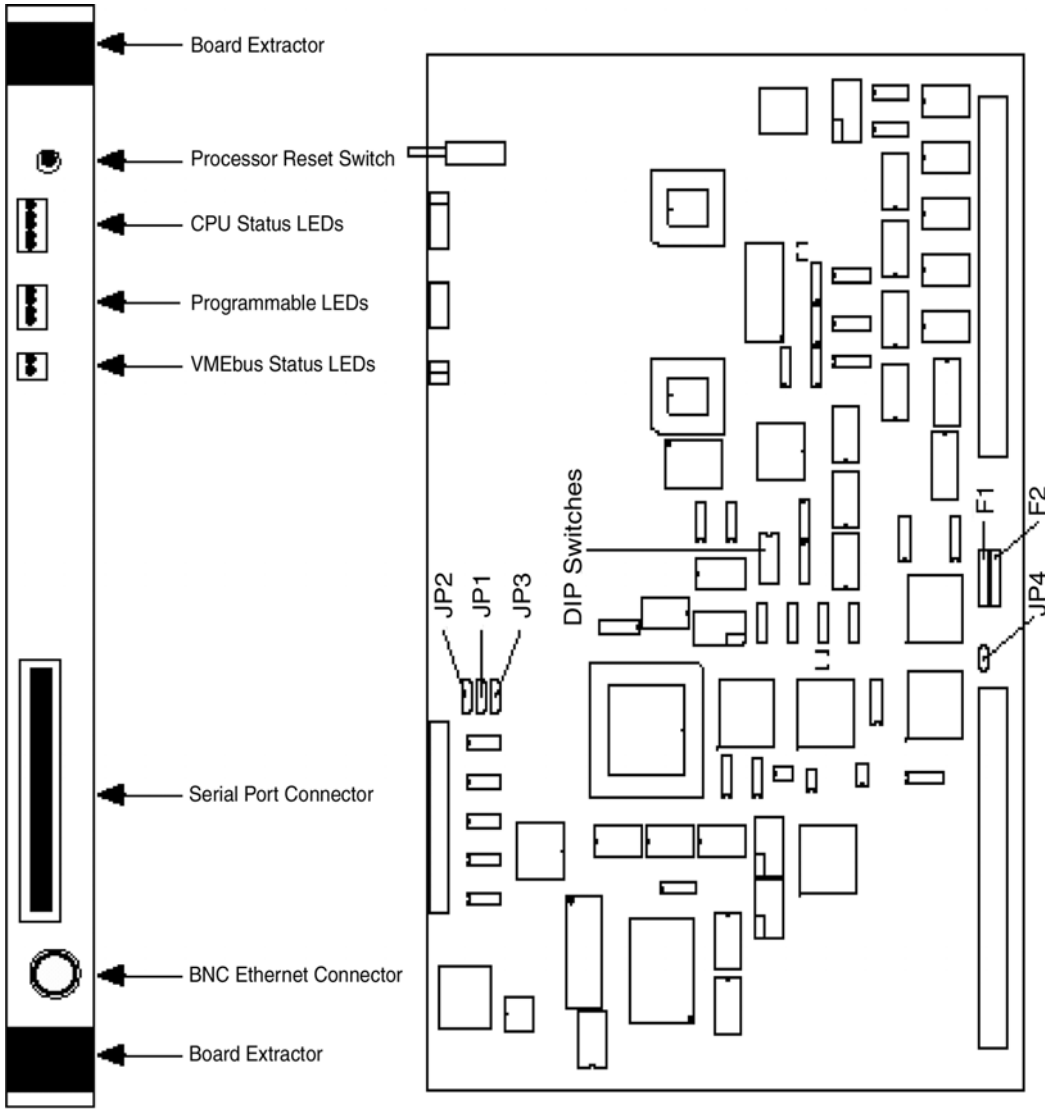

Figure 9-47 OBC CPU (Artesyn) Board Layout

3.19.2 CPU Board Jumpers

JUMPER	FUNCTION	GE CONFIGURATION	COMMENTS
JP1	Port A RI/DCD	J1:1-2	
JP2	Port B RI/DCD	J2:2-3	
JP3	RS-232 Handshaking	J3:1-2	
JP4	Watchdog Enable	removed	Watchdog Disable

Table 9-54 OBC CPU (Artesyn III) Board Jumper Settings

3.19.3 DIP Switch Settings

See board (Figure 9-47, above)

SWITCH NUMBER	CONFIGURATION		FUNCTION	COMMENTS
1	OFF	OPEN	OBC node	Selects board for OBC Chassis
2	ON	CLOSED	OBC node	Selects board for OBC Chassis
3	OFF	OPEN	Primary Nodes	selects primary nodes
4	OFF	OPEN	n/a	Not applicable
5	ON	CLOSED	nbsClient view	View logs via nbsClient/LAN
6	OFF	OPEN	n/a	Not applicable
7	ON	CLOSED	Eprom Boot	Power Up view Eprom Boot
8	OFF	OPEN	Test Disable	Self Test Mode disabled

Table 9-55 OBC CPU (Artesyn) Board DIP Switch Settings

3.19.4 Power-Up Self-Test

The CPU board will undergo a Power-Up Self-Test that lasts approximately 18 seconds. After the proper setting of the EPROMs, DIP switches and board jumpers, the CPU board will be placed into a VME chassis. The **LSCOM** board must be present for the successful completion of the Power-Up Self-Test.

Upon power up, the self test begins, the LED display is at the value ‘E’ and the test will perform the instruction Set and EPROM Checksum Test. When the test is done, the LED value will proceed to the next descending value, ‘D’, and will perform the RAM verification test. In the same manner, when this test is done, the LED value will proceed to ‘C’, then ‘B’, then ‘A’ and finally to ‘9’. After the test at ‘9’, the self test is now done.

When the test is completed, the LED values displayed will indicate if any tests have failed. Reference Table 9-56. If a failure is detected the eproms, DIP-switch settings, Ethernet cable, and the board jumpers should be re-checked to ensure proper setup. Then the self test should be rerun. The board must pass the test before shipment. See Figure 9-47, for location of these LEDS.

LED# 1234	LED HEX	LED ASSIGNMENT	DURATION
xxxo	E	Instruction Set and Eprom Checksum Test	1 second
xxox	D	RAM Verification	13 seconds
xxoo	C	CIO Unit Test	0.3 seconds
xoxx	B	Internal Loop Back	1 second
oxox	A	External Loop Back	1 second
oxxo	9	Transmit Test	1 second
x = on o = off			

Table 9-56 OBC CPU (Artesyn III) Board Power Up LEDS

3.19.5 Power-Up Self-Test Results

On Power-up, the OBC controller displays the results of its self tests. Power must remain off to a controller for at least 60SEC or Self-test may not be run or results may be inaccurate. This is because the dynamic ram retains the CPON information. In this event, power-up tests are bypassed and the results of the last. power-up test displayed on LEDs.

1 2 3 4	HEX	LED ASSIGNMENT
• • • •	F	Not Available - - Do Not Use for a test
• • • o	E	Artesyn (see Table 9-58 for details)
• • o •	D	Artesyn (see Table 9-58 for details)
• • o o	C	Artesyn (see Table 9-58 for details)
• o o o	8	LSCOM (see Table 9-59 for details)
o • • •	7	LSCOM (see Table 9-59 for details)
o • • o	6	LSCOM (see Table 9-59 for details)
o • o o	4	spare for GE future use
o o • •	3	spare for GE future use
o o • o	2	spare for GE future use
o o o •	1	spare for GE future use
o o o o	0	Not Available - - Do Not Use for a test
• = LED ON, o = LED OFF, 1 = LED MSB, 4 = LED LSB		

Table 9-57 OBC Self-Test LED Outputs

3.19.5.1 ETC, STC & OBC (Artesyn) Tests

FUNCTION	LEDS	DESCRIPTION
Initialization	(F: • • • •)	Setup interrupt vectors & CIO
Failure	(E: • • • o)	CPU HALTS
Processor/PROM Checksum	(E: • • • o)	68000 Instruction set check (ram used) ROM Verified using CRC16 based polynomial
Failure	(E: • • • o)	CPU HALTS
Ram Verification -	(D: • • o •)	Each word of memory R/W 16 times
Failure	(E: • • • o)	CPU HALTS
CIO Verification	(C: • • o o)	Checks interrupts, timers, counters (no VME)
Failure	(E: • • • o)	CPU HALTS
• = “on” o = “off”		

Table 9-58 Artesyn Board Related LED Readouts

At this point the type of node (ETC, STC or OBCR) determines the tests that are run.

3.19.5.2 OBC (OBCR) - LSCOM/Communications Test

FUNCTION	LEDS	DESCRIPTION
Module Present test	(8: • o o o)	Checks for Presence of TAXI
Failure	(8: • o o o)	Flashes, possibly with other failures
VME FIFO test	(7: o • • •)	Checks VME path using loop-back
Failure	(7: • o o o)	Flashes, possibly with other failures
DAS FIFO test	(6: o • • o)	Checks DAS path using loop-back
Failure	(6: • o o o)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 9-59 OBCR LSCOM/Communications Related LED Readouts

3.20 OBC Backplane

A manual Laser Light test switch resides on this board. The Filament relay is on the back side of this board. Reference Figure 9-48.

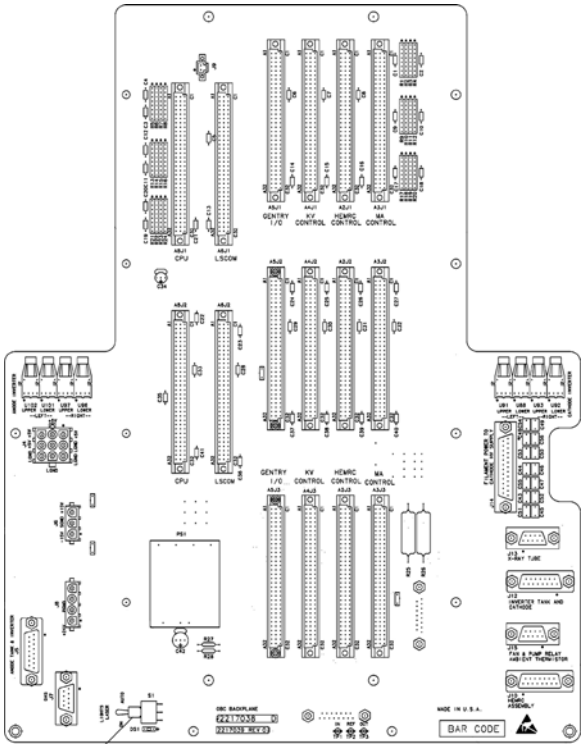

Figure 9-48 OBC Backplane Laser Test Switch

3.21 OBC Power Interface

This board provides the power distribution for the OBC, and HV subsystem. There are several fuses located on this board. Reference Figure 9-49. Additionally there is a circuit to monitor the Tube Fan and Pumps that reports any sensed failures including open fuse detection. Reference the schematics for circuit details.

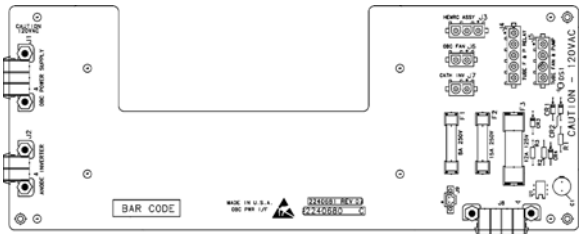

Figure 9-49 OBC Power Interface Board Fuse Locations

FUSE #1	VALUE	DESCRIPTION
F1	8A, 250v	Cathode, Anode Inverter, OBC Fan and OBC power supply.
F2	15A, 250v	HEMRC Assembly.
F3	12A, 125v	Tube Fan and Pumps.

Table 9-60 OBC Power Interface Fuses

Section 4.0
Collimator Theory of Operation

The mechanics of the LightSpeed collimator are controlled by firmware. The Collimator Control Board (CCB) is the interface between the firmware and the mechanics. The basic function of the collimator is to set the x-ray beam width at the patient and provide filtering of the beam for the proper “hardness”.

4.1 Major Functions Collimator Control Board (CCB)

This Collimator Control Board has five major functions:

1.) The Core Controller for processing and control.
2.) Communications using the Controller Area Network (CAN) Interface with Fault & Reset signals.
3.) CAM positioning.
4.) Filter positioning.
5.) Voltage regulation and referencing.

4.1.1 Major Function List

Table 9-61 lists the major functions of the CCB.

1.Core controller	9. Gantry CAN function
2.CPU332	10.LED function
3.Clock and Clock Loss circuitry	11.Exposure Command
4.Reset Bus	12.Trigger Clock
5.TPU and CAM drives	13.System Fault
6.RS232	14.GCAN RESET
7.Power Up Configuration	15.CAM drive
8.FLASH and RAM	16.Filter Drive

Table 9-61 Major Function List of CCB

4.1.2 Location of Parts

Figure 9-50 shows the location of parts on the CCB.

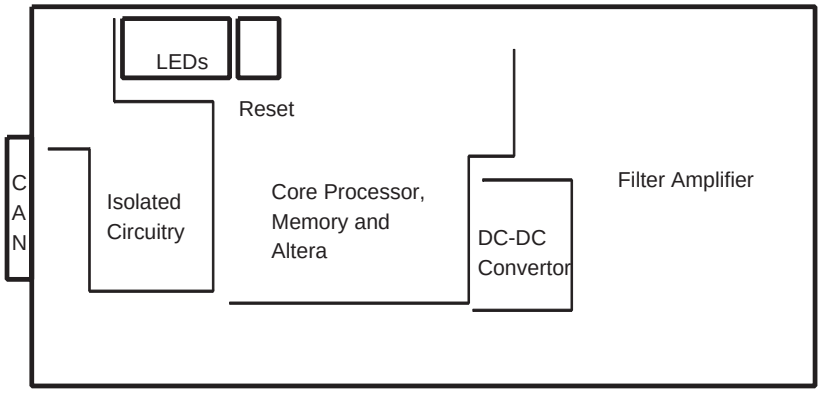

Figure 9-50 Location of Parts (CCB)

4.2 Core Controller

The "Core controller" shares functionality with the controller section of the Data Acquisition Control Board (DCB). The core section consists of the processor, clock and clock processing, RS232 circuitry, Flash memory and RAM.

4.2.1 CPU332

This comes with a 16 MHz clock and the Standard TPU (Time Processor Unit) with enhanced PPWA (Period/Pulse-Width Accumulator). The TPU is essentially a dedicated processor for time related functions.

4.2.2 Clock and Clock Loss Circuitry

The processor clock is derived off a 32.000MHz crystal oscillator, which is divided down to 16 Hz, which is fed into the processor. The clock runs through the processor and exits the chip at the CLKOUT pin before feeding the rest of the board. If the clock stops for over 9.9 mS, the missing pulse detector will pull the reset bus line low and set the clock loss bit in the Altera. This bit can only be reset by firmware command (or power cycling).

4.2.3 Reset Bus

There is one central Reset line on the CCB. This central line connects the CPU, the pushbutton reset, the external GCAN reset, the Background Debugging Mode connection, the Altera, and the 82527 CAN controller.

The external GCAN reset is applied by commanding GCAN_RST_P high relative to GCAN_RST_N. This puts the board into reset.

4.2.4 CPU Signal Buffering/ Conditioning

The CPU does not interface directly to any external devices. It buffers the signals through HCT244 devices. The following are inputs from external devices:

The CAM and Filter encoder signals are buffered inputs to the TPU as are the filter home switch and the DAS trigger signal. The Filter C pulse and the filter home switch are combined to form the filter home signal. The TPU is set up to decode the quadrature of the encoders and provides a 16 bit counter for each axis position.

The filter home switch contacts and the filter encoder C pulse are also buffered to the DATA bus through the “INREG” register (U24). That is the only register outside of the Altera used for data.

Outputs from the TPU are for the CAM and filter drives and these are buffered out through an HCT244.

4.2.5 TPU and CAM Drives

The TPU has a stepper motor control algorithm that is used for the CAM drives. The firmware sets of the TPU with the acceleration and deceleration rates and the step rate. When it sets the desired position the TPU takes care of the actual move. It is set up now for half step commands to the Vexta 5 phase stepper driver at a rate of 2000 steps per second for a standard aperture move.

4.2.6 RS232

The RS232 link is on the board purely for development reasons.

4.2.7 Power-Up Configuration

The Data3, Data9 are held low on reset to configure the 68332. Data3 low on reset release configures the /CS6 pin to be ADDR19 so we can access 1 Meg of memory. Data9 low on release of reset turns the IRQ[7:1] lines into PortF outputs. Holding MODCLK low configures the 68332 to use an external clock source.

4.2.8 FLASH and RAM

The memory for the CCB consists of 8 Mbit (1 Mbyte) of 120 nS FLASH and the same amount of 55 nS RAM. The FLASH interfaces directly to the 68332. The RAM does not. The DCB uses the the same boot firmware. ADDR0 is not used on the memory. The read/write decode from the Altera handles the byte selection.

4.3 Gantry Controller Area Network (CAN)

A CAN (Controller Area Network) is used to communicate with the HEMRC Control Board (HCB) or the DAS. This is a serial link with a protocol and hardware interface. As part of our CAN physical connection we include application specific signals such as: GCAN (Gantry CAN) fault, Fault2, Exposure Command, Triggers and GCAN Reset.

4.3.1 CAN Function

The CAN controller chip is an Intel 82527. Firmware writes and reads from this chip to send and receive messages via the CAN. When pin 2 of the HCPL7101 is high, the output (pin 6) is high. The outputs (pins 6 and 7) of the 82C250 will be floating. This is the "recessive" bus state on the network. A logic zero from the 82527 will result in GCH (Gantry Can High) being pulled to high and GCL (Gantry Can Low) being pulled low.

4.3.2 LED Function

The 82527 has two ports on it: one is used as the data bus interface to the rest of the board; the other is used to light LEDs. The function of these LEDs are defined by firmware.

4.3.3 Exposure Command

The exposure command signal comes from the HCB and is opto-coupled into the collimator control board. When Exposure_Command_P is high relative to Exposure_Command_N, the exposure command signal output of the opto-coupler is high. This signal goes into the Altera device and where the state of the signal is latched and an interrupt to the processor is created.

4.3.4 Trigger Clock

This signal also comes from the HCB and is buffered through an HCT244 and sent to the TPU in the 68332.

4.3.5 System Fault

The CCB has three methods of telling the system it has a fault: by the CAN bus, the fault line driven by the CAN driver, and by the serial Fault2 line. When the firmware senses a fault, it writes to the Altera to create a GCAN_FLT_TX signal. This signal drives an isolated 82C250 CAN interface chip and opens a solid state relay. The relay opens the loopback line that runs from the HCB, through the Collimator, through the DAS, back through the Collimator and the HCB. These boards will detect an open and react to the fault. Both the GCAN FLT and the FAULT2 readback signals go to the Altera where they create an interrupt and are latched for reading by the firmware.

4.3.6 GCAN Reset

This signal comes from the HCB and is opto-coupled into the collimator control board. When GCAN_RST_P is high relative to GCAN_RST_N, the GCAN_RST* signal output of the opto-coupler is low. This then creates a board Reset just as pushing the Reset pushbutton would do.

4.3.7 CAM drive

The CAM drive function consists of the clockwise and counterclockwise pulse commands to the stepper motor driver, encoder feedback, the driver disable signal and the driver current cutback inhibit signal. The clockwise and counter-clockwise pulses are derived in the Altera from quadrature pulses created by the TPU in the 68332. The rate of these is under firmware control. The TPU also decodes the encoder signals to keep track of the count and direction of movement.

Two control signals from the 68332 are for controlling the behavior of the Vexta, 5 phase stepping motor driver. Essentially the 68332 writes to a register to set the signals CURR_HOLD and CAM_OFF_OUT.

When CURR_HOLD is high, it turns on FET Q35 and prevents the stepping motor driver from automatically decreasing its drive to the motor. Normally the current gets cut back by half after a move because it is not needed for acceleration and movement.

When the CAM_OFF_OUT signal goes high, it turns on a FET Q36, which turns off the stepping motor driver and allows the CAMS to “freewheel”.

4.3.8 Filter Drive

The filter driver is a basic H-bridge with high side current sensing for each phase. Sensing the high side allows protection for output shorts to ground. The stepping signals come from the TPU and decoded by the Altera to sequence the high and low FET drive signals.

4.3.9 Current Limit

The current limit circuitry is the same for both phases. An instrumentation amplifier with high common mode rejection senses the current through an effective 0.25 ohm resistance. The output of the amplifier is then fed into two comparators. One comparator is for pulse to pulse current limiting and the other is the short circuit latch comparator. For pulse to pulse current limit, the voltage regulators are divided down to create a reference voltage. This reference is fed into the comparator and when the output from the sensed current exceeds the reference, the comparator switches and shuts off a latch, which turns off the top FET. This cycles at a 15 kHz rate because of the clock into the latch.

4.3.10 Short Circuit Function

The short circuit protection circuitry uses the same concept as the pulse to pulse limit except on a short, the rate of rise of the current is so fast that the current sensed can rise to just over 10 A. This is limited by the 6.8 uH inductor on the board and the reverse recovery charge of the lower FET's parasitic diode. As the current passes the short circuit reference voltage, a comparator switches in a latch that cuts off drive to the top FETs. Only firmware can reset this latch so current stays off after a short until firmware commands otherwise.

4.3.11 Current Cut Back

The Current Cut back function drops the current to the filter. This keeps the motor from unnecessarily dissipating power when it is not moving. The firmware can command this, which then turns on Q5. When Q5 is on, it drops the pulse to pulse current reference.

4.3.12 Basic H-Bridge Function

The H-bridge uses two high side gate driver chips per phase. These create floating voltages to drive the top FETs without transformers or optical circuitry. The resistor - diode combinations around the inverters which feed the gate driver chips and the gates of the FETs are set up to prevent "shoot through" or simultaneous conduction. This is prevented by turning on the FETs slow and turning them off fast. The SD signal into the ir2110 devices disables drive until a command occurs. Holding SD high disables the driver.

4.3.13 Filter Home Switch

The filter home switch tells the CCB when the filter is physically positioned “at home” of course. It does this by feeding back the normally open and normally closed contact signals, which can be read at register U24 (Address 0x800000/1 in the memory map). When at home, the normally open switch is closed and the normally closed switch is closed.

4.3.14 Voltage Regulators and Reference Voltages

The voltage regulators create voltages for the FET gate drivers (12V), and the instrumentation amp (± 8V). The 8V signal is for the pulse to pulse and short circuit currents.

4.3.15 Altera Functionality

The Altera functionality is covered in the Programmable Device Logic (PDL) specification 2208487PDL.

4.3.16 I/O Bit Map

With the exception of the INREG register (Address 0x800000), the input and output registers are in the Altera.

Output Register

Writing a logic one to bit one of the output register will reset the Fault interrupt regardless of the source of the interrupt. The interrupt is generated on the leading edge of the fault signals. There are two fault signals, one is from the CAN (controller area network) and this can also be commanded by firmware on the CCB. The fault signal is created by a break in the loopback wire of the CAN connectors. This second fault path is what is referred to as Fault2 on both the HEMRC Control Board and the Collimator Control Board.

BIT	ADDRESS FFA009 WRITE ONLY	OUTPUT REGISTER LOW CONDITION	HIGH CONDITION
0	Fault Interrupt Reset	No Action	Clears Fault Interrupt
1			
2			
3			
4			
5			
6			
7			

Table 9-62 Collimator Output Registers

Z-Axis Tracking Timer

Within the Altera chip there is a timer-counter function. One function provides 125 kHz for the quadrature decode functions and 15.6 kHz to the filter amplifier circuitry on the CCB. Both these clocks are derived from the 16 MHz crystal.

For the Z-Axis function there is a 14 bit “up” counter with a clock of 3906 Hz derived from the 16 MHz system clock. The timer function comes from the ability to load a digital comparator that compare the value loaded by firmware against the value of the counter. Firmware is given the capability of asynchronously loading the counter, clearing the counter and masking the interrupt that is generated when the compare and count value match.

There are 3 control signals that configure this function:

CONTROL	ADDRESS	DESCRIPTION
cntctlwr	FFA00A	Clocks in the control bits that configure the counter.
cntlo_wr	FFA00B	Clocks in the low byte of the 14 bit compare word.
cnthi_wr	FFA00C	Clocks in the high byte of the 14 bit compare word

cnctlwr is generated by a WRITE to address FFA00A
cntlo_wr is generated by a WRITE to address FFA00B
cnthi_wr is generated by a WRITE to address FFA00C

Figure 9-51 Collimator Z-Axis Control Signals

The interrupt is generated when the count matches the compare value. A write to address FFA00D will reset the Exposure Command interrupt. No bits need to be set.

Collimator Register

The collimator register is used for collimator specific functions. It allows the firmware to command and readback status on the filter drive amplifier currents and also allows the firmware to shut down the collimator cam drives.

4.3.17 Z-Axis Tracking Overview

- The purpose of tracking is to follow the focal spot so that the system can keep the umbra of the beam on the detector to **reduce dose** and still avoid artifacts.
- Dose reduction is approximately 40% less in the 4 x 1.25mm mode and 25% less in the 4 x 5.00 mode.
- Z-Axis tracking is needed because the focal spot moves in Z due to thermal changes in the tube, and in mechanical forces during Gantry rotation and tilt.
- Z-Axis tracking involves the X-Ray Tube Focal Spot, Collimator, Detector, DAS, DCB, CCB, and RCIB/GCAN Communication Networks.

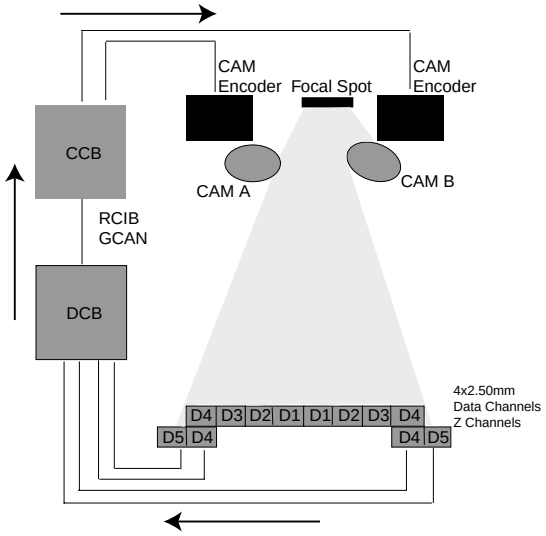

Figure 9-52 Typical Tracking Feedback Loop

4.3.18 Collimator Tracking Control Loop Theory

The purpose of tracking is to follow the focal spot so that we can keep the uniform X-ray of the narrowest possible beam on the detector to reduce dose and still avoid artifacts.The focal spot moves in Z due to thermal changes in the tube and a mechanical forces during gantry rotation and tilt angle. Each cam is basically an independent system.

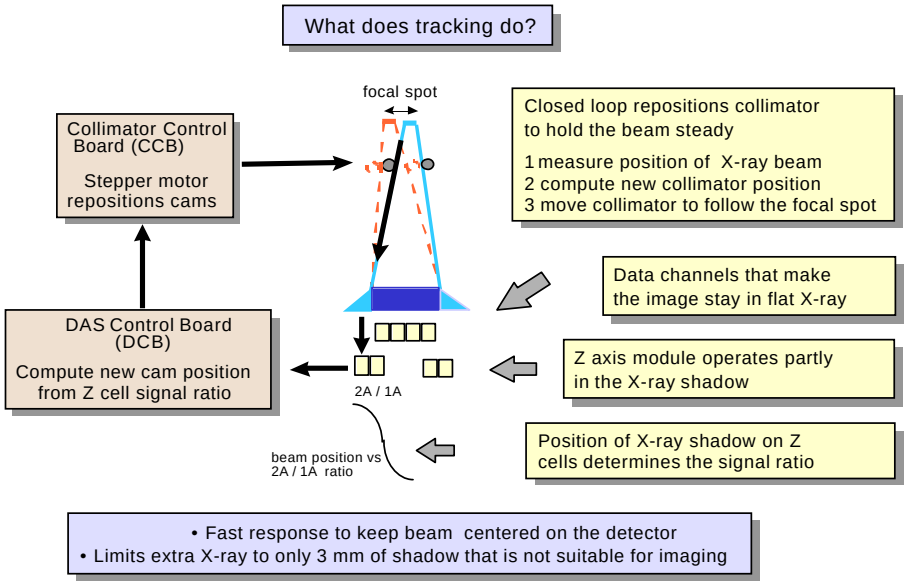

Figure 9-53 Tracking Diagram

1.) Select a safe operating point at the edges of the detector (target beam position at isocenter).

2.) Sample X-ray beam position every view and adjust collimator CAm positions every 20 ms. to keep the beam at the ISO center channel operating point.

a.) Compute Z ratio for each side of the Z module (outer row)/ (inner row). (Channels 763, 764 & 765.)

b.) Convert the ratio to a beam position at the Z module.

c.) Compute the focal spot position given the beam position on the Z module, the cam position for the Z module, and geometric magnification factors at the Z module.

d.) Compute the new cam position for the isocenter channel given the focal spot position and geometric magnification factors for the isocenter channel. During views when portions of the patient, patient table, IV line etc. block the Z module, the beam position measurement can not be used.

e.) We will compare DAS data channel 762 (data channel adjacent to the Z module) to an expected signal as a function of the measured mA, DAS gain, and trigger period. The Z module is blocked if either inner row is less than 0.9 times the expected value. During a blocked condition, the cams will hold constant at the last unblocked position.

- Transient conditions during a tube spit do not require special action.
- Out of range testing against limits provided by collimator calibration will be done. If one side is out of range the opposite side shall be used for positioning. If one side is out of range (except during a blockage) for more than 3 consecutive sample intervals the scan will be terminated.

f.) Measure the beam position and readjust the collimator approximately every 20 ms.

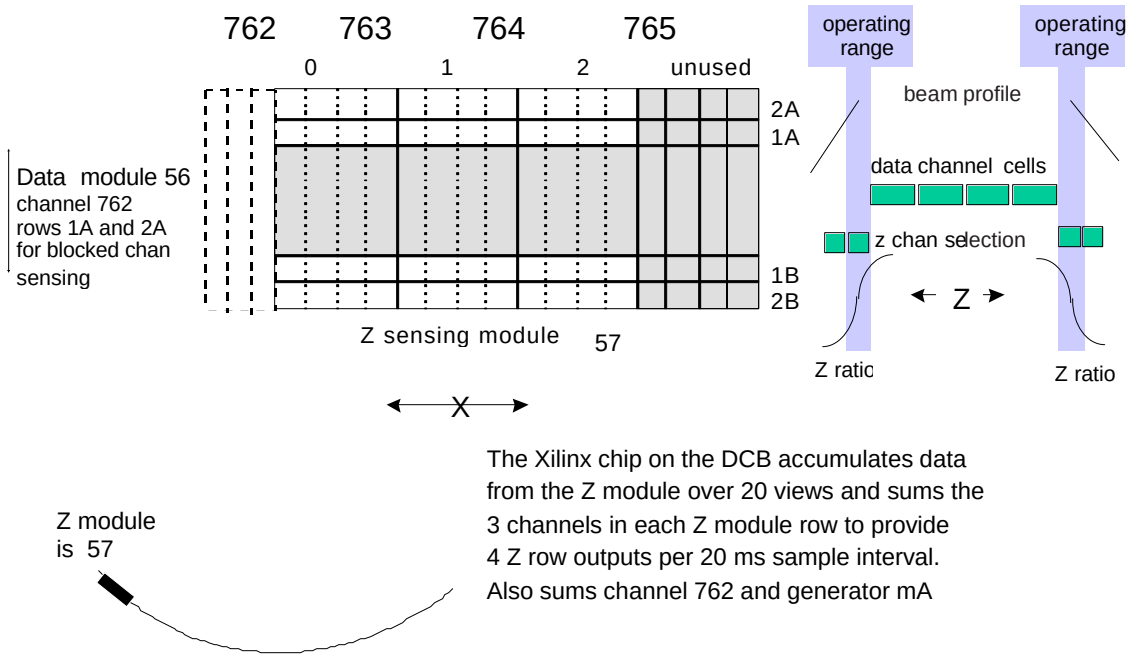

Figure 9-54 Z Sensing Module

Note: Z module cells can be switched independently of the data channels to provide the optimum tracking zratio. Refer to Figures 9-55, 9-56, 9-57, and 9-58, and Table 9-63, on page 787, for details on FET switch modes.

4.3.19 Tracking Loop Variables

4.3.19.1 Blocked Channel Check: 762

The x-ray signal output of DAS Channel 762 is characterized during FASTCAL (Air Scan with No beam obstructions). During patient scanning, if the x-ray signal on DAS channel 762 falls below 10% of the signal characterized during FASTCAL, then it is considered "blocked" and the collimator CAMS will hold constant at the last "un-blocked" position.

4.3.19.2 Z-Channels

- The Z-Channels are DAS channels 763, 764, & 765.
- Each DAS Z-channel is a combination of 4 detector channels in the X direction.
- Z-Channels have a different Detector Row selection than Data channels. This is selected by the Z-FET control lines.
- Beam position is determined by the following equation:

$$R = \frac{OuterRow}{InnerRow} \times DASGainCalCorrectionRatio$$

The R value is then transformed into a 4th degree polynomial to find the Z-Axis Beam position, which determines beam width at detector (mmd) and focal spot length (mmf).

mmd = millimeters at detector

mmf = focal spot length in millimeters.

Note: Errors are reported by the system in umd (micrometers at detector) or umf, due to computational accuracy.

OVERRIDES: value = {

RX_OVERRIDES: value = 0xa

FILAMENT_I: value = 0.0000

ANODE_DAC: value = 0x0

CATHODE_DAC: value = 0x0

ROTORSPEED: value = ROTOR_SPEED_HIGH

XRAY_DELAY_SEC: value = 0.0000

XRAY_DURATION_SEC: value = 1.0000

DCB_OVERRIDES: value = 0x20

Puts the DCB into over-ride mode so FET control can be selected.

CANNEDDCBPATTERNSELECTION: value = 0x0

CANNEDCNVPATTERNSELECTION: value = 0x0

AUTOCORRECTIONDISABLEMASK: value = 0x0

INNERCHANNELCONTROL: value = 0x3

Controls the Center DAS Chassis FET configuration

OUTERCHANNELCONTROL: value = 0x3

Controls the Right and Left DAS Chassis' FET configuration

ZCHANNELCONTROL: value = 0x9

Controls the Z-Channel FET configuration (Channels 763, 764, & 765)

INJECTEDDCVOLTAGE: value = 0x0

CCB_OVERRIDES: value = 0x2

Puts the collimator Control Board in over-ride mode

COLLIMATORWIDTH: value = 0x22c4

Keeps the collimator Cams wide open to flood the Detector

DDC Protocol	Mode	Row 2a	Row 1A	Row 1B	Row 2B	Fet5	Fet4	Fet3	Fet2	Fet 1	Rx Overide Value
das_interconnect4	4 x 1.25mm (Cal 0)	D2	D1	D1	D2	0	0	0	0	0	0
das_interconnect	4 x 2.50mm	D3+D4	D1+D2	D1+D2	D3+D4	0	0	0	0	-5.0	1
das_interconnect2	4 x 3.75mm	D4+D5+D6	D1+D2+D3	D1+D2+D3	D4+D5+D6	0	0	0	-5.0	0	2
das_interconnect3	4 x 5.00mm	D5+D6+D7+D8	D1+D2+D3+D4	D1+D2+D3+D4	D5+D6+D7+D8	0	0	0	-5.0	-5.0	3
das_interconnect5	Cal 1	D3	D2	D2	D3	0	0	-5.0	0	0	4
das_interconnect6	Cal 2	D4	D3	D3	D4	0	0	-5.0	0	-5.0	5
das_interconnect7	Cal 3	D5	D4	D4	D5	0	0	-5.0	-5.0	0	6
das_interconnect8	Cal 4	D6	D5	D5	D6	0	0	-5.0	-5.0	-5.0	7
das_interconnect9	Cal 5	D7	D6	D6	D7	0	-5.0	0	0	0	8
das_interconnect10	Cal 6	D8	D7	D7	D8	0	-5.0	0	0	-5.0	9
das_interconnect11	Cal 7	D1	D8	D8	D1	0	-5.0	0	-5.0	0	a
None	Cal 8	Floating	Floating	Floating	Floating	0	-5.0	0	-5.0	-5.0	b

Table 9-63 Scan Acquisition FET Mode Selection Table

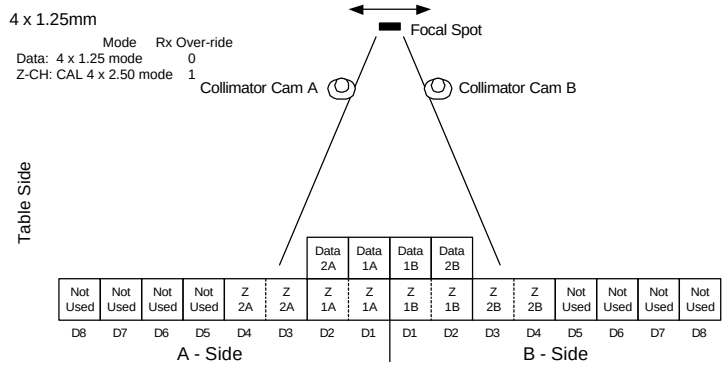

Figure 9-55 4x1.25mm With Tracking Enabled

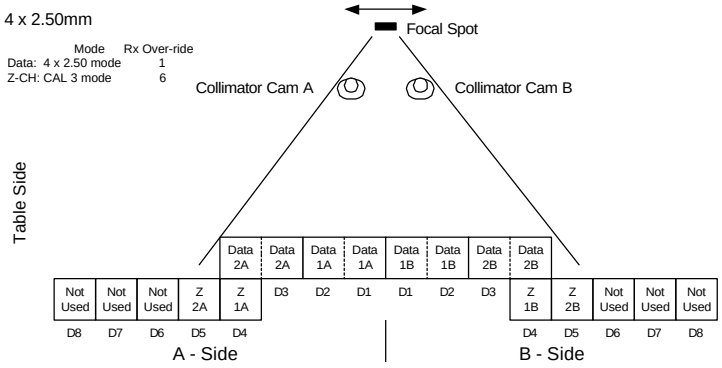

Figure 9-56 4x 2.50mm With Tracking Enabled

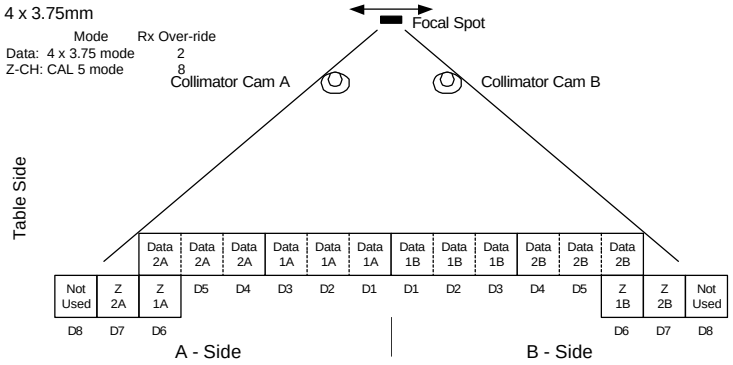

Figure 9-57 4x 3.75mm With Tracking Enabled

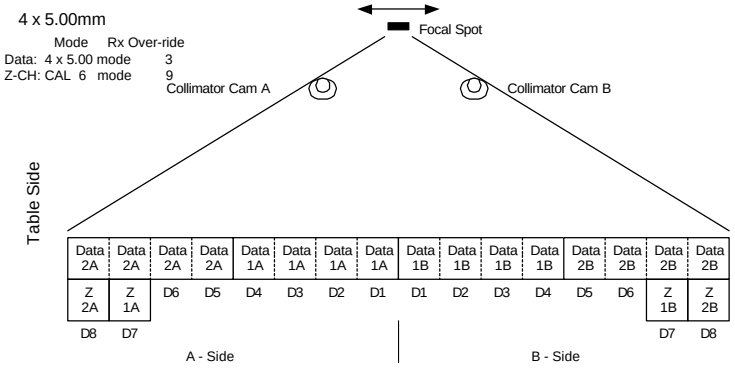

Figure 9-58 4x 5.00mm With Tracking Enabled

4.3.19.3 Focal Spot Length Check

During some conditions the Z module measurement can be corrupted due to a transient undetected blockage or due to a tracking loop malfunction. These conditions can be detected, identified by the DCB firmware, and reported to the gesyslog.

The focal spot length is computed on each sample interval from the measured Z and Cam positions.

- If Z measurements from each side are both valid, then the computed focal spot length should be close to the expected focal spot length from FastCal.
- If the computed focal spot length is not within tolerance of the focal spot length determined during Fast Cal then the control loop will hold the current cam positions.
- If the inconsistent length condition continues for more than 90 degrees of rotation without a normal blocked channel indication from channel 762, then the loop is assumed to be malfunctioning and the scan is aborted.

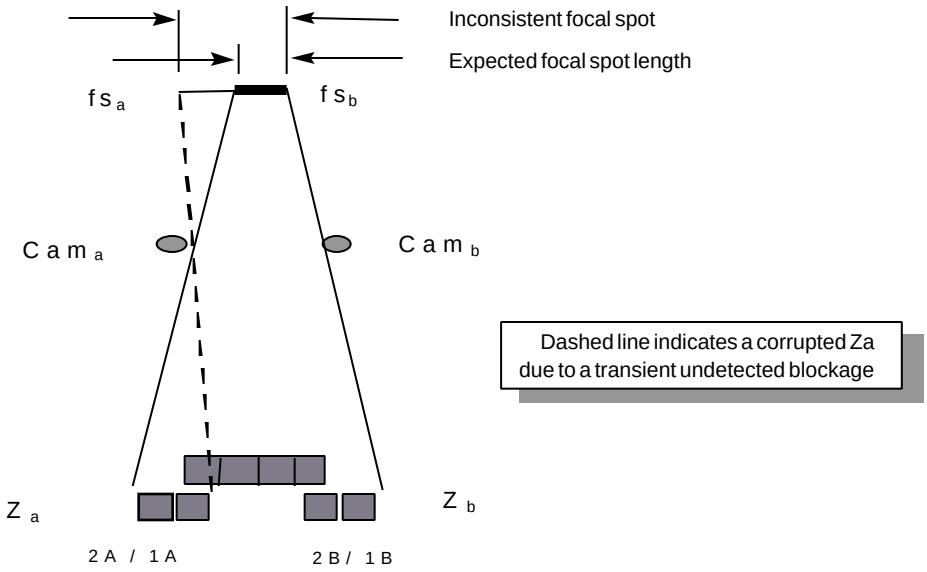

Figure 9-59 Focal Spot Length Check

4.3.20 Special Tracking Characterizations

4.3.20.1 Mylar Window Check

- Takes 4 scans (1 scan at each Patient Acquisition Mode). If a 20 view average of channel 762 falls below .95 of the expected value, then an error prompt informs the user to check and clean the Mylar window.
- Scans are taken without tracking and the collimator fully open to flood all detector rows.
- Technique is 80KV / 20mA / 1 Sec. / Air Filter
- Mylar window check is completed before DAS Gain Cal, Collimator Cal, and FASTCAL.

For more information, see “Dirty Mylar Window Scan,” on page 69.

- Characterizes the differences in DAS Gain (gain ranges 1-31) for DAS channels 762 (used for blocked channel detection) and Z-Channels (763, 764, and 765).
- The differences are a result of Pre-Amp Gain Capacitor tolerances on converter boards 47 and 48.
- The serial numbers of converter boards 47 and 48 are queried and stored during DAS Gain Cal. Collimator Cal and FASTCAL query the DAS and compare the serial numbers since the last time DAS Gain Cal was completed.
- A DAS Gain Cal is required whenever DAS Converter boards 47 or 48 are swapped or changed.

DESCRIPTION

DAS Gain calibration is required to support Z axis tracking. The ratio formed by the Z modules that is used as the basis for beam positioning is effected by the DAS gain selection. Capacitor tolerances on the DAS converter cards can change the ratio causing a beam position error. To avoid this error we measure the outer to inner row gain variation to develop a Z ratio correction factor for each gain selection.

DAS Gain Cal also determines a gain independent blocked channel threshold for the inner rows of DAS channel 762 for the tracking firmware. This gain factor is used to scale the gain normalized blocked channel scale factor to the proper level in the tracking firmware.

The DAS Gain cal flowchart is shown below. Before DAS Gain scans are taken, a mylar window check is done to ensure that the window is clean. Otherwise it can corrupt the tracking cals.

If the check succeeds, the DAS gain scans are taken and the cal proceeds forward. If the check fails, a pop-up is posted asking the user to provide inputs on whether they want to quit, continue anyway or retry the mylar window check after cleaning the mylar window.

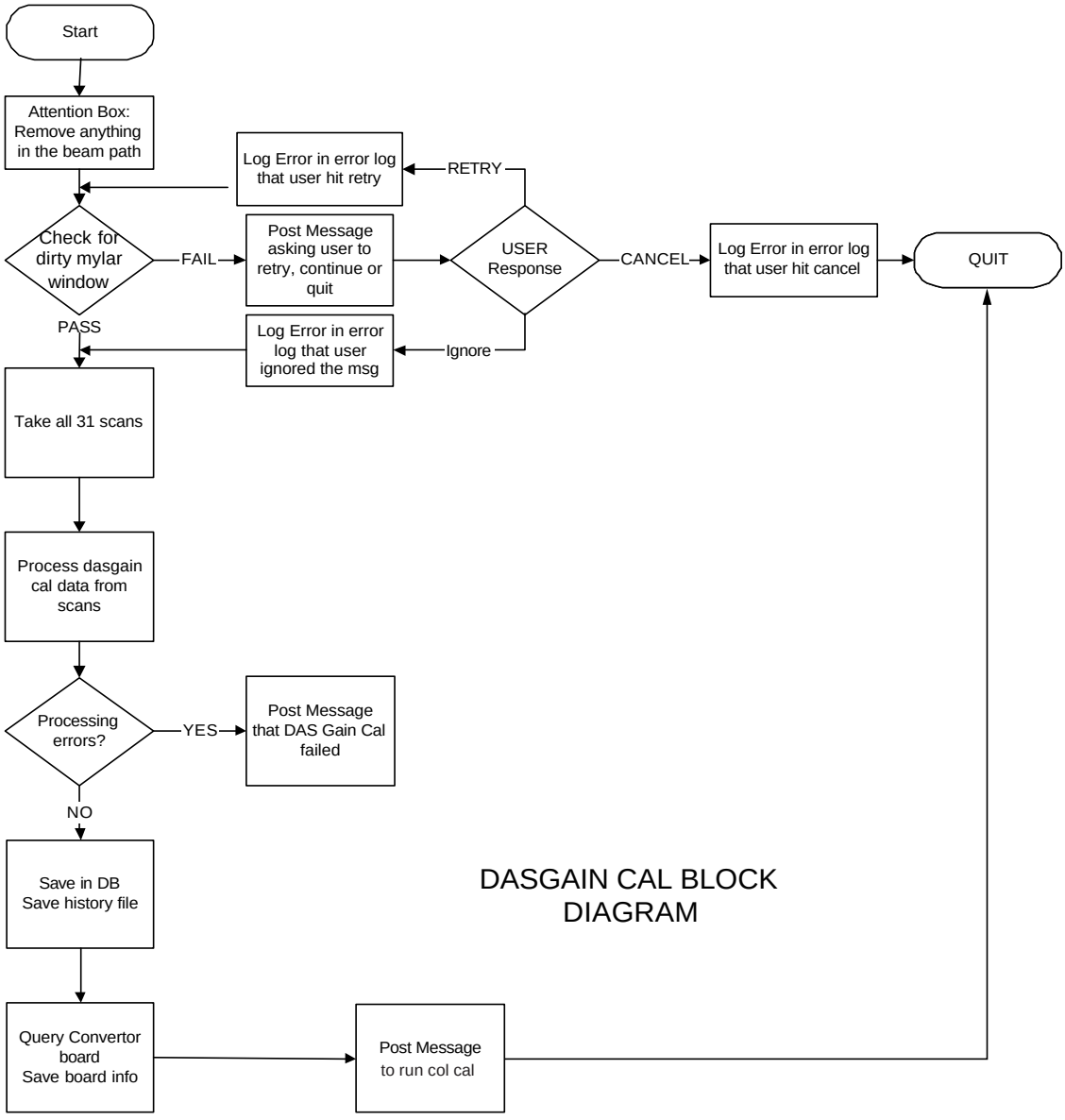

Figure 9-60 DAS Gain Cal Block Diagram

DAS GAIN CAL SCANS

- DAS Gain Calibration consists of 31 scans that are taken consecutively.
  Stationary / 120KV / 20mA / 0.3 Sec / Air / Gain 1
  through
  Stationary / 120KV / 20mA / 0.3 Sec / Air / Gain 31
- Processing is completed after all scans are completed.
- Total time is approximately 4 minutes.
- DAS Gain Cal takes 31 scans to collect signal data for all DAS channels at each of the 31 DAS gain settings using the DAS Gain protocol file.

4.3.20.2 Collimator Cal

Characterizes the beam position based on x-ray signal vs. collimator encoder position.

Eight Air scans taken using the following techniques:

LARGE SPOT		SMALL SPOT		NOMINAL COLLIMATOR WIDTH
120KV/300mA		120KV/150mA		
1	4 x 1.25mm	5	4 x 1.25mm	2100
2	4 x 2.50mm	6	4 x 2.50mm	2900
3	4 x 3.75mm	7	4 x 3.75mm	4470
4	4 x 5.00mm	8	4 x 5.00mm	5960

Table 9-64 Air Scans

- All scans with z-tracking off
- Scan time is 5.9 seconds
- Stationary Scans
- Offset from Nominal: ±900 cts.
- #of views: 100
- Step size: 50 cts.
- # of steps: 37

FASTCAL completes 1 Collimator Cal (Sweep) Scan each time FASTCAL is run. This results in all eight of the scans in Table 9-64 getting updated after FASTCAL is run eight times.

4.3.21 Diagnostics Related to Z-Axis Tracking

- Collimator Aperture Test. Refer to Install Manual for details.
- DAS Tools. See “DAS Tools,” on page 119.
- Interconnect Test. See “Interconnect Test,” on page 123.
- Tracking Analysis. See “Scan Data Analysis Tools (SCAN, Tracking dd, CAL),” on page 99.
- Diagnostic Data Collection. See “Diagnostic Data Collection (DDC),” on page 90.
  - FET Over-ride mode
  - Create and apply non-tracking Cal and DDC Scan

Z-AXIS ERROR CODES

Many of these messages contain variable fields for which some text or values will be substituted.

ERROR CODE	ERROR CODE TEXT	LOG LEVEL	HOST
260002505	“%sThe Beam Tracking Algorithm Encountered a Division by Zero.”	log	myhost>
260002506	“%sThe Prescribed Scan Has Not Been Calibrated For Beam Tracking.\n\ Macro Rows: %d Inner Width: %d Outer Width: %d Z Width: %d kv: %d"	log	myhost>
260002507	“First Data Channel #762”	log	myhost>
260002508	“Second Data Channel #762”	log	myhost>
260002509	“Third Data Channel #762”	log	myhost>
260002510	“mA Summing Channel”	log	myhost>
260002511	“%sThe DCB Digital AUX Data Register FAILED the Read/Write Test.\n\ Possible DCB Z Axis Tracking Hardware Failure.”	log	myhost>
260002512	“%sA Beam Tracking Feedback Message Contained an Invalid Move Sequence Number.\n\ This Indicates a Z-Axis Move Was Potentially Skipped.\n\	log	myhost>
260002513	“%sTwo Or More Tracking Messages Are Outstanding From The Collimator.\n\ Current Sequence #: %d”	log	myhost>
260002514	“%sBeam Tracking Calculated A Focal Spot Size That Has Exceeded The WARNING Tolerance.\n\ Tolerance: %6d umf\n\ Calculated Size: %6d umf\n\ Nominal Size: %6d umf”	log	myhost>
260002515	%sBeam Tracking Calculated A Focal Spot Size That Has Exceeded The ABORT Tolerance.\n\ Tolerance: %6d umf\n\ Calculated Size: %6d umf\n\ Nominal Size: %6d umf” Nominal Size: %6d umf”	log	myhost>
260002516	“%sBeam Tracking Control Loop Error Exceeded The WARNING Tolerance.\n\ Tolerance: %6d umd\n\ Control Error: %6d umd\n\ Beam Side: %b”	log	myhost>
260002517	“%sBeam Tracking Control Loop Error Exceeded The WARNING Tolerance.\n\ Tolerance: %6d umd\n\ Control Error: %6d umd\n\ Beam Side: %b”	log	myhost>
260002518	“A Side”	log	myhost
260002519	“B Side”	log	myhost
260002520	“Beam Tracking Detected a Loss of Signal. Image Quality may Be Effected.\v\ mA Level: %d\n\ Z Channels: %d, %d, %d, %d”	log	myhost

Table 9-65 Z-AXIS Tracking Error Codes

Section 5.0
Replacement Procedures

5.1 Collimator Replacement Procedures

5.1.1 Filter Assembly

5.1.1.1 Required Tools

- 3 mm Hex key sockets
- Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

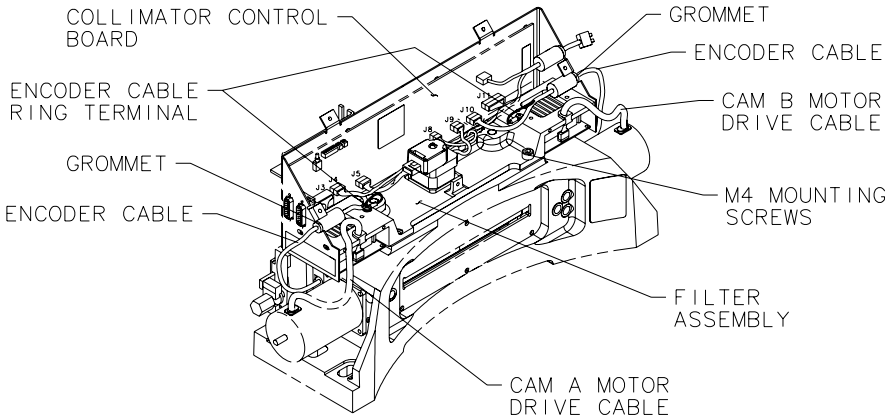

Figure 9-61 Filter Assembly Replacement

5.1.1.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position a drop cloth below the Collimator to collect any hardware that might be dropped.
4.) Follow the procedure for removing the Collimator Control Board.
5.) Follow the procedure for removing the Cam Motor Driver Modules.
6.) Remove driver covers on motor mount asm. (P/N 2120095) and set aside.
7.) Remove the CAM A & B encoder cable ring terminals & washers.
8.) Return the screws & washers to their original location after removing the ring terminals.
9.) Slide the grommet on the CAM A & B encoder cables out of the frame mount to fully disconnect the encoder cables from the frame.
10.) Remove the Filter PWB Mount Bracket (P/N 2148913) by removing the six pan head M4 mounting screws (P/N 2103585) and set aside.
11.) Remove the four hex socket M4 frame mounting screws (P/N 46-328417P4).

Note: Do not damage the fragile aluminum, graphite & copper filter asm. that extends into the Collimator frame during the Filter removal or new Filter installation.

12.) Lift the filter asm. from the steel Collimator frame and set to the side.
13.) Remove the new Filter Asm. from the shipping box.
14.) Seat the new Filter Asm. on the Collimator alignment pins.
15.) Place the old Filter Asm. in to the shipping box.

16.) On the new Filter Asm., insert the four hex socket M4 frame mounting screws and torque to:

3 N-m	**26.6 lb-in**	**2.2 lb-ft**	**30.6 kg-cm**

17.) Replace the Filter PWB Mount Bracket by installing all six pan head screws loosely, then tighten and torque to:.

3 N-m	**26.6 lb-in**	**2.2 lb-ft**	**30.6 kg-cm**

18.) Follow the procedure for re-connecting the Cam Motor Driver Modules.

19.) Replace the driver covers on motor mount asm.

20.) Follow the procedure for re-connecting the Collimator Control Board.

21.) Remove the screw & washer for the ring terminals & use to secure the CAM A &B ring terminals & tighten.

22.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

Note: Ensure the Cam Driver Leads are outside of the cover.

23.) Remove the drop cloth and follow the procedures for closing the gantry.

5.1.2 Collimator Control Board (CCB)

5.1.2.1 Required Tools

- ESD Kit
- 3 mm Hex key
- Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

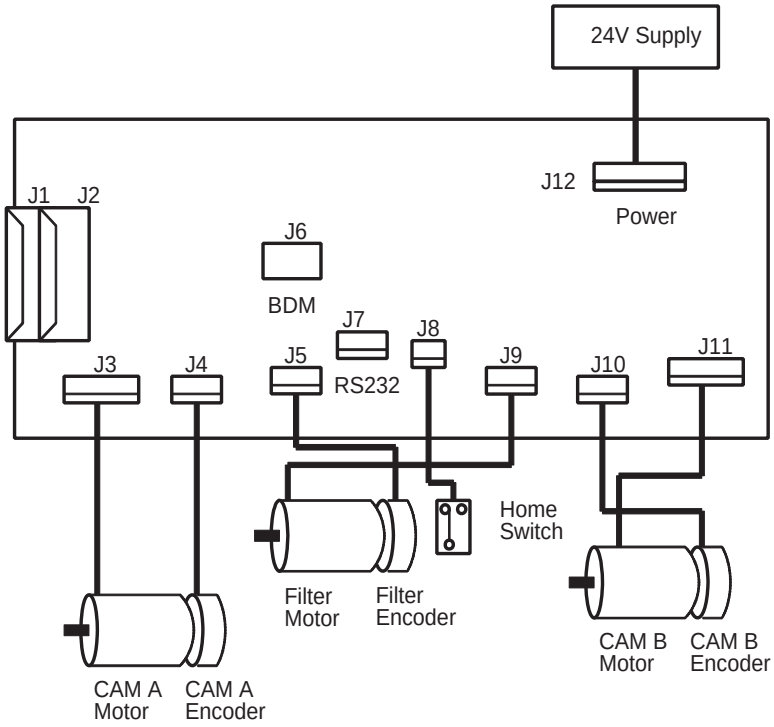

Figure 9-62 Collimator Control Board (CCB) Replacement

5.1.2.2 Procedure Details

NOTICE The CCB is static sensitive. Please follow proper static handling procedures.

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws (P/N 2103585) that have spring washers.
5.) Disconnect the power cable at connector J12, on the lower side on the Collimator.
6.) Disconnect the two 15 pin D CAN bus connections, J1 and J2, on the upper side of the Collimator.
7.) Remove the four CAN bus connection jackscrews (P/N 46-221417P1) with flat washers & lock washers.
8.) Disconnect the CAM A(J4)&B(J10) encoder cables.
9.) Disconnect all of the remaining cables as shown in the illustration.
10.) Remove the six pan head M4 mounting screws (P/N 2103585).
11.) Remove the replacement CCB from it's shipping container.
12.) Place the new CCB on the Collimator.
13.) Place the old CCB in the shipping container.
14.) Install the six pan head screws loosely to hold board in place.
15.) Install & tighten the four CAN bus connection jackscrews.
16.) Tighten the six pan head screws.
17.) Re-connect the power cable at connector J12, on the Collimator lower end.
18.) Re-connect the two 15 pin D CAN bus connections, J1 and J2, on the upper side of the Collimator.
19.) Re-connect the CAM A(J4)&B(J10) encoder cables.
20.) Re-connect the remaining cables as shown in the illustration.
21.) Enter replacement procedures software menu.
22.) Enter Collimator.
23.) Access Flash Download Tool and follow the procedure to flash the characterization file onto the CCB.

Note: CCB PWA is static sensitive and is to be loaded with Collimator characterization file specific to frame assembly and linked to the manufacturer's serial number.

24.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

5.1.3 DAS Power Supply – Left/Right Side

5.1.3.1 Collimator/Detector Heater 24V Power Supply
2225217 DAS 12 VDC POWER SUPPLY
2225212-2 5 VDC LOGIC POWER SUPPLY

The 2225212 and 2225217 are located in the 2225209 Left DAS power Supply Assembly.
The 2225212-2 and a second 2225217 are located in the 222509-2 Right Assembly.
The procedure below applies to each individual power supply.

5.1.3.2 Required Tools

- 5mm Hex key sockets
- 10mm socket.
- Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.1.3.3 Replacement Procedure

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove the right cover.

LEFT POWER SUPPLY

3.) Turn **OFF** the Axial Enable switches on the STC backplane.
4.) Rotate gantry until the power supply assembly is within reach.
5.) Turn **OFF** the HVDC and 120 Vac on the STC backplane.
6.) Disconnect and label all harnesses that interfere with the removal of the external plastic cover.
7.) Remove the external plastic cover by removing 4 screws with the 5mm Hex key sockets.
8.) Remove 4 hex nuts that secure the power supply assembly you are trying to replace using a 10mm socket. This includes the heat sinks.
9.) Disconnect wiring to power supply output terminal lugs.

Note: Do not lose flat washer and lock washer.

10.) Lift the power supply off the threaded rod.
11.) Replace the power supply assembly.
12.) Reassemble gantry.
13.) Reference retest matrix at the end of this chapter.

RIGHT POWER SUPPLY

1.) Remove the five (5) DCB 5mm cap screws.
2.) Fold the DCB assembly over the DAS.
3.) Follow the LEFT POWER SUPPLY steps

5.1.4 Cam Motor Driver Module

5.1.4.1 Required Tools

- 2. 5mm, 3 mm Hex key sockets
- Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

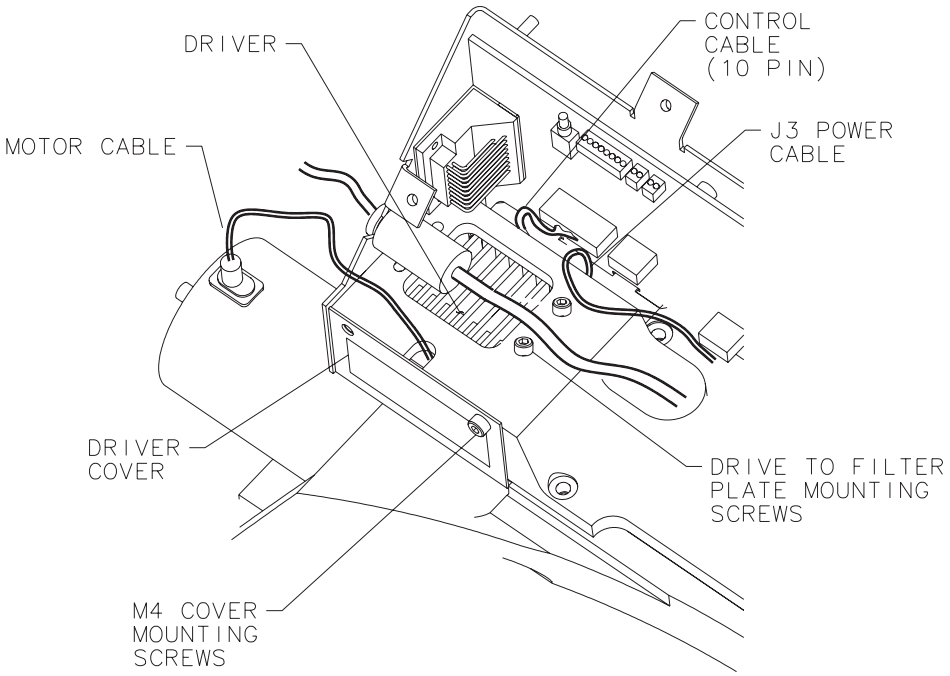

Figure 9-63 Cam Motor Driver Replacement

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.4.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws (P/N 2103585) that have spring washers.
5.) Remove the driver cover on motor mount asm. (P/N 2120095) by removing two pan head M4 screws (P/N 2103585) with washers.
6.) Disconnect the three wire J3 power connector at the rear of the module.
7.) Disconnect the ten pin amp control cable at the rear of the module.
8.) Disconnect the drive to motor cable connection.
9.) Remove the four head cap screws 3 mm cap screws (P/N 46-312577P5) holding the drive to the filter top plate.
10.) Remove the cam motor driver module & place in container for return.
11.) Install new cam motor driver module with the four pan cap screws.
12.) Torque pan cap screws to 1.2 ± 0.1 N-m.
13.) Connect the drive to motor cable.
14.) Connect the six wire motor phase drive connector.

15.) Connect the J3 power connector.

16.) Install the driver cover on motor mount asm. ensuring that the two tabs engage with the slots in the filter PWB Bracket (P/N 2148913).

17.) Tighten the two pan head M4 screws with spring washers.

18.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

5.1.5 Collimator Assembly

5.1.5.1 Required Tools

- Spanner Wrench
- Hoist
- Tube Change Bracket
- 10 mm Hex key sockets

5.1.5.2 Procedure Details

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

Conversion Factor: 1 N-m = 1.356 ft-lb

NOTICE
Potential For Equipment Damage

DO NOT lift the Collimator by the Motors.

1.) Move table to its lowest elevation.

2.) Remove all covers.

3.) Position the tube at 3 o'clock.

4.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.

5.) Engage gantry rotational lock.

DANGER **LOCK GANTRY TO AVOID INJURY DUE TO UNEXPECTED ROTATION.**

6.) Connect and secure hoist and tube change bracket to the tube.

7.) Remove high voltage cables from cathode and anode using spanner wrench.

8.) Remove the tube (see tube removal procedure).

WARNING **BE CAREFUL TO KEEP TUBE AND OIL DROPLETS AWAY FROM CONTAMINATING THE SLIPRING.**

9.) Disconnect connectors J2, J3 and J11 from collimator.

10.) Remove collimator by removing the two (2) bolts from the top and two (2) bolts from the bottom and 2 bolts from the rear of the collimator using 10 mm Hex key sockets.

11.) Install new collimator by replacing the four (6) bolts removed in above step.

12.) Secure the tube back in place.

13.) Replace high voltage cables back using spanner wrench.

Note: If oil needs to be topped off, be careful of spills. Do not use any part of the gantry as a shelf to rest oil on.

14.) Reassemble gantry.

5.1.6 Cam Drive Motor

5.1.6.1 Required Tools

- 3 mm, 4 mm Hex key sockets
- 3/32 Hex key
- Phillips #2 screwdriver
- Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.6.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws (P/N 2103585) that have spring washers.
5.) Remove the three red cap/plugs (P/N 46-230644P10) from the Collimator front surface (on side which motor will be removed).
6.) Remove the driver cover on motor mount asm. (P/N 2120095) by removing the two pan head M4 screws (P/N 2103585) with spring washers.
7.) Disconnect the connector between motor drive and motor.
8.) Use a flashlight aimed through the cap/plug holes to see the set screw in the coupler.
9.) Rotate the motor until the screw is visible and can be loosened on the flexible motor coupler.
10.) Loosen the flexible coupling hex screw.
11.) Remove the four hex socket M4 screws (P/N 46-328417P3) holding the motor to the Motor Mount Plate (P/N 2119358).
12.) Remove the motor and place in the container to be returned.
13.) Install the new motor and tighten the four hex socket screws to 3 ±0.3 N-m.
14.) Tighten the flexible motor coupling screw.
15.) Connect the connector between motor drive and motor.
16.) Install the driver cover on motor mount asm. insuring that the two tabs engage with the slots in the filter PWB Bracket (P/N 2148913).
17.) Tighten the two pan head M4 screws with spring washers.
18.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.
19.) Install the three cap/plugs after all hardware has been torqued.

5.1.7 Cam Encoder Harness

5.1.7.1 Required Tools

- 3 mm, 4 mm Hex key sockets
- 3/32 Hex key
- Phillips #2 screwdriver
- Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.7.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws (P/N 2103585) that have spring washers.
5.) Remove the three red cap/plugs (P/N 46-230644P10).
6.) Remove the driver cover on motor mount asm. (P/N 2120095) by removing the two pan head M4 screws (P/N 2103585) with spring washers.
7.) Disconnect the connector between motor drive and motor.
8.) Disconnect the ground shield lead.
9.) Use a flashlight aimed through the cap/plug holes to see the screw in the coupler.
10.) Rotate the motor until the screw is visible and can be loosened on the flexible motor coupler.
11.) Loosen the flexible motor coupling screw.
12.) Take out the four hexagon socket M4 screws (P/N 46-328417P3) holding the motor to the Motor Mount Plate (P/N 2119358).
13.) Remove the motor.
14.) Remove the four countersunk M6 cap screws (P/N 2103580-12) for the Motor Mount Plate.
15.) Remove the Motor Mount Plate (P/N 2119358).
16.) Disconnect the harness.
17.) Unplug harness from encoder by depressing locking mechanism and pulling out
18.) Remove the screw for the harness shield ground lead.
19.) The harness can now be removed and placed in container for return.
20.) Install the new harness and ensure it is locked in position.
21.) Tighten the screw for the harness shield ground lead.
22.) Connect the harness.
23.) Install the motor mount plate.
24.) Torque the four countersunk 6x12mm cap screws to 17 ± 1.5 N-m.
25.) Install motor & tighten the four hexagon socket screws to 3 ±0.3 N-m.
26.) Tighten the flexible motor coupling screw to 1.5 ±0.15 N-m.
27.) Connect the ground shield lead.
28.) Connect the connector between motor drive and motor.
29.) Install the driver cover on motor mount asm. ensuring that the two tabs engage with the slots in the filter PWB Bracket (P/N 2148913).
30.) Tighten the two pan head M4 screws with spring washers.
31.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.
32.) Install the three cap/plugs after all hardware has been torqued.

5.1.8 Secondary Aperture

5.1.8.1 Required Tools

2 mm Hex key

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.8.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the six countersunk M2.5 flat head mounting screws (P/N 46-328422P4).
5.) Remove the secondary aperture and place in shipping container for return.
Be careful not to damage the collimator output window (P/N 2214248).
6.) Install the new secondary aperture ensuring not to damage any of the interior edges due to the critical nature of x-ray filtering.
7.) Tighten the six flat head screws using Loctite 242 10CC (P/N 46-170686P2).

5.1.9 Primary Aperture

5.1.9.1 Required Tools

- 2 mm, 4 mm, 10 mm Hex key
- 4 mm socket
- Phillips #2 screwdriver
- Tube hoist and boom
- Spanner wrench

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.9.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the four hexagon socket M4 screws (P/N 46-328417P4) for the X-Axis Tube Gauge Mount Bracket.
5.) Remove the X-Axis Tube Gauge Mount Bracket (P/N 2148629).
6.) Follow the procedure for removal of the Collimator Assembly.
7.) Remove the two M5 slotted head shoulder screws (P/N 46-313583P3) for the Interposer Plate.
8.) Remove the Interposer Plate with Interposer Adjuster Block (P/N 2148597) attached.
9.) Remove eight countersunk M2.5 flat head screws to remove the primary aperture.
10.) Remove the aperture and place in the container for shipment.
11.) Install the new primary aperture ensuring not to damage any of the interior edges due to the critical nature of x-ray filtering.
12.) Apply Loctite 242 10CC to the eight flat head screws and tighten.
13.) Apply Loctite 242 10CC to the two shoulder screws and mount the Interposer Plate tightening the screws.
14.) Apply Loctite 242 10CC to the four socket screws and mount the X-Axis Tube Gauge Mount Bracket tightening the screws.
15.) Follow the procedure for mounting the Collimator on the gantry.

5.1.10 Power Harness

5.1.10.1 Required Tools

Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.10.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head 4x8mm mounting screws (P/N 2103585) with spring washers.
5.) Cut the tie-wraps holding down the Power Harness.
6.) Disconnect the Cam A motor drive power connector.
7.) Disconnect the Cam B motor drive power connector.
8.) Disconnect J12 from CCB.
9.) Remove Power Harness and place in packaging to return.
10.) Place the new Power Harness on the frame.
11.) Connect J12 to the CCB.
12.) Connect the Cam A motor drive power connector.
13.) Connect the Cam B motor drive power connector.
14.) Tie-wrap the Power Harness.
15.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

5.1.11 FRU 2's Not Requiring Procedures

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

The following FRU's do not have replacement procedures because of the simplistic nature of removal.

DESCRIPTION	FRU CODE
Capplug, 46-230644P10	Yes
CCB Cover, 2120107	Yes
Driver Harness, 2125241	Yes
Filter Encoder Harness, 2126849	Yes
Filter Switch Harness, 2126848	Yes
CCB Jackscrew, 46-221417P1	Yes, see "Collimator Control Board (CCB)," on page 794.
Interposer Plate, 2243925	Yes
Adjuster Screw, 2120094	Yes
Window, 2214248	Yes, see "Secondary Aperture," on page 800.

Table 9-66 FRU's Not Requiring Procedures

5.2 Transformer Tank Measurement Board

5.2.1 Required Tools

- Phillips #2screwdriver
- Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.2.2 Procedure Details

1.) Position table to lowest elevation.
2.) Turn **OFF** facility power to PDU.

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

3.) Remove, and set aside, both gantry side covers.
4.) Turn **OFF** all 3 switches on the status control box on right side of Gantry.
5.) Lift top cover, and engage prop rod.
6.) Remove Scan window.
7.) Open front cover.
8.) Rotate Measurement Board to 3:00 position.
9.) Unplug connectors J1, J2, J5, and J6
10.) Remove 6 screws and washers that fasten measurement board to High Voltage Supply.
11.) Carefully pry measurement board off High Voltage Tank.
12.) Replace Measurement Board.

Note: Carefully align connector pins from Interface Measurement Board to Round Interface Board on High Voltage Supply.

13.) Reassemble Gantry.
14.) Refer to Retest Verification Table at the end of this chapter.

5.3 High Voltage Tank (Anode)

5.3.1 Required Tools

- Hoist
- 10 mm Hex Ball to 3/8" drive socket
- 19 mm socket or box wrench
- 5/16, 1/2, 9/16 inch sockets or box wrenches
- Paper Towels

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.3.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

5.) Remove the 3 M12 cap screws that will release the support bracket near the STC assembly.

Note: Lower rear "3rd" M12 screw may not be installed. This is normal.

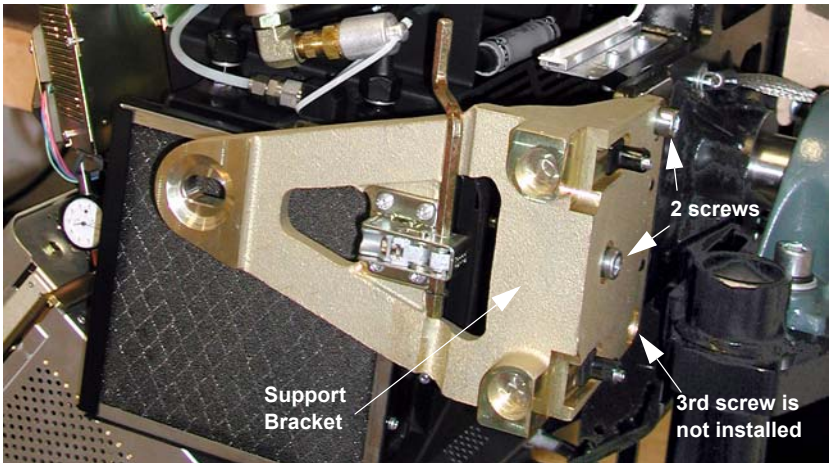

Figure 9-64 Gantry cover support bracket and screws

6.) Rotate gantry to locate the high voltage tank about 9 o'clock.

7.) Engage gantry rotational lock.

DANGER **ENSURE GANTRY ROTATIONAL LOCK IS FULLY ENGAGED TO PREVENT UNEXPECTED GANTRY MOTION.**

8.) Use the spanner wrench to remove the high voltage cable connector from the high voltage transformer tank.

- Ground the ends of the H.V. cable to the Gantry frame, to ensure no voltage exists at the end of the cable.
- Use rags or paper towels to wipe excess oil from the High Voltage Cable Connector and tank well.
- Stuff the tank wells with paper towels to absorb any oil.

9.) Remove cables J1, J2 and J6 from the measurement PWB.

WARNING **OBSERVE THE POSITION OF THE CABLES AND TIE-WRAPS FOR LATER INSTALLATION. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

10.) Remove four screws fastening the cover to the inverter assembly and remove cover.

11.) Measure voltage on the two large capacitors to verify 0 volts.

12.) Disconnect J1 connector from the bottom of the inverter assembly.

13.) Disconnect J6 connector from gate driver PWB.

14.) Carefully disconnect four fiber optic cables from gate driver board, making note of where the tie-wrap is for routing the cable back in its original position.

Note: Optic cables must not come in contact with Green Resistors on the Inverter; contact with the resistors can result in a melting of the optic cables.

15.) Verify HVDC rail or 120 Vac is not present.

16.) Disconnect HVDC cable from capacitor PWB.

17.) Cut tie-wraps from side plate of inverter.

18.) Remove all cables from the Inverter by removing cable restraint at the top of the inverter.

19.) Remove two (2) inverter output leads from H.V. Transformer Tank locations P1 and P2.

20.) Disengage gantry rotational lock.

CAUTION **Be careful not to damage any of the loose cables while you rotate the gantry to position the tank for removal.**

21.) Carefully rotate the gantry clockwise to the 2 o'clock position.

22.) Engage gantry rotational lock.

DANGER

ENSURE GANTRY ROTATIONAL LOCK IS FULLY ENGAGED TO PREVENT UNEXPECTED GANTRY MOTION.

23.) Remove the four (4) 3/8 bolts from the inverter baseplate, that fasten the inverter assembly to the H.V. Transformer Tank.

24.) Remove the inverter assembly from the gantry:

- Attach the hoist to the boom arm in the gantry.
- Attach the hoist lifting chain to the lifting bracket on the transformer tank bottom.
- Remove slack from the hoist chain.

25.) Remove the four (6) M12 screws that fasten transformer tank to the rotating base.

26.) Use the hoist to lower the transformer tank to the floor.

27.) Install the new transformer tank.

Note: When installing the four (4) M12 mounting bolts, DO NOT use (discard) the four (4) Adapter Bushings supplied with the replacement tank (see Figure 9-65). Torque the mounting bolts to 66.4 N-m

The 2 bolts with nuts need to be torqued at the cap screw not the nut.

Figure 9-65 Adapter Bushings

28.) Mount the inverter to the HV tank. Torque the 4 3/8 inch bolts to 20 ft-lbs.

29.) Remove the host and boom.

30.) Disengage gantry rotational lock.

31.) Rotate the gantry counterclockwise to the 9 o'clock position.

32.) Engage gantry rotational lock.

33.) Reassemble all cabling and secure with tie-wraps as observed in step 9 through19.

WARNING **ENSURE CABLES ARE PROPERLY SECURED. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

34.) Before you install the HV Cable Connector, add 20 cc of dielectric oil to the HV Connector well in the HV Transformer Tank.

35.) Align the cable terminal orienting key with the notch in the receptacle.

36.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.

- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).0

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

37.) Carefully wipe up all excess oil.

38.) Secure HV Cables using Large tie-wraps as shown in Figure 9-68, on page 813.

39.) Reassemble Gantry.

40.) Refer to Retest Verification Table at the end of this chapter.

5.4 High Voltage Tank (Cathode)

5.4.1 Required Tools

- Hoist
- 10 mm Hex Ball to 3/8” drive socket
- 19 mm socket or box wrench
- 5/16, 1/2, 9/16 inch sockets or box wrenches
- Paper towels

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

5.4.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.

2.) Remove side, top and front gantry covers.

3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.

4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

5.) Remove the 3 M12 cap screws that will release the support bracket near the STC assembly. Reference Figure 9-64, on page 804.

6.) Rotate gantry until the Cathode HV transformer tank reaches the 3 o’clock position.

7.) Engage gantry rotational lock.

DANGER **ENSURE GANTRY ROTATIONAL LOCK IS FULLY ENGAGED TO PREVENT UNEXPECTED GANTRY MOTION.**

8.) Use the spanner wrench to remove the high voltage cable connector from the high voltage transformer tank.
   - Ground the ends of the H.V. cable to the Gantry frame, to ensure no voltage exists at the end of the cable.
   - Use rags or paper towels to wipe excess oil from the High Voltage Cable Connector and tank well.

9.) Remove cables J1, J2 and J6 from the measurement PWB.

WARNING **OBSERVE THE POSITION OF THE CABLES AND TIE-WRAPS FOR LATER INSTALLATION. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

10.) Remove four screws fastening the cover to the inverter assembly.
   Remove cover.

11.) Measure voltage on the two large capacitors to verify 0 volts.

12.) Disconnect J1 connector from the bottom of the inverter assembly.

13.) Disconnect J6 connector from gate driver PWB.

14.) Carefully disconnect four fiber optic cables from gate driver board, making note of where the tie-wrap is for routing the cable back in its original position.

Note: Optic cables must not come in contact with Green Resistors on the Inverter; contact with the resistors can result in a melting of the optic cables.

15.) Verify HVDC rail or 120 Vac is not present.

16.) Disconnect HVDC cable from capacitor PWB.

17.) Cut tie-wraps from side plate of inverter.

18.) Remove all cables from the Inverter by removing cable restraint at the top of the inverter.

19.) Remove two (2) inverter output leads from H.V. Transformer Tank locations P1 and P2.

20.) Remove the four (4) 3/8 bolts from the inverter baseplate, that fasten the inverter assembly to the H.V. Transformer Tank.

21.) Remove the inverter assembly from the gantry:
   - Attach the hoist to the boom arm in the gantry.
   - Attach the hoist lifting chain to the eyebolt on the transformer tank.
   - Remove slack from the hoist chain.

22.) Remove the four (4) bolts that fasten transformer tank to the rotating base.

23.) Use the hoist to lower the transformer tank to the floor.

24.) Install the new transformer tank.

Note: Install four (6) M12 tank mounting bolts, and torque to 66.4 Nm.
   The 2 bolts with nuts need to be torqued at the cap screw not the nut.

25.) Mount the inverter to the HV tank. Torque the 4 3/8 inch bolts to 20 ft-lbs.

26.) Remove the host and boom.

27.) Reassemble all cabling and secure with tie-wraps as observed in step 9 through19.

WARNING **ENSURE CABLES ARE PROPERLY SECURED. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

28.) Before you install the HV Cable Connector, add 20 cc of dielectric oil to the HV Connector well in the HV Transformer Tank.

29.) Align the cable terminal orienting key with the notch in the receptacle.

30.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.

- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).

NOTICE **Do not over-tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

31.) Carefully wipe up all excess oil.

32.) Secure HV Cables using Large tie-wraps as shown in Figure 9-68, on page 813.

33.) Reassemble Gantry.

34.) Refer to Retest Verification Table at the end of this chapter.

5.5 HP Anode/Cathode Inverter

5.5.1 Required Tools

- 5/16, 1/2, 9/16 inch sockets or box wrenches
- Flat-blade screwdriver
- Loctite 242

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.5.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.

2.) Remove side, top and front gantry covers.

3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.

4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

5.) Position Gantry with the tube at the 12 o'clock position.

6.) Engage gantry rotational lock.

7.) Remove four screws fastening cover to inverter assembly, and remove cover.

8.) Measure voltage on the two large capacitors to verify 0 volts.

9.) Disconnect J1 connector from the bottom of the inverter assembly.

10.) Disconnect J6 connector from gate driver PWB.

11.) Carefully disconnect four fiber optic cables from gate driver board, making note of where the tie-wrap is for routing the cable back in its original position.

Note: Optic cables must not come in contact with Green Resistors on the Inverter; contact with the resistors can result in a melting of the optic cables.

12.) Disconnect HVDC cable from capacitor PWB.

13.) Remove all cables from the Inverter by removing cable restraint at the top of the inverter.

14.) Remove two inverter output leads from Transformer Tank locations P1 and P2.

15.) Remove four (4) 3/8 bolts from inverter baseplate, which fastens inverter assembly to H.V. Transformer Tank.

16.) Remove inverter assembly from gantry.

17.) Install new inverter assembly.

Note: Use Loctite 242, and torque the four (4) 3/8 tank mounting bolts to 20 ft-lbs.

18.) Reassemble Gantry.

19.) Refer to Retest Verification Table at the end of this chapter.

Figure 9-66 HP Inverter

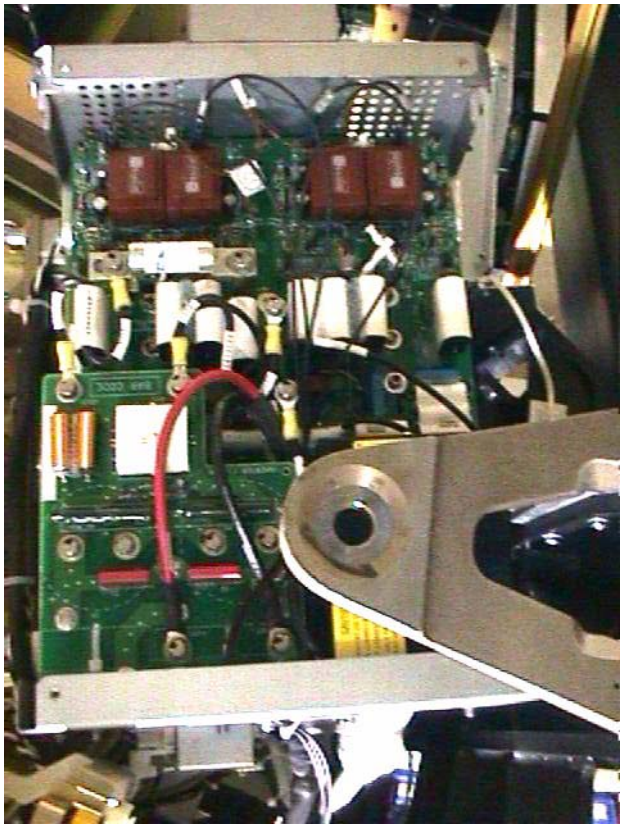

Figure 9-67 HP Inverter Cover removed

5.6 HV Cables

5.6.1 Required Tools

- Spanner wrench
- 3 mm Hex key
- Large tie-wraps 46-208758P5
- Transformer oil
- Paper towels

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.6.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

Removal

1.) Move table to its lowest elevation.
2.) Remove side gantry covers and rear base covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove top gantry covers.
5.) Position tube at 3:00 o'clock position
6.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

7.) Remove tie-wraps securing the hv cables.

8.) Using spanner wrench remove hv candlestick from tube well.
- Ground the end of the cable to the Gantry Frame to verify no voltage.
- Wipe excess oil with paper towels.
- Cover tube well.

9.) Rotate Gantry until the tube reaches the 12 o'clock position.
- Position HV cable toward front of gantry.

10.) Use the spanner wrench to remove the candlestick at the HV tank.
- Wipe excess oil with paper towels.
- Cover the hv tank well.

11.) Place the tilt relay board in the manual mode.

12.) Restore power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

13.) Manually tilt gantry backward to 30 degrees.

Note: Tilting the gantry is optional. This provides for easier access to the cable clamps while standing at the rear of the gantry.

14.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

15.) For the Cathode cable;
- Cut tie-wraps at rear of HEMRC assembly.
- Remove 2 cable clamps behind tube attached to the rotating base casting.

16.) For the Anode Cable;
- Carefully cut tie-wraps securing the rotating harness to the hv cable.
- Remove the 2 cable clamps on both sides of the OBC assembly attached to the rotating base casting.

17.) Carefully remove the cable from the Gantry.

Installation

WARNING **ALWAYS START AT THE HV TANK. EXCESS SLACK IN THE HV CABLES CAN RESULT IN SYSTEM DAMAGE. ENSURE CABLES ARE PROPERLY SECURED. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

1.) Insert the HV Cable candlestick into the HV tank well. No oil yet.

2.) Loosely tighten the cable in the well.

3.) For the Cathode cable;
- Route the cable behind the HEMRC assembly.
- Loosely tie-wrap cable to the HEMRC frame at 2 points.
- Verify the HV cable can be removed from the hv tank. **USE THE ABSOLUTE MINIMUM AMOUNT OF CABLE SLACK**.
- Secure the tie-wraps.
- Install the cable clamps as originally oriented behind the tube.

4.) For the Anode cable;
- Route the cable behind the OBC assembly.
- Install the cable clamp near the stamped "-" on the rotating base casting.
- Verify the HV cable can be removed from the hv tank. **USE THE ABSOLUTE MINIMUM AMOUNT OF CABLE SLACK**.

- Install the second cable clamp between the tube and the OBC assembly on the rotating base casting.

5.) Remove the candlestick from the HV tank well.

6.) Restore power to the main (A1) panel. Do not turn on the STC backplane switches.

7.) Manually tilt the gantry to zero degrees.

8.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

9.) Add 20 ml (0.7 oz) of dielectric oil to the well of the HV transformer tank.

10.) Align the cable terminal orienting key with the notch in the receptacle.

11.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.

- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).

⚠

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

12.) Carefully wipe up all excess oil.

13.) Rotate tube to the 3:00 o'clock position.

14.) Secure HV Cables using Large tie-wraps as shown in Figure 9-68.

15.) Add 20 ml (0.7 oz.) of dielectric oil to the HV connector well of the x-ray tube.

16.) Align the cable terminal orienting key with the notch in the receptacle.

17.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.

- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).

⚠

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

18.) Carefully wipe up all excess oil.

19.) Place tilt relay board back to normal mode.

20.) Restore power at main disconnect (A1) panel.

21.) Turn **ON** the 120 Vac at the STC backplane.

22.) Manually rotate the gantry and verify there are no obstructions.
23.) Turn **ON** the Axial Enable and HVDC on the STC backplane.
24.) Rotate the Gantry at a speed of 1 Revolution per second, for several revolutions.
25.) Rotate the Gantry at a speed of 0.5 Revolution per second, for several revolutions.
26.) Check the tube and transformer tank wells for oil leaks.
27.) Reassemble Gantry.
28.) Refer to Retest Verification Table at the end of this chapter.

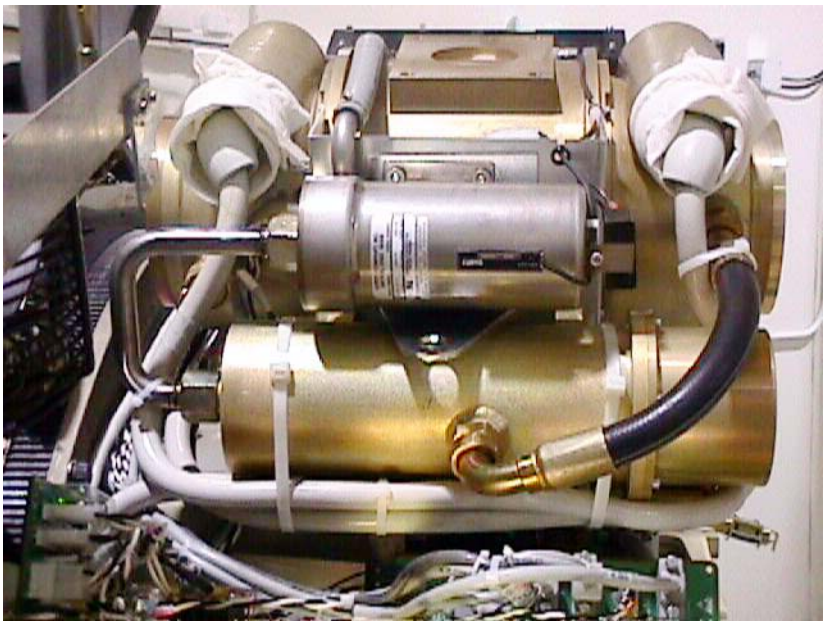

Figure 9-68 HV Cable Routing

5.7 HEMRC

5.7.1 Filament Power Supply

5.7.1.1 Required Tools

- 10 mm open end/box wrench
- 3 mm, 5 mm Hex key sockets
- 7 mm, 10 mm and 9/16”socket
- Flathead screwdriver
- Phillips #2 screwdriver
- Tie-wraps 7.5 inch 46-208758P3

Before beginning this procedure, please read the safety information in “Gantry,” on page 41.

5.7.1.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

Removal

1.) Move table to its lowest elevation.

2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Disconnect all connectors from HEMRC Interface board.
8.) Disconnect HVDC Power Cable from HVDC+ and HVDC- lugs (3/8" brass nuts).
9.) Disconnect HVDC cable ground bracket, cut choke tie-wraps and set cable aside.
10.) Remove (6) 4 mm cap screws and washers and remove HEMRC Interface board.
11.) Cut tie-wraps to Cathode High Voltage Cable.
12.) Position cable behind HEMRC assembly.
13.) Remove the J15 DB 9 connector on the left side of the T1 transformer.
14.) Remove J3/J9 CAN communication cable shield ground bracket. (7 mm nuts and washer).
15.) Remove (2) 10 mm nuts and washers securing HEMRC Filter mounting bracket. Set aside bracket.
16.) Remove (4) 10 mm nuts and washers to remove top-tier mounting bracket and remove bracket.
17.) Remove wires at Allen Bradley R, S.
Flip the Safety cover up by lifting on the black left and right tabs.
18.) Remove wires X1, X3 and H1, H4 from T1 transformer.
19.) Disconnect connections to HEMRC Drive. DC+, DC-.
20.) Disconnect FWB+ (Orange) and FWB- (Purple) at the Full wave Diode bridge on the HEMRC Filter bracket.
Remove tie-wraps from chopper harness choke. (DC+, DC- cable)
21.) Disconnect stator cable shield ground bracket and ground wire from the HEMRC filter board.
(2) 7 mm nuts and 1, 4 mm cap screw with washer.
22.) Disconnect Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
23.) Set HEMRC Filter bracket aside
24.) Disconnect SCR1-1 SCR1-2, SCR1-3 wires.
25.) Disconnect Filament power supply wires from fuse next to T1 transformer. Feed them through the grommet into the bottom-tier.
26.) Remove the T1 transformer.
a.) Remove (4) 6 mm cap screws.
b.) Remove (4) 9/16" standoffs.
27.) Remove the (4) 7 mm nuts securing the Allen Bradley amplifier.
28.) Remove the amplifier and set aside.
29.) Free the chopper harness from the quick release wire guides.
30.) Carefully thread the chopper power harness through the mid-tier plate to the white J7 connector. Do not attempt to force the connector through the hole. It will not fit.
31.) Remove remaining (2) 10 mm nuts and washers for mid-tier plate.
32.) Remove the (2) 10 mm nuts on the bottom center support brace.
33.) Carefully lift and flip the mid-tier plate and rest it on the HV tank next to the HEMRC assembly.
34.) Remove the (3) 4 mm cap screws from both sides rear air diverter on bottom plate.

⚠ **CAUTION** **This is sharp spring steel.**

35.) Remove the (4) 10 mm nuts and washers using the box wrench. (2 are beneath the transformer.)
36.) Remove filament power supply.

Installation

1.) Install new filament power supply. Torque (4) 10 mm nuts and washers to 5.9 Nm.
2.) Install spring steel air diverters. Torque 3 per side, 4 mm cap screws to 5.9 Nm.
3.) Install mid-tier plate.
   - Torque 2 bottom center brace, 10 mm nuts to 5.9 Nm.
   - Torque 2 center mid-tier plate, 10 mm nuts and washers to 5.9 Nm.
4.) Carefully work chopper power harness back out to mid-tier.
5.) Secure chopper harness in quick clip wire guides.
6.) Install T1 transformer. Torque 9/16" standoffs and (4) 6mm cap screws and washers to 5.9 Nm.
   - Remember the top spacer plate.
   - X1 and X3 terminals are tank side.
7.) Install Allen Bradley amplifier. Torque (4) 7 mm nuts to 1.7 Nm.
8.) Connect the SCR1-1, SCR1-2, SCR1-3 and Filament power supply fuse wires.
9.) Connect the FWB+ (Orange) and FWB- (Purple) wires to the Full wave Diode bridge.
   - Make sure you get the polarity correct.
   - Make sure you tie-wrap the FWB choke to the bracket TY-RAP LOCK INSIDE.
   - Make sure you connect the Stator ground to the HEMRC filter board. (4 mm cap screw).
10.) Connect the Stator cable shield ground bracket to the HEMRC Filter Bracket. Torque to 1.7 Nm.
11.) Connect the DC+, DC- lead from the filter board and Chopper harness to the amplifier.
12.) Connect the Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
13.) Connect the T1 transformer X1, X3 and H1, H4 wires. (X3 and H4 is toward the rear).
14.) Connect the T1 transformer R and S wires to the Allen Bradley amp.
15.) Install the top-tier bracket. Torque the (4) 10 mm nuts and washers to 5.9 Nm.
16.) Install the J15 DB 9 connector. Make sure to tighten the finger screws.
17.) Secure the HV cable to the rear of the HEMRC assembly.
18.) Install the HEMRC Interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
19.) Connect all HEMRC connectors.
20.) Secure the J3/J9 CAN communications cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
21.) Route HVDC cable loop under top-tier bracket. Secure HVDC cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
22.) Secure HVDC choke to left side top-tier support bracket with 2 tie-wraps.
   This should be flat against the bracket to not interfere with the cover.
23.) Install HEMRC cover. Tighten 1/4 turn past seated finger tight.
24.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
25.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
26.) Perform hardware reset.
27.) Assemble gantry.
28.) Refer to Retest Verification Table at the end of this chapter.

5.7.2 HEMRC Fuse Replacement

46-170021P104 (10 amp.) Located on the HEMRC bottom-tier right front side.

46-170021P43 (3 amp.) Located on the HEMRC Interface Board**.**

46-170021P15 (8 amp.) Located on the HEMRC Interface Board**.**

46-170021P101 (20 amp.) Located on the HEMRC Interface Board**.**

5.7.2.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.2.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove fuse and confirm that it has opened.
9.) Replace fuse.
10.) Replace HEMRC cover and secure 1/4 turn past seated finger tight.
11.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
12.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
13.) Assemble gantry covers.
14.) Refer to Retest Verification Table at the end of this chapter.

5.7.3 Fuse Block on the HEMRC Resistor Panel Asm

5.7.3.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM
- 3 mm Hex key sockets

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.3.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove 10 amp fuse. from fuse holder on bottom-tier front right side.

9.) Disconnect wires from fuse holder.
10.) Remove two (2) 4 mm cap screws attaching fuse holder.
11.) Remove and replace fuse holder. Torque 2 4 mm cap screws to 1.7 Nm.
12.) Replace leads removed in step 9.
13.) Replace 10 Amp fuse.
14.) Replace HEMRC cover and secure 1/4 turn past seated finger tight.
15.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
16.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
17.) Assemble gantry covers.
18.) Refer to Retest Verification Table at the end of this chapter.

5.7.4 HEMRC Dropping Resistors

5.7.4.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM
- 7 mm socket

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.4.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove tie-wraps and disconnect from HEMRC Interface board J4/J5 connectors.
9.) Remove 2 per resistor, 7 mm cap screws.
10.) Replace resistor. Torque 7 mm cap screws to 1.7 Nm
11.) Connect to HEMRC interface board.
12.) Tie-wrap wires as originally found.
13.) Replace HEMRC cover and secure 1/4 turn past seated finger tight.
14.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
15.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
16.) Assemble gantry covers.
17.) Refer to Retest Verification Table at the end of this chapter.

5.7.5 HEMRC Braking Resistors

5.7.5.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM

- 3 mm, 5 mm Hex key sockets
- 10 mm box wrench

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.5.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 6 o'clock.
6.) Remove (2) 4 mm cap screws and washers.
Cover under the HEMRC Assembly closest to ISO Center.
7.) Using a DVM measure both sides of the resistors to chassis ground. Verify zero (0) volts.
8.) Remove electrical connection from defective resistor.
- Write down wiring connections and hardware arrangement.
- Do not drop the hardware into the HEMRC assembly

9.) For both resistors perform the following:
- Remove 6 mm lock nut and star lock washer.
- Remove 6 mm tensioning nut.
- Loosen, do not remove, the (2) 10 mm nuts to separate the resistor mounting covers.
- Slide the covers apart. Note the original position.
- Carefully retract long bolt to pivot the failed resistor up out of the assembly.
- Catch the insulating washers.

10.) Replace failed resistor.
11.) Loosely install the tensioning nut on both long bolts.
12.) Carefully position resistors and insulating washers while you slide the mounting covers together. Make sure the covers engage properly.
13.) Snug the tensioning bolts finger tight to hold the mounting covers together.
14.) Position the mounting covers as identified in step 9. Torque both 6 mm nuts to 5.9 Nm.
15.) Rotate the resistors so that the connectors are parallel to the HEMRC assembly to prevent electrical arcing or shorts.
16.) Torque the tensioning nut to 5.9 Nm.
17.) Install the star lock washer and 6 mm lock nut. Torque to 5.9 Nm.
18.) Replace electrical connections to resistor.
- Careful not to drop hardware into HEMRC assembly.
- Orient hardware as identified in step 8.

19.) Replace HEMRC resistor cover. Torque (2) 4 mm cap screws and washers to 5.9 Nm
20.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
21.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
22.) Assemble gantry covers.
23.) Refer to Retest Verification Table at the end of this chapter.

5.7.6 HEMRC Interface Board

5.7.6.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM
- 3 mm Hex key sockets

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.6.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove electrical cable connections from the interface board.
9.) Remove (6) 4 mm cap screws and washers.
10.) Replace HEMRC interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
11.) Reinstall cable connections to interface board.
12.) Replace HEMRC cover and secure 1/4 turn past seated finger tight.
13.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
14.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
15.) Assemble gantry covers.
16.) Refer to Retest Verification Table at the end of this chapter.

5.7.7 HEMRC Step-up (T1) Transformer

5.7.7.1 Required Tools

- 3 mm, 5 mm Hex key sockets
- 10 mm and 9/16"socket
- Flathead screwdriver
- Phillips #2 screwdriver
- Tie-wraps 7.5 inch 46-208758P3

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.7.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

Removal

1.) Move table to its lowest elevation.

2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Disconnect all connectors from HEMRC Interface board.
8.) Disconnect HVDC Power Cable from HVDC+ and HVDC- lugs (3/8" brass nuts).
9.) Disconnect HVDC cable ground bracket, cut choke tie-wraps and set cable aside.
10.) Remove (6) 4 mm cap screws and washers and remove HEMRC Interface board.
11.) Remove J3/J9 CAN communication cable shield ground bracket. (7 mm nuts and washer).
12.) Remove (4) 10 mm nuts and washers to remove top-tier mounting bracket and remove bracket.
13.) Remove wires X1, X3 and H1, H4 from T1 transformer.
14.) Remove the T1 transformer.
    a.) Remove (4) 6 mm cap screws.
    b.) Remove (4) 9/16" standoffs.

Installation

1.) Install T1 transformer. Torque 9/16" standoffs and (4) 6mm cap screws and washers to 5.9 Nm.
    - Remember the top spacer plate.
    - X1 and X3 terminals are tank side.
2.) Connect the T1 transformer X1, X3 and H1, H4 wires. (X3 and H4 is toward the rear).
3.) Install the top-tier bracket. Torque the (4) 10 mm nuts and washers to 5.9 Nm.
4.) Install the HEMRC Interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
5.) Connect all HEMRC connectors.
6.) Secure the J3/J9 CAN communications cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
7.) Route HVDC cable loop under top-tier bracket. Secure HVDC cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
8.) Secure HVDC choke to left side top-tier support bracket with 2 tie-wraps.
    This should be flat against the bracket to not interfere with the cover.
9.) Install HEMRC cover. Tighten 1/4 turn past seated finger tight.
10.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
11.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
12.) Perform hardware reset.
13.) Assemble gantry.
14.) Refer to Retest Verification Table at the end of this chapter.

5.7.8 SCR Module

5.7.8.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM
- 3 mm Hex key sockets
- Thermal compound (46-170212P1)

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.8.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Note and record position of three (3) wires (Red, Pur and Wht) attached to SCR.
9.) Note and record position of two (2) wires (Blk and Wht) attached to SCR.
10.) Note and record position of SCR terminals.
11.) Remove leads identified in steps 8 and 9.
12.) Remove two (2) 4 mm cap screws.
13.) Clean SCR mounting surface on resistor mounting panel, using a dry tissue to remove thermal compound.
14.) Prepare new SCR by coating the mounting surface with thermal compound (46-170212P1).
15.) Mount SCR in position recorded in step 10. Torque (2) 4 mm cap screws to 1.7 Nm.
16.) Replace leads removed in steps 8 and 9.
17.) Install HEMRC cover. Tighten 1/4 turn past seated finger tight.
18.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
19.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
20.) Perform hardware reset.
21.) Assemble gantry.
22.) Refer to Retest Verification Table at the end of this chapter.

5.7.9 Bridge Rectifier

5.7.9.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter DVM
- 3 mm Hex key sockets
- Thermal compound (46-170212P1)

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.9.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.

6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Note and record position of bridge rectifier terminals and polarity mark.
9.) Note and record the position of four (4) leads connected to bridge rectifier. (Red, Blk, Pur and Orn)
10.) Remove the four leads from bridge rectifier.
11.) Remove 7 mm hex nut and washers holding the bridge rectifier to the HEMRC mounting plate.
12.) Remove bridge rectifier.
13.) Clean bridge rectifier mounting surface on mounting plate, using a dry tissue to remove thermal compound.
14.) Prepare new bridge rectifier by coating mounting surface with thermal compound (46-170212 P1).
15.) Mount bridge rectifier as recorded in step 8. Torque 7 mm hex nut and washers 1.7 Nm.
16.) Replace leads removed in step 10 as noted in step 9.
17.) Install HEMRC cover. Tighten 1/4 turn past seated finger tight.
18.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
19.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
20.) Perform hardware reset.
21.) Assemble gantry.
22.) Refer to Retest Verification Table at the end of this chapter.

5.7.10 HEMRC Filter Board

5.7.10.1 Required Tools

- Flat-blade screwdriver
- Phillips #2 screwdriver
- Digital Volt Meter DVM
- 3 mm Hex key sockets

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.10.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Engage gantry rotational lock.
9.) Remove five (5) bolts fastening cover to HEMRC assembly and remove cover.
10.) Remove the (2) 6 mm nuts and washers securing the HEMRC Filter bracket.
11.) Remove the DC+ and DC- wire from the Allen Bradley amplifier.
12.) Remove the (4) 4 mm cap screws and washers securing the filter board.
13.) Install the new filter board. Torque the (4) 4 mm cap screws to 1.7 Nm.
Remember to install the Stator ground wire.
14.) Connect the DC+ and DC- wire to the Allen Bradley amplifier.
15.) Install the HEMRC Filter bracket. Torque the (2) 6 mm nuts to 5.9 Nm.
16.) Install HEMRC cover. Tighten 1/4 turn past seated finger tight.
17.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
18.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
19.) Perform hardware reset.
20.) Assemble gantry.
21.) Refer to Retest Verification Table at the end of this chapter.

5.7.11 HEMRC AC Drive Replacement

5.7.11.1 Required Tools

- 3 mm, 7 mm, 10 mm Hex key sockets
- Flathead screwdriver
- Phillips #2 screwdriver
- Tie-wraps 7.5 inch 46-208758P3

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.11.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

Removal

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position HEMRC at 1 o'clock to clear fan obstruction.
6.) Remove HEMRC cover.
7.) Disconnect all connectors from HEMRC Interface board.
8.) Disconnect HVDC Power Cable from HVDC+ and HVDC- lugs (3/8" brass nuts).
9.) Disconnect HVDC cable ground bracket, cut choke tie-wraps and set cable aside.
10.) Remove (6) 4 mm cap screws and washers and remove HEMRC Interface board.
11.) Remove J3/J9 CAN communication cable shield ground bracket. (7 mm nuts and washer).
12.) Remove (2) 10 mm nuts and washers securing HEMRC Filter mounting bracket. Set aside bracket.
13.) Remove (4) 10 mm nuts and washers to remove top-tier mounting bracket, and remove bracket.
14.) Remove wires at Allen Bradley R, S. Flip the Safety cover up by lifting on the black left and right tabs.
15.) Disconnect connections to HEMRC Drive. DC+, DC-.
16.) Disconnect Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
17.) Remove the (4) 7 mm nuts securing the Allen Bradley amplifier.
18.) Remove the amplifier and set aside.

Installation

1.) Install Allen Bradley amplifier. Torque (4) 7 mm nuts to 1.7 Nm.
2.) Connect the DC+, DC- lead from the filter board and Chopper harness to the amplifier.
3.) Connect the Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
4.) Connect the T1 transformer R and S wires to the Allen Bradley amp.
5.) Install the top-tier bracket. Torque the (4) 10 mm nuts and washers to 5.9 Nm.
6.) Install the HEMRC Interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
7.) Connect all HEMRC connectors.
8.) Secure the J3/J9 CAN communications cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
9.) Route HVDC cable loop under top-tier bracket. Secure HVDC cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
10.) Secure HVDC choke to left side top-tier support bracket with 2 tie-wraps. This should be flat against the bracket to not interfere with the cover.
11.) Install HEMRC cover. Tighten 1/4 turn past seated finger tight.
12.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
13.) Turn **ON** HVDC and 120 Vac on the STC backplane. Verify no smoke or arching.
14.) Perform hardware reset.
15.) Assemble gantry.
16.) Refer to Retest Verification Table at the end of this chapter.

5.7.12 Tube Fan/Pump Relay

5.7.12.1 Required Parts

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 MM. Hex Key

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.12.2 Procedure Details

Figure 9-69 OBC Tube Fan/Pump Relay

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Position OBC at 2 o'clock.
5.) Remove (2) 4 mm cap screws that secure safety cover over tube fan/pump and relay.
6.) Remove the (4) wires from the relay.
    Write down the wiring and relay orientation for later assembly.
7.) Remove (2) 4 mm cap screws and washers.
8.) Install new relay and safety cover. Torque 4 mm cap screws to 2.3 Nm.
9.) Restore power.
10.) Verify no errors in system log and tube fan is operating.
11.) Reassemble gantry.

5.7.13 OBC Filament Relay

5.7.13.1 Required Parts

Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 41.

5.7.13.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, HVDC, 120 Vac) on the STC backplane.
4.) Position OBC at 2:00 o'clock. Reference Figure 9-70.
5.) Carefully remove the Filament relay retaining clip on the OBC backplane. Observe how the clip is mounted for later assembly.
6.) Remove Filament Relay.
7.) Install new relay and make sure retaining clip is properly installed.

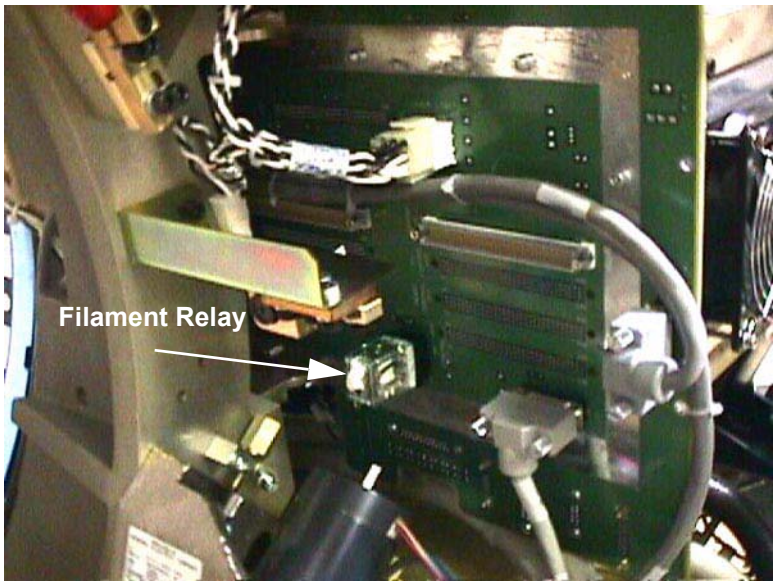

Figure 9-70 OBC Backplane Filament Relay

Section 6.0
Retest Matrix: High Voltage Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust a high voltage part.**

HV SYSTEM COMPONENTS	TASK	VERIFICATION TEST
Tube	Pull and complete tube data for old tube and install new tube. See Table 9-52, on page 767.	Verify mA meter, new Auto mA Cal (Seed Shift only), (10) slices of micro phonics, Alignments, calibrate HV Tank Feed back, kV meter*, heat soak and season the tube, verify mA and kV, QCal, Cals, “N” number check, then do image series.
HEMRC Filament power Supply	Replacement, “HEMRC,” on page 813.	Auto mA Cal, verify kV and mA, and “System Scanning Test,” on page 660.
HEMRC FUSES	Replacement, “HEMRC Fuse Replacement,” on page 815.	“System Scanning Test,” on page 660.
HEMRC Fuse Block	Replacement, “Fuse Block on the HEMRC Resistor Panel Asm,” on page 816.	“System Scanning Test,” on page 660.
HEMRC Dropping Resistors	Replacement, “HEMRC Dropping Resistors,” on page 817.	“System Scanning Test,” on page 660.
HEMRC Braking Resistors	Replacement, “HEMRC Braking Resistors,” on page 817.	“System Scanning Test,” on page 660.
HEMRC Interface Board	Replacement, “HEMRC Interface Board,” on page 819.	“System Scanning Test,” on page 660.
HEMRC Step-up T1 Transformer	Replacement, “HEMRC Step-up (T1) Transformer,” on page 819.	“System Scanning Test,” on page 660.
HEMRC SCR Module	Replacement, “SCR Module,” on page 820.	“System Scanning Test,” on page 660.
HEMRC Bridge Rectifier	Replacement, “Bridge Rectifier,” on page 821.	“System Scanning Test,” on page 660.
HEMRC Filter Board	Replacement, “HEMRC Filter Board,” on page 823.	“System Scanning Test,” on page 660.
HEMRC AC Drive	Replacement, “HEMRC AC Drive Replacement,” on page 823.	“System Scanning Test,” on page 660.
HV Cable	Replacement, “HV Cables,” on page 810.	“Auto mA Calibration,” on page 761.

Table 9-67 High Voltage System Retest Matrix

HV SYSTEM COMPONENTS	TASK	VERIFICATION TEST
HV Tank (Anode or Cathode)	Replacement, "High Voltage Tank (Anode)," on page 803.	"KV Gain Pots Adjustment," on page 758. "Verify kV Meter," on page 754. "Verify mA Meter," on page 755. "Auto mA Calibration," on page 761. "KV Rise and Fall Times," on page 762. "System Scanning Test," on page 660.
HV Inverter (Anode or Cathode)	Replacement, "HP Anode/ Cathode Inverter," on page 808.	"Verify kV Meter," on page 754. "Verify mA Meter," on page 755. "Auto mA Calibration," on page 761. "System Scanning Test," on page 660.
Measurement Board	Replacement, "Transformer Tank Measurement Board," on page 803.	"KV Gain Pots Adjustment," on page 758. "Verify kV Meter," on page 754. "Verify mA Meter," on page 755. "Auto mA Calibration," on page 761. "KV Rise and Fall Times," on page 762. "System Scanning Test," on page 660.
Filament Relay	Replacement, "OBC Filament Relay," on page 826.	"Auto mA Calibration," on page 761. "System Scanning Test," on page 660.
Tube Cooling Relay	Replacement, "Tube Fan/ Pump Relay," on page 825.	• Plane of Rotation (POR). • X-Ray Beam on Window (BOW) • Isocenter • Center Body Filter (CBF) and SAG
mA Board	Replacement, "OBC Circuit Boards," on page 651.	"Verify mA Meter," on page 755. "Verify kV Meter," on page 754. "Auto mA Calibration," on page 761. Exposure Time Accuracy, and "System Scanning Test," on page 660.
kV Board	Replacement, "OBC Circuit Boards," on page 651.	"Verify kV Meter," on page 754. "Verify mA Meter," on page 755. "KV Gain Pots Adjustment," on page 758. "Auto mA Calibration," on page 761. "KV Rise and Fall Times," on page 762. "System Scanning Test," on page 660.
HEMRC Control Board	Replacement, "OBC Circuit Boards," on page 651.	Select kV & mA under Troubleshoot; refer to information that begins on page 684. "System Scanning Test," on page 660.
Collimator Assembly	Replacement, "Collimator Assembly," on page 798.	"Characterization Software Procedure," on page 747, Complete Tube alignments, Collimator Calibration, Detailed Phantom Calibrations and Perform IQ test Chapter 10.

Table 9-67 High Voltage System Retest Matrix (Continued)

HV SYSTEM COMPONENTS	TASK	VERIFICATION TEST
Collimator Control Board	Replacement, "Collimator Control Board (CCB)," on page 794.	"Characterization Software Procedure," on page 747 and Collimator calibration.
Collimator/Detector Heater Power Supply	Replacement, "Collimator/ Detector Heater 24V Power Supply," on page 796. Adjustment, "Collimator/ Detector Heater Power Supply," on page 740.	Adjust for a reading of 24 volts ± 1.0 volts at the -out and + out terminals
Collimator Filter	Replacement, "Filter Assembly," on page 793.	Perform CBF adjustments in Chapter 11, Perform IQ test Chapter 10
Collimator CAM Motor Drive Module	Replacement, "Cam Motor Driver Module," on page 797.	Perform "CAM A/B Amplifier Checkout Procedure," on page 743.
Collimator CAM Drive Motor	Replacement, "Cam Drive Motor," on page 799.	Perform "CAM A/B Motor Checkout Procedure," on page 745.
Collimator Encoder Harness	Replacement, "Cam Encoder Harness," on page 799.	Perform "CAM A/B Encoder Checkout Procedure," on page 744.
Collimator Secondary Aperture	Replacement, "Secondary Aperture," on page 800.	Perform CBF adjustments in Chapter 11, Perform IQ test Chapter 10
Collimator Primary Aperture	Replacement, "Primary Aperture," on page 801.	Complete Tube alignments, Detailed Phantom Calibrations and Perform IQ test Chapter 10.
Collimator Power Harness	Replacement, "Power Harness," on page 802.	Perform Collimator Functional Tests starting with "CAM A/B Amplifier Checkout Procedure," on page 743.

Table 9-67 High Voltage System Retest Matrix (Continued)

Chapter 10
Power Distribution Unit

Section 1.0
Overview

The PDU provides a single location to connect input power for the entire CT system. Its function is to provide the following features to the System:

- Compensation means for a wide range of input voltages via tap selection
- Provide required system AC power from a single source
- Provide High Voltage DC power for x-ray generation
- Provide power for gantry axial rotation
- Provide a means for emergency shutdown of all x-ray and drives power circuits
- Provide system AC power circuit protection
- Provide an interface for an external UPS connection
- Meet the requirements of IEC601 for both radiated and conducted emissions

The PDU is designed to comply with United States Federal Regulations and the European Medical Device Directive. It bears the certification marks of a United States National Recognized Test Laboratory with Canadian deviation or a Canadian certified test house. Each unit is identified as being in compliance by being labeled with the official mark(s) of each respective agency.

Section 2.0
Specifications

2.1 Power Requirements

Input Voltage Range	380 to 480V 3 phase
Frequency	50 / 60 Hz (47 to 53 or 57 to 63) Hz
Power Rating	90 kVA momentary 20 kVA continuous
Regulation	6% max.

2.2 Operational

Temperature range	5 to 40C
Temperature gradient	< 10C / Hr.
Humidity range	20 to 80% Relative Humidity (non-condensing)
Humidity gradient	< 30% / Hr.
Altitude	-150 meters (-492 FT) to 3048 meters (10,000 FT)
Shock and vibration Random	5-350 Hz 0.020 (m/s 2) 2 /Hz 350-500 Hz -6db/decade 500 Hz 0.010 (m/s 2) 2 /Hz

2.3 Cooling Requirements

The H2 Compact PDU is convection cooled using only facility ambient air.

2.4 Storage, Shipment and Non-Operating

Temperature range	-34 to 60C
Temperature gradient	< 20C / Hr.
Humidity range	5 to 95% Relative Humidity
Humidity gradient	< 30% / Hr.
Altitude	-150 meters (-492 FT) to 3048 meters (10,000 FT), or equivalent
Shock and vibration	per GE Healthcare test guideline 46-316745

2.5 Size & Weight

- Height 50.0 inches Max.
- Width 30.0 inches Max.
- Depth 22.0 inches Max.
- Weight Complete of the unit is approximately 640 lbs (291 kg).

2.6 Acoustical Noise

While in the stand-by mode, the H2 PDU does not generate sound levels in excess of 50dbA, when measured at a distance of one meter from the nearest cabinet surface, in any direction.

Section 3.0 Physical

3.1 Mechanical Enclosure

The enclosure has a front, back and top access covers. The top cover is hinged at the rear and is provided with a lock to prevent unauthorized access. The top cover is provided with supports, such that it will remain in the open position safely without service personnel assistance. Two captive fasteners at the top and two guide pins at the bottom hold the front cover in place. The front cover weighs less than 25 lbs.

A single full-width Lexan safety shield is provided under the front cover. It extends ½" below the top front edge of the assembly to the bottom of all HVDC Supply components, including the PDU Control Board. There's a cutout in the lower left corner of the shield to provide access to the low voltage portion of the PDU Control Board.

The rear cover is held in place by twelve 10-32 machine screws. To maintain a good high frequency ground between internal subassemblies, all internal metal surfaces are solidly grounded to each other.

The enclosure is painted Mist Gray (GE Healthcare Gray #1).

3.2 Component Locations

The main input transformer is located in the rear accessible chamber near the bottom of the cabinet, allowing enough room for cable access beneath. For ease of installation and serviceability the remaining components for the HVDC Supply and AC Power Distribution are located on the vertical dividing panel behind the front cover. Refer to Table 10-1 below, for general component information. Items numbers in table appear in circles of Figure 10-1.s

ITEM	NAME / DESCRIPTION
1	8A, 250V, Slow-Blow Fuse
2	2A, 250V, Slow-Blow Fuse
3	1.5A, 250V, Fuse
4	80A, 600V, Semiconductor Fuse
5	60A, 600V, Dual Element Fuse
6	6uF, 370Vac Capacitor
7	20A, 3P, 4W Receptacle NEMA Type L14-20R-Flange Mount
8	0.025uF, 480V, 100A, Feed-through Capacitor
9	Transformer 2113764-26
10	2133533-2 1.2 mH, 140 A, DC Inductor
11	4600 µF, 450 V, Capacitor
12	32/50A Contactor, 120Vac, 60Hz Coil
13	Warning light control Relay
14	Front Cover
15	110A, 1600V Diode Bridge
16	PDU Control Board
17	18/35A Contactor, 24Vdc Coil
18	30A, 4P, 5W Receptacle NEMA Type L21-30R-Flange Mount
19	15A, 1P Circuit Breaker
20	30A, 1P Circuit Breaker
21	15A, 2P Circuit Breaker 10A, 3P Circuit Breaker
22	15A, 3P Circuit Breaker
23	30A, 3P Circuit Breaker

Table 10-1 Major Components

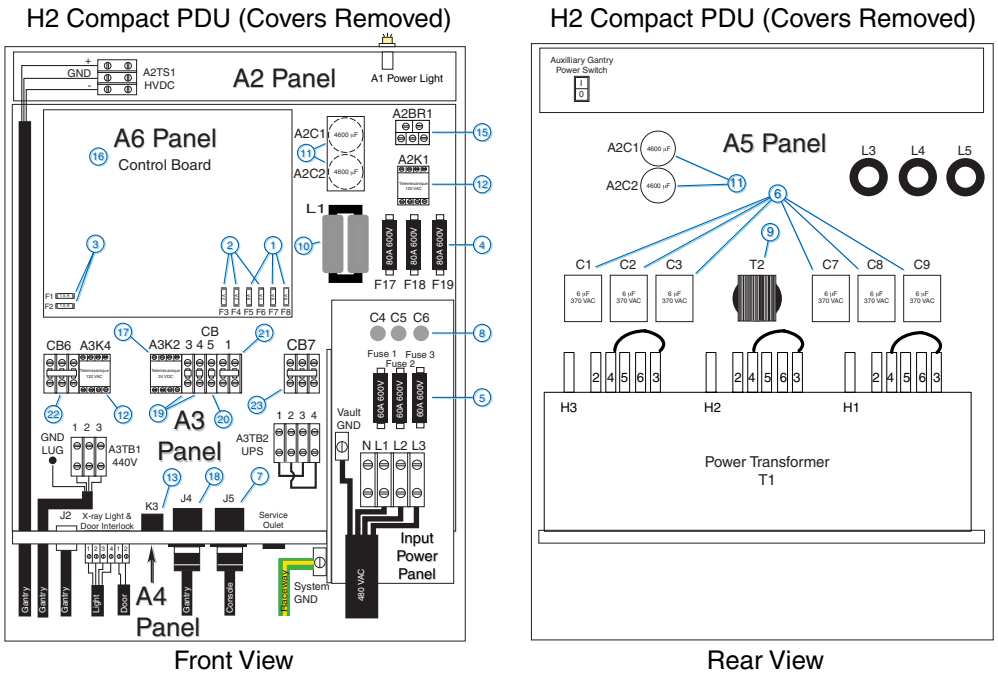

Figure 10-1 Component/Physical Layout

3.3 Product Labeling

3.3.1 Rating Plate

The PDU has a rating plate permanently attached to the rear edge of the top cover. It contains the following information:

Manufactured for GE Healthcare
Milwaukee, Wisconsin
by (Vendor Name)

Power Distribution Unit
Model No. 2269902 / (Vendor model #)
Serial No. _____

Input Voltage: 3 ~ 380 // 480 V
Line Frequency: 50 / 60 Hz
Input Power:
Momentary 90 kVA @ 0.85 PF
Continuous 20 kVA

Weight 640 lbs. (291 kg.)
Date Code: _____ Made in USA
(appropriate test house markings, e.g., UL, ETL, CSA or eq.)

3.3.2 Auxiliary Rating Plate

For ease of service identification, an auxiliary rating plate is also located inside the unit, under the top cover. It includes the GE Healthcare model number and unit serial number.

Section 4.0
Service

4.1 Planned Maintenance

The PDU does not require any specific periodic maintenance. An annual inspection for lint & dust is suggested along with a check of electrical terminals for proper tightness.

4.2 Replacement Parts / Interchangeability

All replacement parts required for servicing the PDU are directly interchangeable without need of any re-adjustment. Circuit boards and sub-assemblies are given unique part numbers and revisions are completely backward compatible.

4.3 Service Tools

The PDU is designed so no special service tools are required. The assembly can be serviced with standard off-the-shelf service tools.

Section 5.0
Electrical

5.1 Primary Input Power

The input power terminals accommodate #4 to #1/0 (fine strand) wire sizes. Ferrules are provided for the maximum wire capacity allowed. Input line fuses rated 60A per phase are used to protect the system. Dual element, time delay motor starting fuses are used.

The primary input power terminations & fuses are mounted in a dedicated enclosure within the PDU. Bulkhead mounted, low inductance, feed through filter capacitors are connected in series with each of the three primary lines on the load side of the primary fuses. The capacitance of each device is 0.025μF to ground.

5.2 Input Filtering

Low inductance, AC filter capacitors rated for mains connection are installed in a floating wye configuration on the three primary lines, on the load side of the fuses. Each capacitor is rated at 6.0 μF.

5.3 Input Transformer

The main input transformer is an indoor style, multiple winding, 3-phase isolation transformer. It has an open frame, varnish impregnated core & coil construction. It is suitable for continuous duty without requiring forced air-cooling. The insulation system used is UL, CSA, & IEC recognized for 180C (Class H) or better, and each transformer is labeled accordingly.

5.3.1 Magnetic Circuit

The magnetic circuit is designed for nominal 50/60 Hz operation (47 to 63 Hz limits). It accommodates a daily variation of ±10% input voltage, (i.e., 110% input voltage doesn't cause excessive exciting current and core losses). Under worst case conditions, the transformer's peak inrush current is less than 1000A when properly connected and energized at 380 V, 50 Hz.

5.3.2 Primary

All power for the CT System passes through the primary winding of the input transformer. It is protected by the primary input fuses described above.

The primary winding is designed for delta connection. Voltage selection taps are provided on each phase to accommodate 20 volt steps over the input voltage range of 380 to 480 V. All leads are brought out to a panel for external voltage selection. Leads are designated as follows:

System Voltage:	380	400	420	440	460	480
Lead Connections:	2-6	2-5	2-4	3-6	3-5	3-4

Ex. Phase A" "	S	2	3	4	5	6	F
(Tap voltage from "S"	0	180	240	240	260	280	480)

Figure 10-2 Compact PDU Primary taps

At shipment, the primary taps are set to the 480 volt connection.

5.3.3 Secondary #1 (designated as the "X" winding)

Secondary #1 is a 208Y/120V wye connected power winding. The phase leads are labeled X1, X2, and X3. The neutral, labeled X0, is isolated and brought out for external connection to ground.

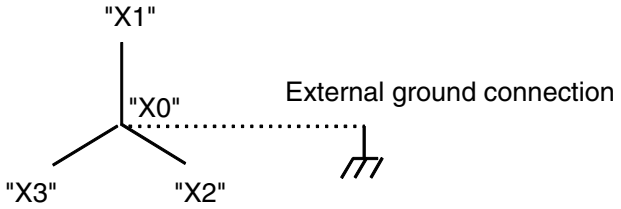

Figure 10-3 Secondary "X" Winding Configuration

The full winding feeds general-purpose power to the CT system. The winding is protected at 30A per phase with a three-pole, 30A circuit breaker labeled CB7.

5.3.4 Secondary #2 (designated as the "Y" winding)

Secondary #2 is a 494Y/285V wye connected power winding. The phase leads are labeled Y1, Y2, and Y3. The neutral, labeled Y0, is isolated and brought out for external connection to ground.

This winding contains three (3) normally closed thermal cutout switches, one securely embedded in each phase coil. These switches are set to open at a nominal temperature of 180C. When actuated, they generate an over-temperature fault on the PDU Control Board and disable the HVDC output.

Taps are provided on each phase (labeled Y4, Y5, and Y6) to provide a 440Y/254V, wye connected source. These taps are used to power the gantry axial drive.

In addition, a second set of taps is provided on each phase (labeled Y7, Y8, and Y9) to provide a 52Y/30V, wye connected source. These taps are used for intermittent service diagnostic tests only, and their load is mutually exclusive of all other loads on this winding.

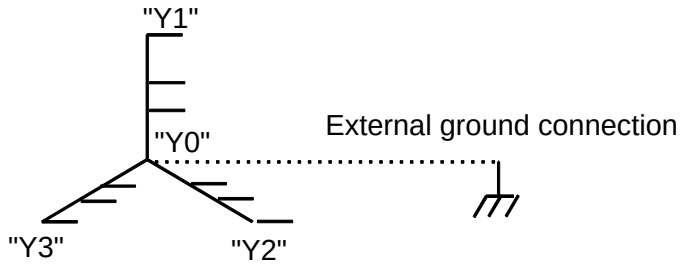

Figure 10-4 Secondary "Y" Winding

The #2 secondary winding provides x-ray & drives power to the system. The full winding powers the HVDC supply. This is a six-pulse unregulated DC supply, which feeds the X-Ray source. The output of the full winding is protected by 80A semiconductor fuses, F17, F18 and F19. Winding protection is accomplished electronically by the load control circuitry for both short-circuit and thermal overloads.

The 440Y/254V taps feed an external Variable Speed AC Motor Drive. These taps are protected at 15A per phase with a three-pole, 15A circuit breaker, labeled CB6.

As mentioned above, the second set of taps providing a 52Y/30V, wye connected source are used for intermittent service diagnostics only. These taps provide an alternate source for the unregulated DC supply normally fed by the full winding. They are protected electronically by the DC supply circuitry, and no fusing is provided.

5.3.5 Shields

Full width electrostatic shields are provided between the primary and secondary windings. Each shield is grounded to the core and frame. (The lead position and attachment method minimizes shield impedance to high frequency noise signals.)

5.4 AC Power Distribution

A general overview of the AC Power Distribution of the H2 CT system is shown in the diagram below.

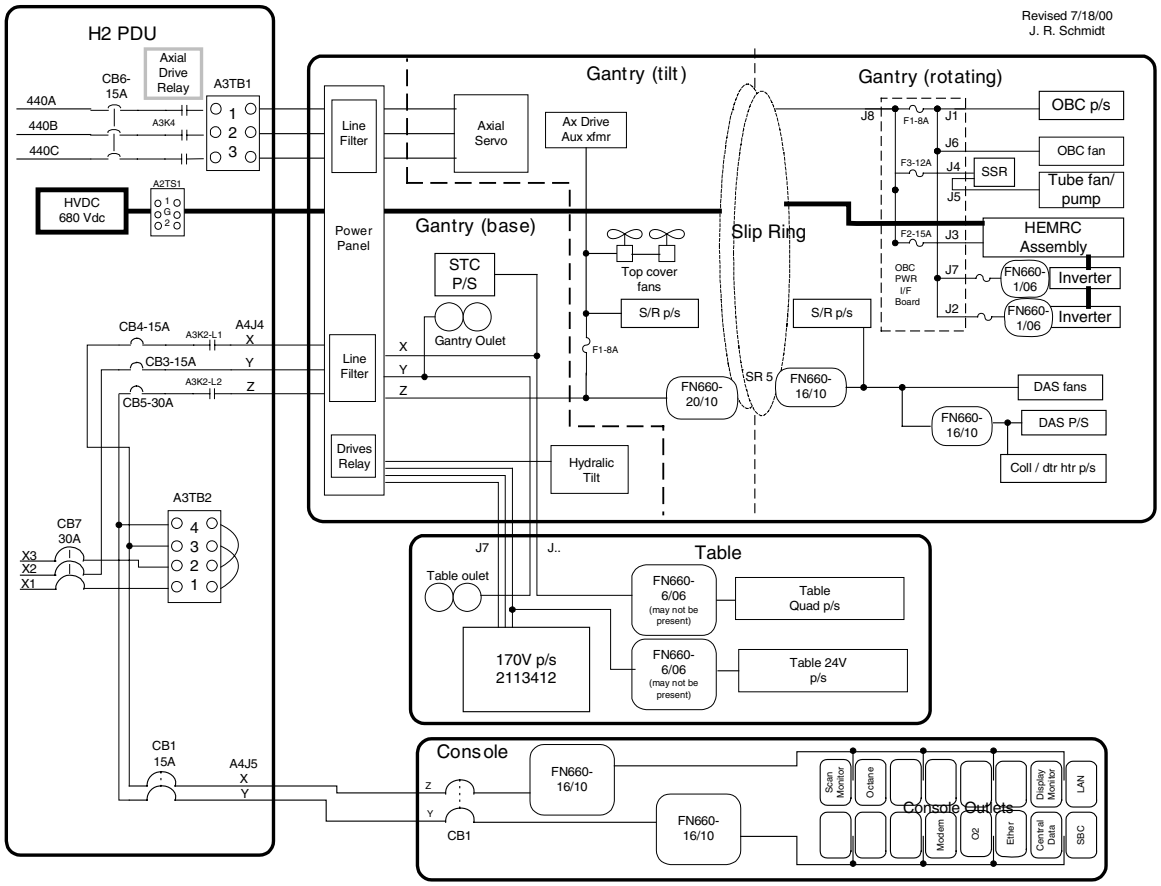

Figure 10-5 AC Power Distribution

5.5 General Purpose 120/208V AC Power Distribution

5.5.1 Full Winding Protection

The H2 PDU Isolation Transformer, Secondary #1, supplies low voltage AC subsystem power. It is protected at 30A per phase with a three-pole, 30A circuit breaker. The full winding protection breaker is labeled CB7.

5.5.2 UPS Interface

Phases A & C on the load side of CB7 is wired to terminals 1 & 2 of a four-position terminal block, labeled A3TB2. Jumpers connect terminals 1 to 3 and 2 to 4, with the PDU loads connected to the outputs of terminals 3 & 4. These jumpers are removed whenever an *optional* UPS is used with the system.

5.5.3 Circuit Protection

AC power is distributed to the CT System via four (4) separate branch circuits. These branches are protected by individual circuit breakers as follows:

BREAKER	RATING	POLES	PHASE	LOAD DESCRIPTION
CB1	15A	2	A, C	Console via J5-X, J5-Y
CB3	15A	1	B	Table* & Gantry Service Outlets via J4-Y, also PDU Service Outlet
CB4	15A	1	A	Table 24Hr power & Gantry Stationary Loads via A3K2-L1 & J4-X
CB5	30A	1	C	Gantry Rotating Loads via A3K2-L2 and J4-Z
*Table service outlet is limited to 10 amperes.				

Table 10-2 Circuit Breaker

5.5.4 AC Power Output Connections

The output connectors for AC power distribution to external subsystems shall be as follows:

SUBSYSTEM	PDU CONNECTOR TYPE
Gantry	30A, 4P, 5W Receptacle, NEMA Type L21-30R-Flange Mount. Labeled “J4 GANTRY”
Console	20A, 3P, 4W Receptacle, NEMA Type L14-20R-Flange Mount. Labeled “J5 Console”

Table 10-3 AC Output Connectors

5.6 High Voltage DC Power Supply

5.6.1 Electrical Requirements

The HVDC power supply is an unregulated, six pulse DC power source that feeds the high voltage subsystem used to generate x-rays. The output voltage of this supply ranges between a maximum of 750VDC (No Load) and a minimum of 500VDC (Full Load). The full load current capacity of this supply is 100ADC.

5.6.2 Circuit Protection

The input to the HVDC Supply is the 3-phase, 494V output from the transformer secondary #2 as previously described. Each phase of this winding is protected by an 80 AMP semiconductor fuse.

5.6.3 Construction / Description

The load side of the fuses is connected to a three-pole contactor. The operating voltage of the coil is115 VAC 50/60Hz. The contactor has an auxiliary switch with a single pole, normally open contact used for sensing the status of the device. The load side of the contactor is connected to the input of a 3 phase, full wave bridge rectifier. The bridge rectifier is mounted to an aluminum heat sink, approximately 2” X 6” X 1/4”. Thermal compound is used between the heat sink and rectifier and between the heat sink and chassis mounting surface.

The DC output of the bridge rectifier is filtered with an L-C network composed of a 1.2mH series inductor, and two 4600uf, 450 volt electrolytic capacitors. The capacitors are connected in series and across the output leads of the inductor.

5.6.4 Output Terminations

Output leads from the capacitors are terminated in a three position terminal strip. This terminal strip is labeled “A2TS1”. It is mounted horizontally on the vertical surface above the PDU Control Board. The terminal strip positions are labeled: Top “TS1-1 (+)”, Center “GND” and Bottom “TS1-2 (-)”. A Lexan cover is provided over the terminal strip to prevent service personnel from accidentally contacting live parts.

The internal wiring is connected to the right side of the terminal strip, leaving the left side open for field installation of the system cable. A cable clamp is provided at the transformer bulkhead, which is used for strain relief and termination of the shield of the field installed cable.

5.7 Axial Drive Circuit

5.7.1 Electrical Requirements

The 440V taps of secondary #2 are used to power an external variable speed AC motor drive used for axial rotation of the gantry. The drive uses a conventional three-phase full wave bridge rectifier input circuit. This produces strong 5th & 7th harmonic currents typical of 6-pulse rectification. The maximum load under gantry acceleration conditions is 15A.

5.7.2 Circuit Protection

The circuit is protected at 15A per phase with a three-pole, 15A circuit breaker, labeled CB6.

5.7.3 Axial Drive Contactor

The CB6 circuit breaker feeds a three-pole contactor, labeled A3K4. The contactor’s 115 VAC coil is controlled externally by the CT system. Auxiliary contacts on the contactor provide status feedback information to the system.

5.7.4 Output Terminations

Output leads from the A3K4 contactor terminate in a three position terminal strip. This terminal strip is labeled “A3TB1”. It is mounted on the vertical surface below the contactor. A Lexan cover is provided over the terminal strip to prevent service personnel accidentally contacting live parts.

The internal wiring is connected to the top of the terminal strip, leaving the bottom open for field installation of the system cable. A cable clamp is provided at the transformer bulkhead, which is used for strain relief and termination of the shield of the field installed cable. In addition, a 10-32 ground stud is provided in the vertical panel left of the A3TB1 terminal strip.

5.8 Control Signals

The PDU provides all power to the CT system. A PDU Control Board is located within the unit and provides for proper sequencing of the sub-system power, servo system, and x-ray backup contactor when commanded by the system. To facilitate control, the PDU Control Board contains a low voltage limited energy (LVLE) 24Vdc power supply, which provides the necessary communication power to the system. The output voltage of this supply is 24 VDC, +6 / -4 volts for all conditions of line and load.

5.8.1 Subsystem Signal List

The following is a list of PDU Control Signals, that are accessible by means of a 37 position, female subminiature D type receptacle connector located in the output bulkhead at the bottom of the enclosure. This connector is labeled A4J2.

PIN #	SIGNAL NAME	FUNCTIONAL DESCRIPTION
1	PDU_24B	+24Vdc output to Gantry E-Stop Control circuits.
2	PDU_24B	+24Vdc output to Gantry E-Stop Control circuits.
3	LP_CONT_CLSD	Switched +24Vdc output indicating contactor A3K4 is closed.
4	HV_MODE	Current limited +15Vdc output for HV Mode circuit in gantry.
5	PDU_24A	+24Vdc output to Gantry X-Ray Control circuits.
6	PDU_24A	+24Vdc output to Gantry X-Ray Control circuits.
7	LITESHI	+24Vdc signal to indicate the status of the x-ray and drive power enable. Three states are possible: • Lamp on steady indicates x-rays and all drives enabled. • Lamp flashing rapidly indicates all table motion and gantry tilt disabled • Lamp flashing slowly indicates all drives and x-rays disabled.
8	FOUR	Switched 24Vdc input from E-Stop push button control loop.
9	ONE	Switched +24Vdc output to E-Stop/Gantry reset push buttons.
10	TBLOFF	Switched +24Vdc output to table tape switch circuit.
11	DRIVEON	Switched +24Vdc output to gantry to enable elevation, tilt & cradle drives contactors.
12	120_RDBK	Switched +24Vdc output indicating contactor A3K2 is closed.
13	BU_CONT_CLSD	Switched +24Vdc output indicating contactor A2K1 is closed.
14	MAN_HVDC	Switched +24Vdc output to gantry to command HVDC on.
15	MAINS_UV+	Current limited +15Vdc output for Mains Under-voltage circuit in Gantry.
16	N/C	no connection
17	N/C	no connection
18	DRRDBKRN	Contact closure w.r.t. pin 37 indicating the drives relays are commanded “on”.
19	GND	Redundant chassis ground connection for cable shield.
20	PDU_PGND	Signal Ground return for 24Vdc circuits to/from gantry.
21	PDU_PGND	Signal Ground return for 24Vdc circuits to/from gantry.
22	CLOSELOOP	+24VDC input signal to close the Axial Drive contactor, A3K4.
23	HV_MODE_RTN	Switched +15Vdc HV_MODE signal from gantry.
24	XRAYLITE	+24VDC input signal to close the Hospital Room Light relay, A4K3.
25	EXP_INTLK	Exposure Interlock loop to PGND via Room Door Interlock at A4TS1-5 & 6.
26	LITESRTN	Signal Ground return for LITESHI circuit from gantry.
27	ESTP_SRC	+24Vdc output to Gantry E-Stop Control circuits.
28	DRIVON	Switched +24Vdc input from E-Stop/Gantry reset push buttons.

Table 10-4 Subsystem Signal List

PIN #	SIGNAL NAME	FUNCTIONAL DESCRIPTION
29	TABLEOFF	Switched +24Vdc input from table tape switch circuit.
30	DRVRTN	Signal Ground return for DRIVEON circuit from gantry
31	GANTRY_PWR	+24VDC input signal to close the Gantry Power Contactor, A3K2.
32	BUCONT	+24VDC input signal to close the Backup Contactor, A2K1.
33	N/C	no connection
34	MAINS_UV-	Switched low-side output for mains under voltage circuit.
35	N/C	no connection
36	N/C	no connection
37	DRRDBK	Contact closure w.r.t. pin 18 indicating the drives relays are commanded “on”.

Table 10-4 Subsystem Signal List (Continued)

5.8.2 Room Warning Light & Door Interlock Connections

A six position terminal block, labeled A4TS1, is provided in the output bulkhead at the bottom of the enclosure. This terminal block has compression type terminals approved for use with bare or stranded wire and suitable for a wire size range of 22 to 10AWG.

Terminals 1 through 4 are used for connection of an external hospital room warning light as described below. Terminals 5 & 6 are used for connection of a room door interlock switch in the system x-ray enable circuit.

- EXTERNAL XRAY WARNING LIGHT - Positions 1 and 3 of the terminal block is connected across a normally open set of relay contacts rated at 250 VAC, 20 Amps. The relay is labeled A4K3.
- Positions 2 and 4 of the terminal block is jumpered together with a series RC network having a resistance of 100 ohms, a capacitance of 0.5 uF and a voltage rating of 250 VAC.
- The terminal block shall be labeled as follows:
  - Positions 1 and 2, “INPUT POWER”.
  - Positions 3 and 4, “LOAD”.

  In addition, the following label appears near the terminal block:

CAUTION
Potential for electrical shock

TURNING OFF POWER TO THE PDU MAY NOT REMOVE POWER TO THIS TERMINAL BLOCK. VERIFY REMOVAL OF POWER WITH AN APPROPRIATE MEASURING DEVICE BEFORE SERVICING. INPUT VOLTAGE NOT TO EXCEED 30VAC.

- ROOM DOOR INTERLOCK - Positions 5 & 6 of the terminal block provide for a Room Door interlock in the X-Ray Exposure control of the system. Terminal 5 is connected to the EXP_INTLK signal at A4J2-25. Terminal 6 is connected to PGND at A6J7-30 on the PDU Control Board.
- These terminals are labeled “DOOR INTERLOCK SW”. Each unit is shipped with a jumper installed between pins 5 & 6 (by default).

5.8.3 Auxiliary Gantry Power Switch

An auxiliary gantry power switch is mounted on the right rear surface of the enclosure. The switch is connected to the 24Vdc control circuit of contactor A3K2, in series with the “GANTRY_PWR” signal at A4J2-31. “UP” is “ON”, and is the default position.

Section 6.0 Drawings

6.1 Gantry Power Control

When the 120VAC ON signal is received at the GANTRY_PWR connection, given the auxiliary power switch is closed, relay coil A6K8 is energized and its contacts close. This relay completes the circuit to the coil of A3K2, which in turn completes the 120VAC circuit to the gantry and table. See Figure 10-6. Stationary gantry and table power is protected by CB4 and gantry rotating power by CB5.

Table and gantry service outlet power is unaffected by 120VAC ON signal and can only be disabled by its associated circuit breaker CB3. Note that CB3, CB4 and CB5 are slaves to master circuit breaker CB7. Table service outlet is limited to 10 amperes.

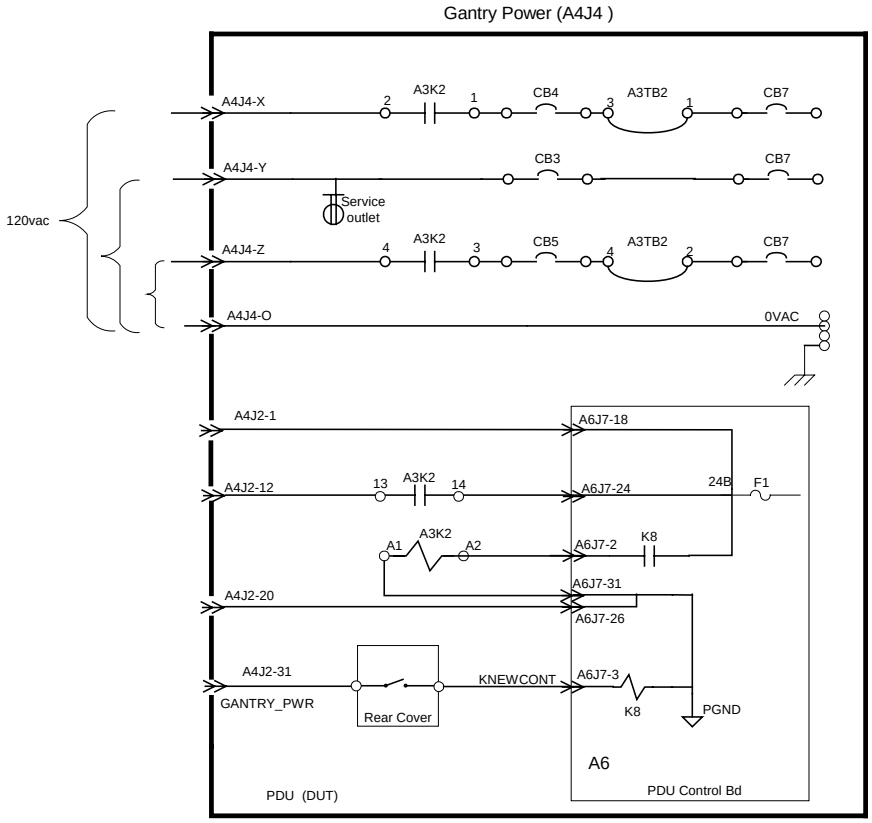

Figure 10-6 Gantry Power Control

6.2 Axial Drive Power Control

Axial Drive Power is controlled by relay A3K4 and is protected by circuit breaker CB6. When the PDU control board senses an e-stop condition, coil A6K6 (e-stop) locks out operation of relay coil A6K13, which prevents activation of the relay A3K4.

Axial Drive Power and Feedback

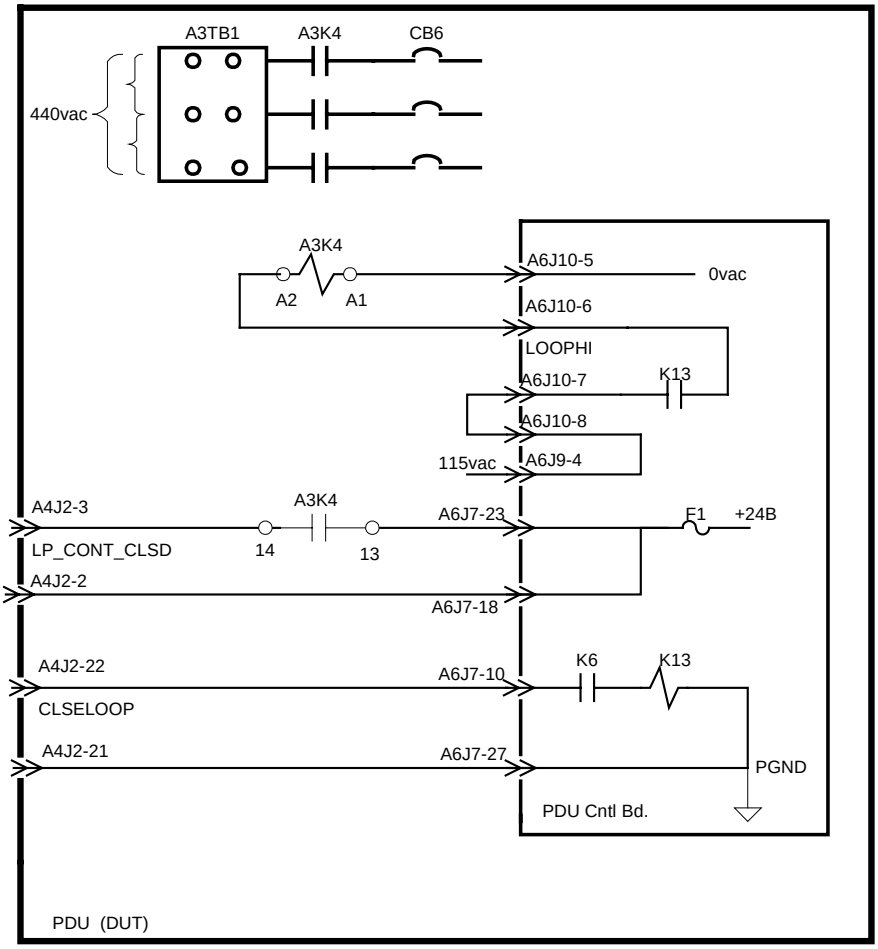

Figure 10-7 Axial Drive Power Control

6.3 HVDC Supply Control

When the BUCONT signal is received and the connection between HV_MODE and HV_MODE_RTN is made, the HVDC supply will produce output. When the coils K12 and K11 are energized, the coil A2K1 is energized. The contacts on A2K1 close and supply power to the HVDC supply. This operation can be inhibited by the PDU control board “E-stop” circuit, through relay contacts A3K2. See Figure 10-8.

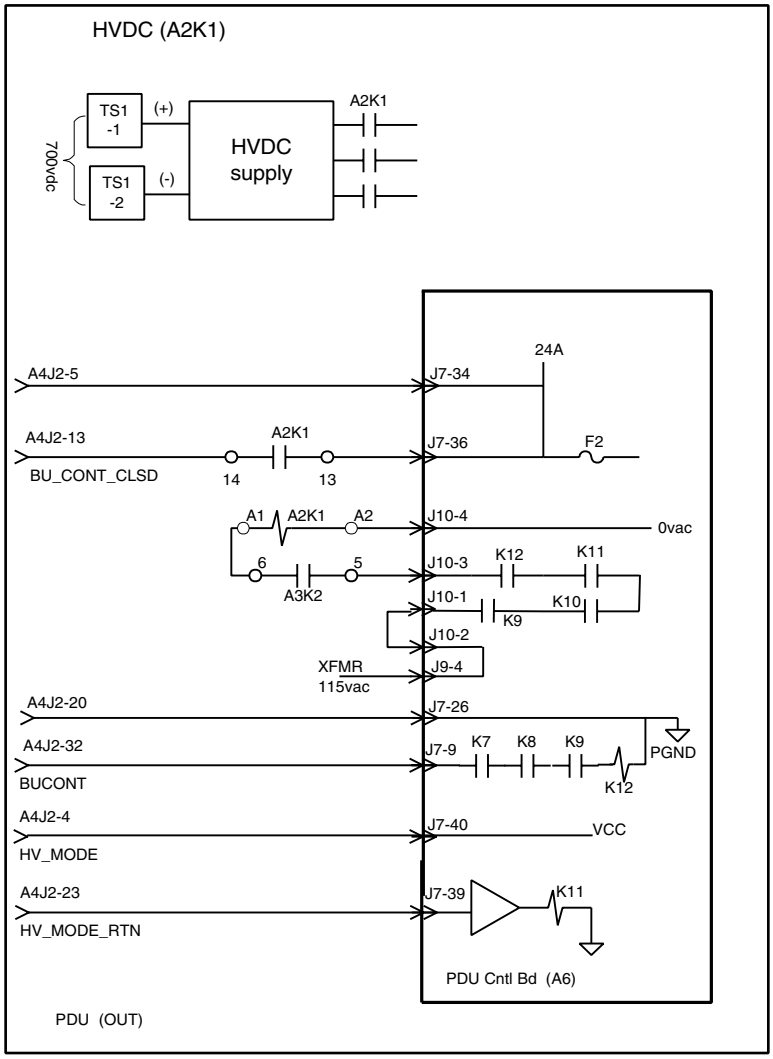

Figure 10-8 HVDC Supply Control

6.4 Console Power Control

120VAC Power for the console is derived from two legs of 208VAC. Console power is protected by circuit breaker CB1. CB1 is a slave to CB7.

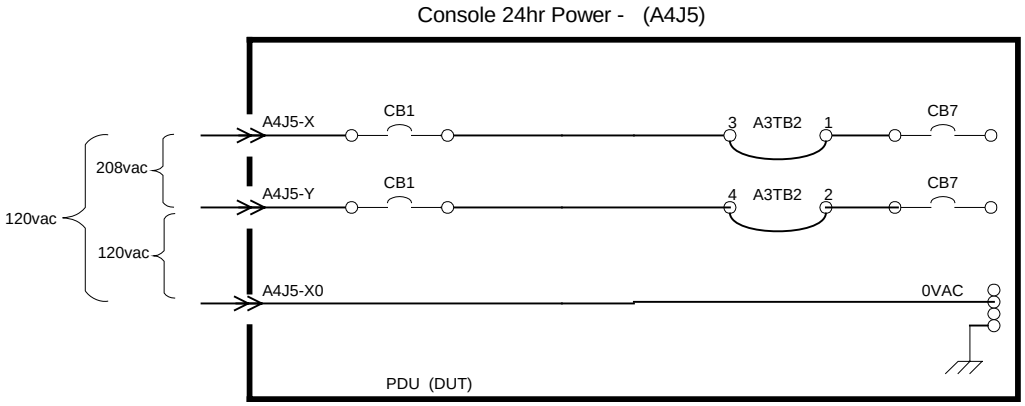

Figure 10-9 Console Power Control

6.5 Room Light Control

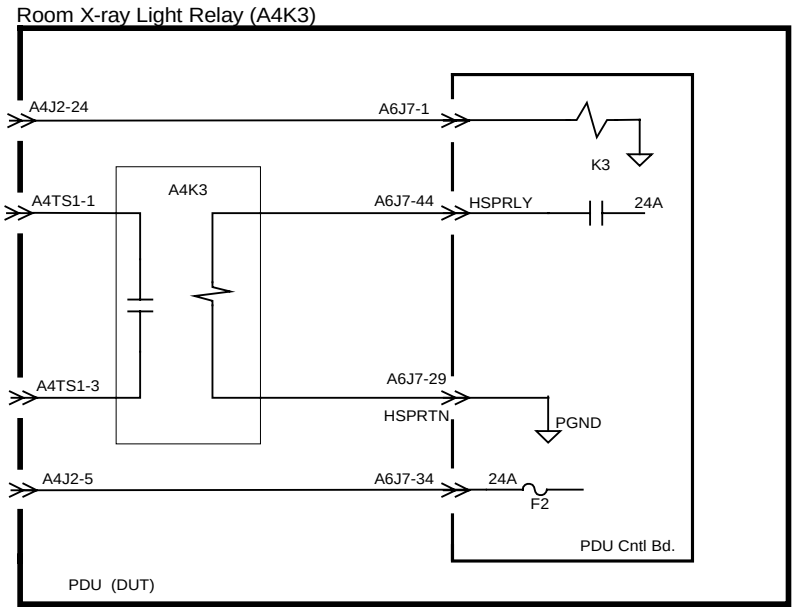

Figure 10-10 Room Light Control

6.6 E-Stop/Drives Control

For the following discussion, see Figure 10-11.

NORMAL STATE

With the E-stops and tape sensors in normal state, a connection is made between ESTP_SRC and FOUR, and between TBLOFF and TABLEOFF respectively. In this condition, the reset and drives enable lamps are illuminated steadily, the reset light being controlled by the connection between LITESHI and LITESRTN, the drives light by DRIVEON and DRVRTN connections.

TAPE SENSOR

When a table tape sensor is activated, the connection between TBLOFF and TABLEOFF is opened. This situation opens the circuit between DRIVEON and DRVRTN, and turns the drive enable lamp off. The blinking circuit now pulses the reset lamp slowly to indicate the condition.

E-STOP

When an E-stop switch is activated, the connection between ESTP_SRC and FOUR is opened. This situation opens the circuit between DRIVEON and DRVRTN, and turns off the drive enable lamp. The blinking circuit now pulses the reset lamp fast, to indicate the e-stop condition, through the connection LITESHI and LITESRTN.

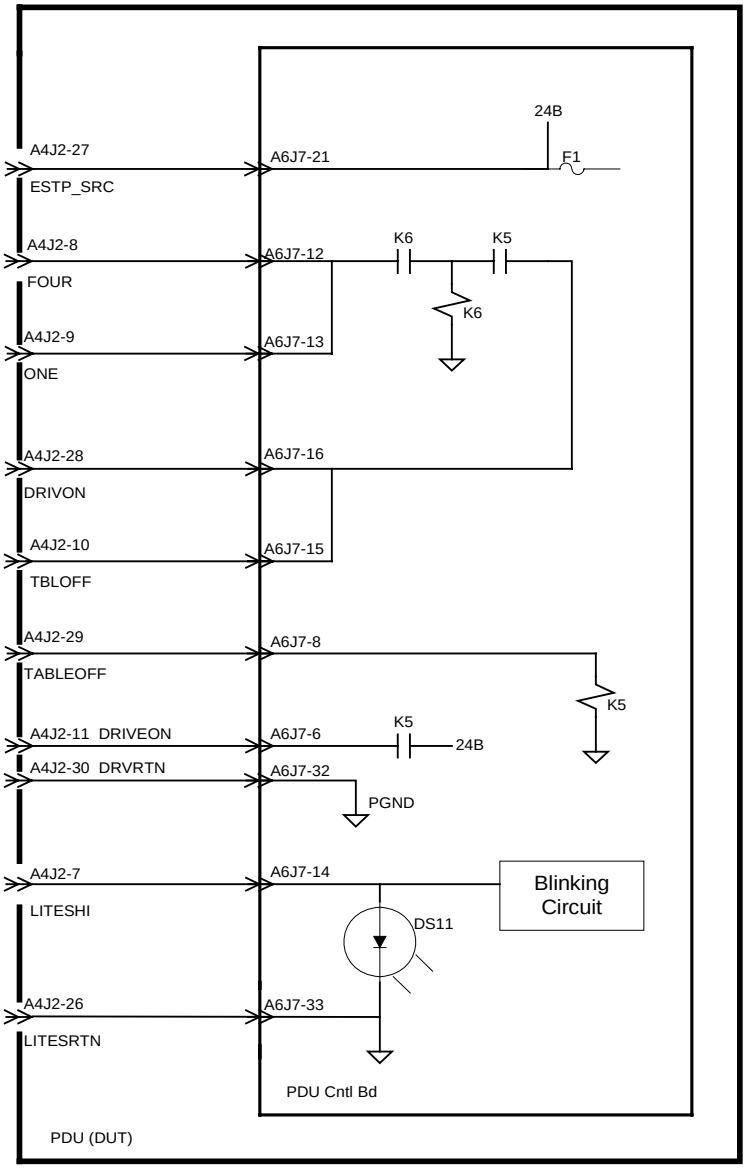

Figure 10-11 E-Stop/Drives Control

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USA

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GE Healthcare

LightSpeed 2.X

Service Manual - General

OPERATING DOCUMENTATION

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Rev 22

Book 6 of 6:

- Chapter 11 (System IQ)
- Chapter 12 (X-Ray Tube)
- Appendices
- Glossary
- Index

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Effectivity

The information in this manual applies to the following GE Healthcare LightSpeed 2.X CT Scanners:

- LightSpeed Plus (SDAS)
- LightSpeed QX/i (SDAS)

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Chapter 11
LightSpeed Plus System and Image Quality

Section 1.0
LightSpeed Plus System

1.1 Introduction

The purpose of this section is to explain the organization and data flow within the Plus scanner system. The intent of this overview is to explain how the complete system works at a rather high level. Each of the following sections covers more detail. Please see the LightSpeed Plus System Block Diagram, shown in Figure 11-1, during this discussion.

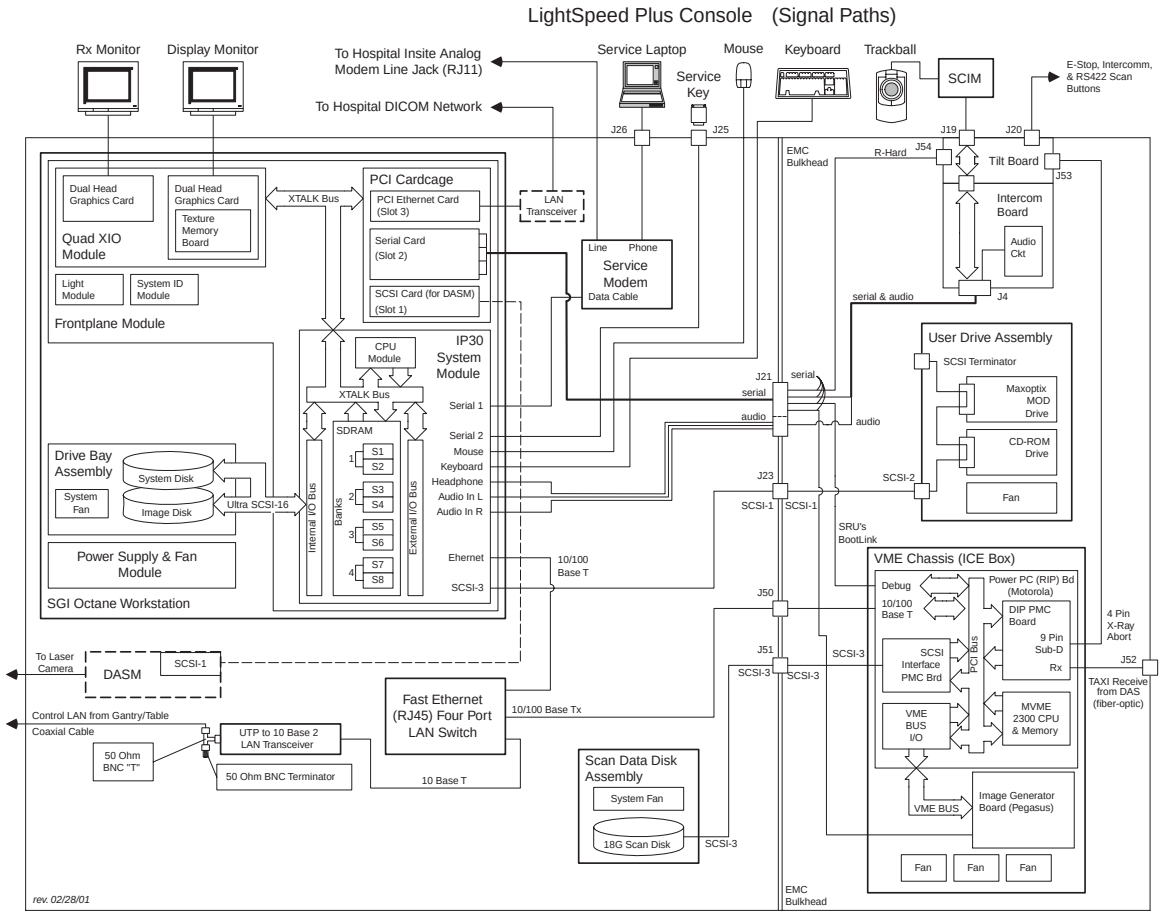

Figure 11-1 System Block Diagram

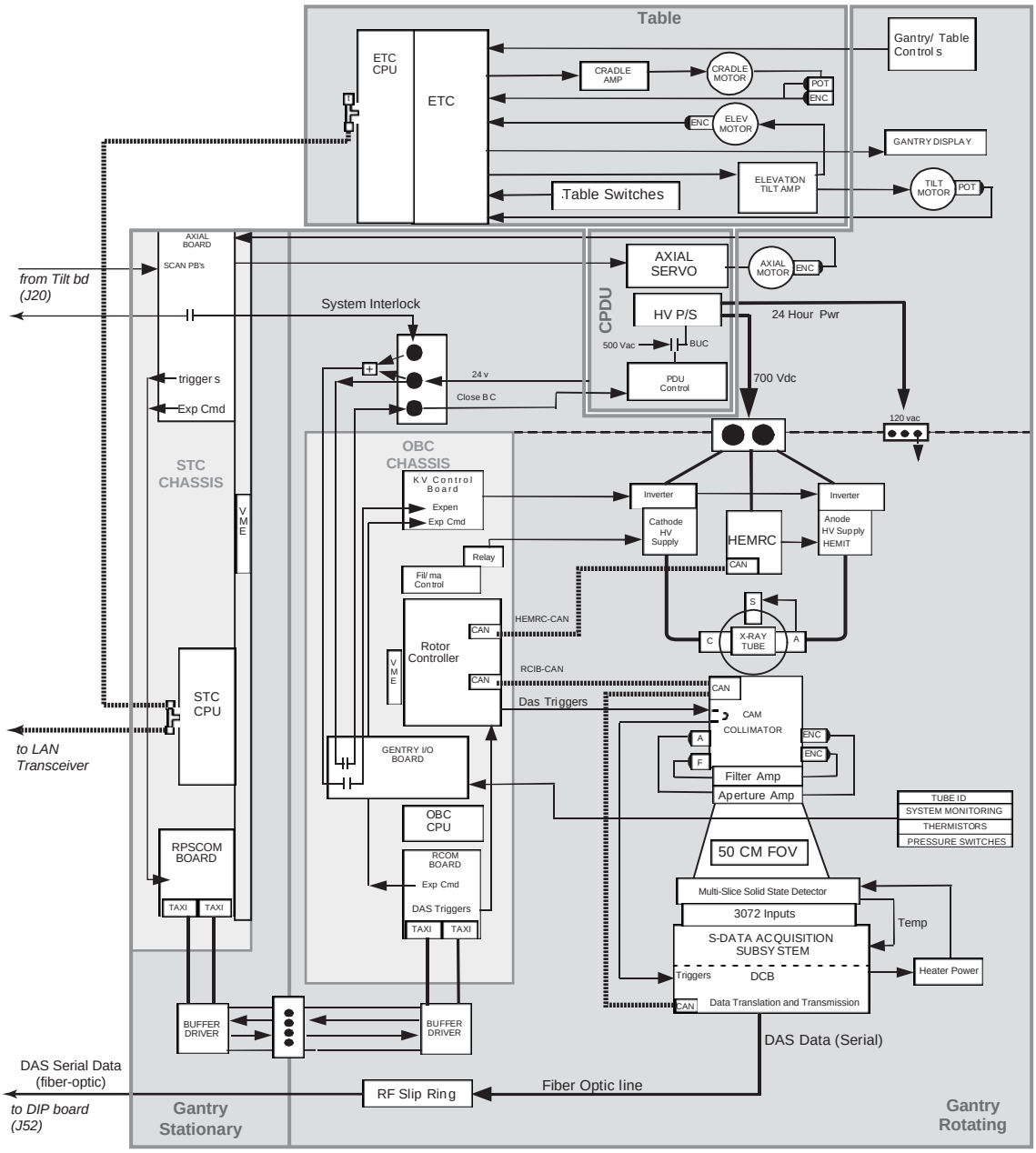

Figure 11-1 System Block Diagram(Continued)

1.2 Primary Sections of the System Block Diagram

- Console
- Gantry- Stationary
- Gantry- Rotating
- Table
- CPDU

1.2.1 Console

For the following discussion, please refer to Figure 11-1, on page 859.

The console contains the Host computer (OC, SGI-Octane) and ICE Box (Image chain engine), along with the system CD-ROM and MOD drives.

1.2.1.1 Host Computer

The Host computer (OC) controls and interfaces with the following hardware:

Scan CRT- This unit displays the scan parameter screens utilized by the operator to perform Scout, Axial, and Helical scans, and recon control, plus routine operator functions on the system. No images are displayed on this screen. The OC uses the Solid Impact interface board to control the display of data on the monitor.

Display CRT - Utilized to display images scanned by the system and also contains screens to allow the operator access to functions to troubleshoot the system, view the system error log, view other images or exams stored in the system, archive images, select images for filming, or functions to allow the operator to do analysis, processing and management of displayed images, and network functions. The OC utilizes the High Impact board to control the display of data on the monitor.

Mouse - Connects to the OC and is used by the operator to make selections on the display screens on either of the two display screens.

Keyboard - Allows operator to input text, IRIX or UNIX commands or selections required by the system software. Also the keyboard contains the intercom speaker, microphone, and volume controls.

Trackball - Used by the operator to manipulate displayed images, instead of using the mouse. Allows one person to use the mouse for the system and another person to view/film images via the trackball simultaneously.

MOD & CD-ROM - The OC controls operation of the MOD drive and CD-ROM via an external SCSI interface. The MOD is used for the storing or retrieving of images using DICOM 3.0 format. The MOD can hold 4700 loss-less (JPEG compressed 512x512) image files per side, or 350 uncompressed scan data files per side. The CD-ROM is used primarily for the on-screen tutorial support function called “Sherlock”. This audio and video program provides support of the Exam Rx and Image Works functions for system help. This drive is also used for software load, or reading Service publications in Adobe Acrobat format.

External Connections - External connections are provided on the OC for the support of a service key, Insite, DASM for a laser camera operation and external LAN interface.

Local Disk - The OC computer operates on SGI’s IRIX software located on its own local disk, called the system disk. There is room for 3700 uncompressed 512x512 images. There is provision for an additional system disk that will expand image storage by 7400 uncompressed 512x512 images for a total of 11,100 images. All images are stored on this disk.

1.2.1.2 Image Chain Engine

1.) Data from the S-DAS is applied to the DAS Interface Processor (DIP). The DIP board receives the serial DAS data, checks the serial data for correctness and applies forward error correction when required. If the scan data cannot be corrected then a scan abort condition is generated. Scan data is stored in one of two 2MB memory modules on the DIP. The serial data is sent to the scan data disk, for temporary storage.

2.) When sufficient data has been sent to disk, it is then sent on to the Recon Interface Processor (RIP) in the ICE box. The serial data is sent in 100 view data packets to the RIP, which does a checksum on the data. The RIP then sends the scan data to the Pegasus Image Generator board (PEG-IG), for scan data corrections. The PEG-IG performs preprocessing, calibration and scout image functions.

3.) The PEG-IG board then performs convolution and back-projection upon the data. When complete, the PEG-IG board sends the image data back to the RIP, where post-processing is

performed to create the final image in DICOM 3.0 format.

4.) The RIP sends the completed image to the OC via the LAN switch. The OC then places the image on the system disk and also sends a copy to the High Impact board for image display.

1.2.2 Gantry Stationary

For the following discussion, please refer to Figure 11-1 (page 860).

1.) The Gantry stationary control is located within the STC computer chassis. Within this chassis is located the STC computer, an axial board and the RPSCOM board.

2.) Under STC control, the axial board is the interface that controls gantry rotation. The axial board connects to, and controls the operation of the Servo amplifier, which is located in the top of the Compact Power Distribution Unit (CPDU).

3.) When commanded by the system, the STC through the axial board enables the servo-amp, to supply's current to the axial drive motor. The STC can rotate the gantry at rotational speeds of 360 degrees in 1,2,3, or 4 seconds. (Optional 0.8 sec rotation is available). Connected to the drive motor is an encoder. The output of the encoder is applied to the axial board as feedback, which the STC uses as a means to determine if the gantry is rotating at the correct speed.

4.) The axial board using the rotational information provided by the encoder has a specialized circuit on it that outputs two signals used by the system. These signal are DAS triggers and the X-Ray on/off command.

5.) DAS triggers are timing signals that are generated at a frequency of 984 Hz. These signals (triggers) are sent to the S-DAS, which then causes the S-DAS to go through its function to convert X-Ray information from the Detector into digital data, which is sent to the DIP and the ICE Box to produce an image.

6.) The X-Ray ON/OFF command is sent to the KV board in the OBC chassis. This signal causes the KV board to enable the High Voltage circuits of the Gantry, which in turn cause the X-Ray tube to produce X-Rays. As its name implies, the signal turns high voltage on and off, which via the X-Ray tube, turns on or off X-Rays.

7.) A LAN network is located on the axial board, which connects directly to the VME bus and to the STC. Through this LAN network, the STC receives its operating software and interacts with the OC during the scan process.

8.) The RPSCOM board is used to provide 2-way serial data transmission across the Gantry slip-rings. Data or commands is what is sent across the slip-rings between the RPSCOM under control of the STC, and the same for the RCOM board under control of the OBC. Parallel data received by the RPSCOM is converted into serial data packets with CRC checking and send across the low resistance slip-rings to a similar type board called the RCOM. The RCOM receives the serial data, checks the CRC value, if correct the RCOM then converts the data back to parallel and sends it to the OBC. If the transmitted CRC character does not check out, then the RCOM will ask the RPSCOM to retransmit the data. There is no error correction function provided by either the RPSCM or the RCOM boards.

9.) The RCOM board performs the same functions as the RPSCOM.

10.) The STC computer via the axial board has control of what is called the "system interlock" line. This is a relay contact located on the axial board, which is in series with the X-ray abort relay located on the DIP board. This provides the STC with a way to abort a scan in the event the STC detects a fault.

1.2.3 Gantry Rotating

For the following discussion, please refer to Figure 11-1 ("System Block Diagram," on page 859).

1.) All of the functions located on the rotating gantry is under control of the OBC computer. These functions are:
- Generation of High voltage
- Rotor Control
- Collimator and Filter control
- Filament and tube current control
- Detector
- DAS Operation
- Tube
- Control of the 700 vdc in the CPDU
- Alignment lights
- System monitoring functions

2.) **High Voltage Control** - The system uses a High Frequency controlled High Voltage generator. The OBC sends to the KV board a calibration word based upon the High Voltage value selected by the operator for the specific scan prescription. The choice's are; 80, 100, 120, and 140KV. The calibration word is used to set up the KV board and output a timing signal in the range of 20KHz to 33KHz. The frequency of the signal is directly related to the KV value and tube current selected. A 20KHz provides 75KV. Moving towards 33KHz produces 40KV. This timing signal is sent out to the power inverter's. The job of the power inverter's is to convert the 700 vdc applied to them into 700 vac at the frequency applied to them by the KV board. The 700 vac is then applied to the High Voltage tank, which produces one half of the selected KV. There are two high voltage tanks, the anode and the cathode. The anode tank produces a positive bias high voltage, and the cathode tank produces a negative bias high voltage. These voltages are applied to the anode and cathode connections of the X-ray tube, so that the full selected KV value is felt across the tube. The output of each tank has a scaled feedback signal that goes to the KV board and provides a closed loop control of the KV being generated. Since there are two tanks there are two closed loops, one for the anode tank and one for the cathode tank.

3.) **Rotor control** - The x-ray tube utilizes a rotating target. The rotor control circuits are used to allow the tube rotor to be brought up to normal speed, of 8000 rpm, and when the system is finished scanning, to brake the rotor. This process uses the rotor control board within the OBC chassis, which connects to the High Efficiency Motor Rotor Controller module within the gantry (HEMRC). The HEMRC connects to the anode high voltage tank, to a special transformer called the HEMIT. The HEMIT makes it connection to the stator windings of the tube via the anode high voltage cable. Control signals and fault conditions are sent over a CAN (control area network) network (HEMRC-CAN) between the rotor controller and the HEMRC.

4.) **Collimator and Filter control** - The collimator unit is under control of the OBC via the RCIB-CAN network. In this system configuration, the collimator is used as a post-collimation. The collimator uses two eccentric cams that are used to position the x-ray beam over the selected area of the detector. This in turn is based upon the selected image/ thickness by the operator. For instance if the operator selects a 4 X 1.25mm detector collimation (4 images @ slice of 1.25mm each), the final image could be in one of the following image/ thickness; 4 X 1.25mm, 2 X 2.25mm, 1 X 5mm. The filter is under software control and has two positions used at scan level, one for head scans and another for body scans. The purpose of the filter is to attenuate the X-ray beam output of the X-ray tube by filtering out soft X-ray energy and to provide more X-ray energy over the patient channels of the detector, and less X-ray energy over the non-patient channels of the detector.

5.) **Filament power and Tube current control** - Provided by the MA control board. The operator can select tube current in the range of 10ma to 400ma (440ma with the CPDU) in 10ma

increments. At the start of a scan sequence the tube current selection is sent to the MA control board, and under control of the OBC, the filament will be powered on for 2 seconds at low power for warm up. Then the filament is powered up to 97% of the selected tube current value until high voltage is turned on to product X-rays. Then the tube current feedback from the high voltage tanks to the MA control board will cause the tube current to be regulated to the selected value.

6.) **Detector** - New design that allows up to 4 images to be acquired in one 3600 scan. The detector is arranged with 768 output channels. Each channel is made up of 16 cells. Each cell is 1 mm wide and 1.25 mm long. Using FET switching within the detector design the individual cells of a channel are arranged in a unique way to provide four images in one scan. The selections are:

- 4 X 1.25 mm (uses the center 4 cells per channel) gives 4, images, each 1.25 mm thick.
- 4 X 2.5 mm (uses the center 8 cells per channel) gives 4 images, each 2.5 mm thick
- 4 X 3.75 mm (uses the center 12 cells per channel) gives 4 images, each 3.75 mm thick
- 4 X 5 mm (uses all 16 cells per channel) gives 4 images, each 5 mm thick.

Because of the ability of the detector to output 4 images per selection, the total output connections from the detector is 3072 signals. The detector has a strip heater applied to it to maintain its temperature at 32 degrees C ± 1 degree C.

7.) **S-DAS** - The S-DAS is a very high speed A/D converter. It takes the 3072 inputs from the detector, and converts these signals into 16 bit digital words, and sends them to the DIP in less than one millisecond. The DAS is normally triggered at a 984 Hz sample rate. The S-DAS does the selection of the FET switches in the detector based upon operator scan selections. The S-DAS monitors and controls the detector temperature at 32 degrees C ± 1 degree C. The OBC communicates to the S-DAS over the RCIB-CAN. This connection serves as a path for commands and detector FET selection to the S-DAS and status and fault reporting from the S-DAS.

8.) **Tube** -The Plus system uses the Performix 630 Metal-Ceramic tube. This tube is designed for exams requiring a large number of scans without pausing for tube cooling. The tube has a heat storage capacity of 6.3 MHU and a maximum power capacity of 53.2 KW. This tube also incorporates a tube cooling design that uses serviceable air filters.

9.) **700VDC Power Supply** - Located within the CPDU, is the unregulated 700vdc power supply. This 700vdc is used in the system for the generation of high voltage and also by the rotor controller to accelerate and run the rotor. The OBC controls the normal turning on and off of this DC supply.

10.) **Alignment lights** - used by the operator for positioning patients for the starting point for scans. These lights are solid state laser type with built in diffusers.

11.) **System monitoring** - The OBC computer uses the Gentry I/O board to monitor scanner operation. Located on the Gentry I/O board is an A/D converter, through which there are many connections throughout the Gantry. The OBC is then able to measure items like: KV output, MA output, chassis voltages, tube temperature etc.

12.) **Slip-Rings** - there are 12 slip-rings and one RF slip-ring used in the gantry. The uses of the slip-ring is as follows:

- Four slip rings are utilized for communications between the RPSCOM and RCOM boards.
- Three slip-rings are used for the connection of 120 vac to power the power supplies within the gantry.
- Three slip-rings are used for what is called “System Interlock.”
- Two slip-rings are used for the connection of the 700 vdc.
- One RF slip-ring used only for the high speed transfer of data output from the S-DAS to the DIP.

1.2.4 Table

For the following discussion, please refer to Figure 11-1 ("System Block Diagram," on page 859).

1.) All functions that the table performs are under control of the ETC or table computer. Mounted on the gantry cover are control buttons that cause the table to go up/down or to move the cradle in/out, establish the landmark position, to turn on the alignment lights, or to tilt the gantry. These buttons do not control the function directly, but instead interrupts the ETC, which identifies which button was/ is pushed, and then perform the function as long as the button is depressed. The ETC receives its software, scan parameters, and fault reporting over the LAN network located on the ETC controller board from the OC.

2.) **UP/Down** -By using either the gantry buttons or foot switches will cause the table to move up or down depending upon which button is pushed. The ETC computer, under software control, will enable the elevation amplifier, connect it to the elevation motor and thereby cause the table to move. The table will stop in its travel either by releasing the button, or because the computer has stopped the motion because of reaching a "software stop point".

3.) **Cradle Motion** - By using gantry mounted buttons the operator can cause the cradle to move into or out of the gantry area. This is usually done for the initial positioning of a patient for a scan. By depressing the cradle move button the ETC will enable the cradle amplifier and connect its output to the cradle motor and cause the cradle assembly to move. The cradle will move as long as the operator holds the button down or when the computer has reached a "software stop point". When the system is doing a scan, the ETC will automatically move the cradle based upon scan parameters sent to it by the OC, which is based upon values selected by the operator for the scan prescription.

4.) **Table Specifications**:

- Table can handle a 400 pound load, with a maximum load of 450 pounds with a minor shift in positional accuracy.
- Table moves from a low of 51 cm to a high of 107 cm.
- Elevation speeds are 5mm/sec and 40mm/sec
- Cradle has a range of 107cm.
- Cradle moves at a speed up to 75 cm/sec

5.) **Gantry Tilt** - By pressing gantry mounted buttons, the operator can tilt the gantry ± 30 degrees, in minimum of 0.5 degree increments. For safety requirements, holding the tilt button down will cause the system to tilt the gantry only 50 degrees. To go further requires the operator to release the button and press again. For the tilt function the ETC enables the tilt amplifier and connects its output to the tilt motor, which moves the gantry at a speed of 1 degree a second. A potentiometer connected to the tilt motor provides feedback to the ETC as tilt position.

6.) **Gantry Display** - The ETC computer controls everything on the gantry display. The display indicates; gantry tilt, table position, cradle position, and table/ gantry limits.

Section 2.0 Image Series

2.1 Scan Protocol

The person who acquires the image series has the responsibility to review the images, and verify they meet the specifications listed on data sheets. Responsibilities also include means and standard deviation measurements, and keeping a record of failures that occur during the image series.

Unless otherwise stated, use the following scan parameters during the image series acquisition:

- Scan FOV equal to display FOV (Field of View)
- 512x512 matrix size

Note: **Consider *any* image series scan that does not meet specifications as failing.**

For means and standard deviations, 90% of the slices must pass. Any failure on a particular technique requires at least ten additional slices to evaluate effectively.

Systems with metal-free cradles have a phantom holder with a perpendicular adjustment (Z-axis) knob on it. **Each time you change phantoms,** make sure you use a bubble level, and the Z-axis knob on the phantom holder, to level the phantom.

2.2 Data Recording: Means and Standard Deviation

Any failure on a particular technique requires at least a ten additional slices to evaluate effectively. For means and standard deviations, 90% of the slices must pass.

- Record means to two decimal places, and round to the nearest one-tenth, (one decimal place) when you compare the resulting values to the spec.
- Record standard deviations to two decimal places, then round off to one decimal place, to compare it to the spec.
- Average standard deviations: Use two decimal places to average the values, then round off to one place.

Before you record the means and standard deviations, check the image data sheets to determine whether to average the means and standard deviations, or record them slice by slice. Make sure you record all the required image data on the HHS data sheets.

2.3 Term Definitions

Xc - Mean CT number for the specified center coordinates of the phantom image.

AvXc - Average Mean CT number for the center of the phantom image: Average the mean CT value for all specified center coordinates of all slices in an exam.

Xo - Mean CT number for the outside of the phantom image: Average the mean CT value for all specified outside coordinates of one slice.

AvXo - Average outside mean CT number for the number of slices in an exam.

AvSDc - Average image noise about the center image coordinate (measured as the standard deviation) of all slices in an exam.

AvSDo - Average image noise (standard deviation) for the outside of a phantom: Average of all outside coordinates of all the slices in an exam.

2.4 48cm Phantom Image Series Image Performance Verification

2.4.1 Acquiring the 48cm Phantom Image Series

1.) Mount the Phantom Holder on the head-end of the table.
2.) Mount the 48cm Phantom on the Phantom Holder.
3.) Align, level, & center the 48cm Phantom.
- Align phantom using the internal laser lights.
- Level phantom using bubble level and the Z Axis knob on the Phantom Holder.
- Center phantom using the CENTER PHANTOM utility in the left head SCANNER UTILITIES selection and the X and Y Axis knobs on the Phantom Holder.

4.) Set up the system to scan a four scan, 16 image, 48cm Phantom image series.

MANUAL SCAN PROTOCOL SETUP

Refer to Table 11-1 and set-up an Axial scan with the parameters as shown.

SERIES DESCR.	SCAN TYPE	START LOC.	END LOC.	TOTAL # OF IMAGES	THICK SPEED	INTERVAL (MM)	GANTRY TILT	SFOV	KV	MA	TOTAL EXPOSURE TIME	DFOV (CM)	RECON TYPE
48 Lg Series 1	Axial Full 1.0 sec.	I7.50	S7.50	16	5.0 4i	0.00	S0.0	Large	120	340	4.0 sec.	50.0	Std

Table 11-1 LightSpeed Plus 48cm Phantom Image Series Scan Parameters

AUTO SCAN PROTOCOL SETUP

a.) On the Exam Rx desktop, select NEW PATIENT.
b.) Type the following entries in the two listed Patient Information fields:
Patient ID: Service
Name:48cm Phantom Image Series
c.) From the Protocol display, click on the infant box.
d.) On the infant display window, click on the area below the infant's right foot to display the Miscellaneous menu.
e.) Click on the 20:10 IMAGE SERIES 48 CM button.
f.) Select the first series (Series Description filed should display 48cm Lg Series 1)

5.) Set internal Landmark.
6.) Acquire a four-scan, 16 image, 48 cm Phantom image series.

2.4.2 Brightness Uniformity and Noise

2.4.2.1 Image Performance Verification

1.) Select the 48cm Phantom image series exam acquired in the previous section.
a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.
b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.
c.) Select the exam and series acquired in the previous section.
d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 45 x 45 pixel reference ROI Box using the Image Works Viewer tools.

a.) Click on the grid button to place a grid on the first image.

b.) Click on the MEASURE button and select the box ROI icon.

c.) Adjust the size of the ROI box to be a square 45 mm x 45 mm (2025 mm2) box. Tolerance: 45 mm +/- 5 mm (1600 mm2 to 2500 mm2).

If required, magnify the image to adjust to proper dimensions. See Figure 11-2 for additional ROI size and placement information.

3.) Collect Mean and Standard deviation values for five reference ROI Box positions on the sixteen 48cm Phantom images.

If required, magnify the image to adjust to proper dimensions. See Figure 11-2 for additional ROI placement information.

a.) Position the reference ROI Box built in step 2 directly over the center of the image using the grid cross-hairs as a guide.

b.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

c.) Click on the MEASURE button and select the box ROI icon to display Box # 2. The system places an ROI box labeled # 2 at the center of the image with the exact same dimensions as Box # 1.

d.) Reposition Box # 2 to the left center portion on the first image (Box # 2 position in Figure 11-2).

e.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 2 ROI (size and position) on the remaining images.

f.) Repeat steps 3.c. through 3.e. for each of the remaining ROI box positions shown in Figure 11-2 (Box # 3 through 5).

g.) Record the Mean and Standard Deviation values of the 16 images in the series for each of the five box positions in Table 11-2.

Each image can only display text for the mean, standard deviation, and box area for three images at a time. To view the data for a particular box, select the box on the image and the system displays the data for the box number selected.

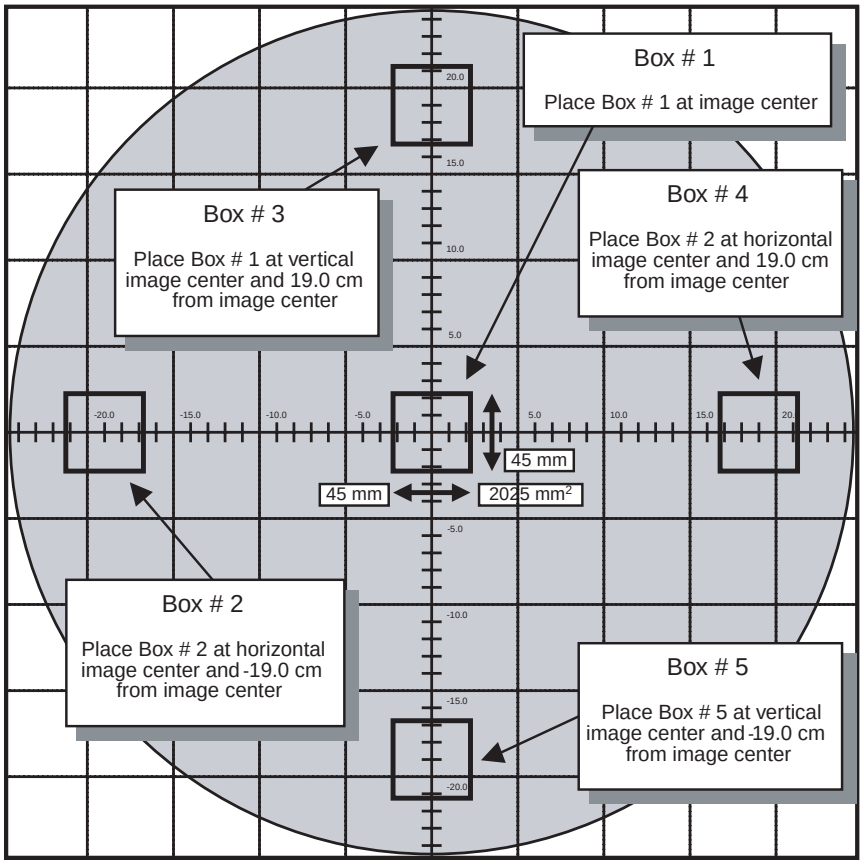

Figure 11-2 48cm Phantom Brightness Uniformity & Noise Measurement – Building Placing Reference ROI Boxes

Image	Box 1 (Center)	Box 2 (Left Center)		Box 3 (Top Center)		Box 4 (Right Center)		Box 5 (Bottom Center)		Outside Boxes Avg	
	Means (Xc)	Means	Std dev	Means	Std dev	Means	Std dev	Means	Std dev	Means (AvXo)	Std dev (AvSDo)
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											

Table 11-2 48cm Phantom CT# Brightness Uniformity & Noise Image Performance Worksheet

Box Size = 1600 mm2 to 2500 mm2
45 mm (+/- 5 mm) x 45 mm (+/- 5 mm)
45 (+/- 4 pixels) x 45 (+/- 4 pixels)

Box Positions: Box 1 = 0 mm x 0 mm
Box 2 = 0 mm x -190 mm
Box 3 = 190 mm x 0 mm
Box 4 = 0 mm x 190 mm
Box 5 = -190 mm x 0 mm

Row	Images	Center Box Means (AvXc)	Outer Boxes Means Averages (AvXo)	Outer Boxes Means Averages minus Center Box Means (AvXo - AvXc)	Outer Boxes Standard Deviation Averages (AvSDo)	Comments
2A	1, 5, 9, 13					
1A	2, 6, 10, 14					
1B	3, 7, 11, 15					
2B	4, 8, 12, 16					
Specifications		**n/a**	**n/a**	**± 8.5**	**< 70**	

Table 11-3 48cm Phantom CT# Brightness Uniformity & Noise Row Performance Worksheet

4.) Calculate the Brightness Uniformity and Noise values for each image in the series, record values in Table 11-3, and compare to specifications.

a.) Calculate and record the average means and average standard deviation values for the four outside Boxes (Boxes 2 through 5) for each of the images and record in Table 11-2.

b.) Calculate and record the center box (Box 1) average means values (AvXc) for each row in Table 11-3.

c.) Record the outside boxes (Box 2 through 5) average means values (AvXo) and average standard deviation values (AvSDo) for each row in Table 11-3.

d.) Calculate the Brightness Uniformity (AvXo - AvXc) value for each row and record in Table 11-3.

e.) Verify Brightness Uniformity (AvXo - AvXc) value and Noise value (AvSDo) for each row meets specifications listed in Table 11-3.

f.) Record the 48cm Phantom Brightness Uniformity (AvXo - AvXc) value and Noise value (AvSDo) for each row in the HHS Record Tables.

2.4.2.2 Failure Recovery

Specifications

Each Row (2A, 1A, 1B, and 2B) of the series *must* pass 48cm Brightness Uniformity and Noise (for the first series scan parameters) specifications:

- AvXo - AvXc: < +/- 8.5
- AvSDo: < 70.0

Recommended Recovery

A.) Perform DETAILED CAL.

B.) Perform AUTO CT# ADJUST.

C.) Repeat this procedure to verify 48cm Phantom Image Performance.

2.5 20cm QA Phantom Image Series Image Performance Verification

2.5.1 Acquiring the 20cm QA Phantom Image Series

1.) Mount the Phantom Holder on the head-end of the table.
2.) Mount the 20cm QA Phantom on the Phantom Holder.
3.) Align, level, & center the 20cm QA Phantom.
- Align the etched line (QA#1 position) on phantom using the internal laser lights.
- Level phantom using bubble level and the Z Axis knob on the Phantom Holder.
- Center phantom using the CENTER PHANTOM procedure in the left head SCANNER UTILITIES selection and the X and Y Axis knobs on the Phantom Holder.

4.) Set up the system to scan the QA#1, QA#2, and QA#3 positions on the 20cm QA Phantom.

MANUAL SCAN PROTOCOL SETUP

Refer to Table 11-4 and set-up an Axial scan with the parameters shown

Series Description	Scan Type	Start Loc.	End Loc.	Total # of Images	Thick Speed	Interval (mm)	Tilt	SFOV	kV	mA	Total Exposure Time	DFOV (cm)	Recon Type
QA#1	Axial Full 1.0 sec.	I5.00	S5.00	4	10.0 2i	0.00	S0.0	Small	120	260	2.0 sec.	25.0	Std
Recon 2: Q	Recon #2 of Series #1–4 images											15.0	Bone
QA#2	Axial Full 1.0 sec.	S40.00	S50.00	8	10.0 2i	0.00	S0.0	Small	120	260	4.0 sec.	25.0	Std
QA#3	Axial Full 1.0 sec.	S55.00	S65.00	8	10.0 2i	0.00	S0.0	Small	120	260	4.0 sec.	25.0	Std

Table 11-4 LightSpeed Plus 20cm QA Phantom Image Series Scan Parameters

AUTO SCAN PROTOCOL SETUP

a.) On the Exam Rx desktop, select NEW PATIENT.
b.) Type the following entries in the listed Patient Information following fields:
* Patient ID: **Service**
* Name: **20cm QA#3 Phantom Image Series**

c.) From the Protocol display, click on the infant box.
d.) On the Infant display window, click on the area below the infant's right foot to display the Miscellaneous menu.
e.) Click on the 20:12 IMAGE SERIES QA button.
f.) When the scan prescription appears on the left monitor, select the 1st series.

5.) Set internal Landmark.
6.) Acquire the QA#1, QA#2 and QA#3 positions of the 20cm QA Phantom.

2.5.2 High Contrast Spatial Resolution

2.5.2.1 Image Performance Verification

1.) Select the first 20cm QA Phantom image series (QA#1) from the exam acquired in the previous section.
a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.
b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.
c.) Select the exam and the first series acquired in the previous section.

d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 17 x 17 pixel reference ROI Box using the Image Works Viewer tools.

a.) Click on the grid button to place a grid on the first image.

b.) Click on the MEASURE button and select the box ROI icon.

c.) Adjust the size of the ROI box to be a square of approximately 8 mm x 8 mm (64 mm^2) box.

If required, magnify the image to adjust to proper dimensions. See Figure 11-3 for additional ROI size and placement information.

3.) Collect Mean and Standard deviation values for three reference ROI Box positions on the four 20cm QA#1 Phantom images.

If required, magnify the image to adjust to proper dimensions. See Figure 11-3 for additional ROI placement information.

a.) Position the reference ROI Box built in step 2 directly over the 1.6 mm Line Pair Pattern on the QA#1 phantom image. Fine adjust size of Box #1 ROI to ensure that the box does not exceed the line pair boundaries. See Figure 11-3.

b.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

c.) Click on the MEASURE button and select the box ROI icon to display Box # 2. The system places an ROI box labeled # 2 at the center of the image with the exact same dimensions as Box # 1.

d.) Reposition Box # 2 over the Plexiglas portion of the QA#1 phantom image (Box # 2 position in Figure 11-3).

e.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 2 ROI (size and position) on the remaining images.

f.) Click on the MEASURE button and select the box ROI icon to display Box # 3. The system places an ROI box labeled # 3 at the center of the image with the exact same dimensions as Boxes # 1 and 2.

g.) Reposition Box # 3 over the water portion of the QA#1 phantom image (Box # 3 position in Figure 11-3).

h.) Record the Mean and Standard Deviation values of the four images in the series for each of the three box positions in Table 11-5.

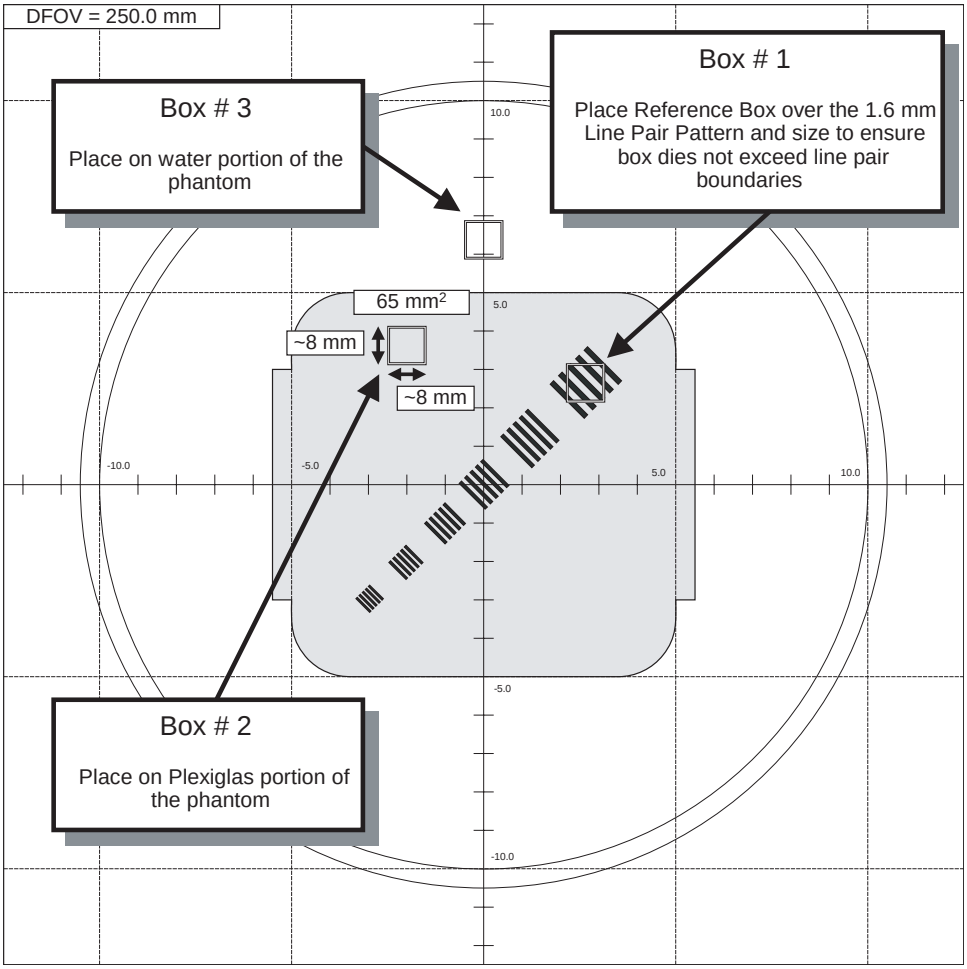

Figure 11-3 20cm QA#1 Phantom High Contrast Spatial Resolution Testing - Building And Placing Reference ROI Boxes

Image	Box 1		Box 2		Box 3		Contrast Scale (Box 2 Means – Box 3 Means)	Std Dev Average (Box 2 Std Dev – Box 3 Std Dev / 2)
	Means	Std Dev	Means	Std Dev	Means	Std Dev		
1								
2								
3								
4								

Table 11-5 20cm QA#1 Phantom High Contrast Spatial Resolution Image Performance Worksheet #1

Image	MTF	MTF 4-slice average	Contrast Scale	Comments
1		n/a		
2		n/a		
3		n/a		
4		n/a		
Specifications	**n/a**	**0.65 to 1.0**	**110.0 to 130.0**	**n/a**

Table 11-6 20cm QA#1 Phantom High Contrast Spatial Resolution Image Performance Worksheet #2

4.) Calculate the Contrast Scale value and four-image average MTF values for each image in the series, record values in Table 11-6, and compare to specifications.

a.) Calculate and record the Contrast Scale value (Means value of Box 2 - Means value of Box 3) for each image and record in Table 11-5 and Table 11-6.

b.) Calculate and record the MTF value for each image in Table 11-6 using the following formula. Record Standard Deviation Average (Std Dev AVE) values in both Table 11-5 and Table 11-6.

Std Dev AVE = $(\text{Std Dev}_{\text{Box 2}} - \text{Std Dev}_{\text{Box 3}}) + 2$

Modulation = $\sqrt{\text{StdDev}^2_{\text{Box1}} - \text{StdDev}^2_{\text{AVE}}}$

MTF = (2.2 x Modulation) + Contrast Scale

c.) Calculate the average MTF value for each image and record in Table 11-6.

d.) Verify Contrast value for each image and the four-image MTF value meets specifications listed in Table 11-6.

e.) Record the 20cm QA Phantom High Contrast Spatial Resolution values (Contrast Scale for each image and four-image MTF value) in the HHS Record Tables.

5.) View each image of the Recon 2 Series, record all the visible Line Pair Patterns in Table 11-7, and verify each image meets specifications.

a.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.

b.) Select the exam and the second series (Recon 2: Q) acquired in the previous section.

c.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

d.) While viewing each image, indicate in Table 11-7 all the Line Pair Pattern groups that can be visually distinguished. See Figure 11-4.

e.) Verify Line Pair Pattern visual check meets specifications and record in the HHS Record Tables.

Image	Line Patterns Visible	Comments
1		
2		
3		
4		
Specifications	**B, C, D, E, F**	**n/a**

Table 11-7 20cm QA#1 Phantom High Contrast Spatial Resolution Image Performance Worksheet #3

2.5.2.2 Failure Recovery

Specifications

Each image of the series must pass 20cm QA#1 High Contrast Spatial Resolution parameter (Contrast Scale, Four-Image MTF Average and Visible Line Pair (for the first and second series scan parameters) specifications:

- Contrast Scale: 110.0 to 130.0
- MTF Average: 0.65 to 1.0
- Visible Lines: B, C, D, E, F

Recommended Recovery

A.) Check Phantom Alignment (leveling is critical) and repeat this scanning and High Contrast Spatial Resolution Performance Test.

B.) Perform Alignment Procedures (POR Alignment, BOW Alignment, CBF/SAG Alignment, ISO Alignment, and Hot ISO Alignment), perform Full Calibration (Detailed Calibration and Auto CT# Adjust, and repeat this scanning and High Contrast Spatial Resolution Performance Test.

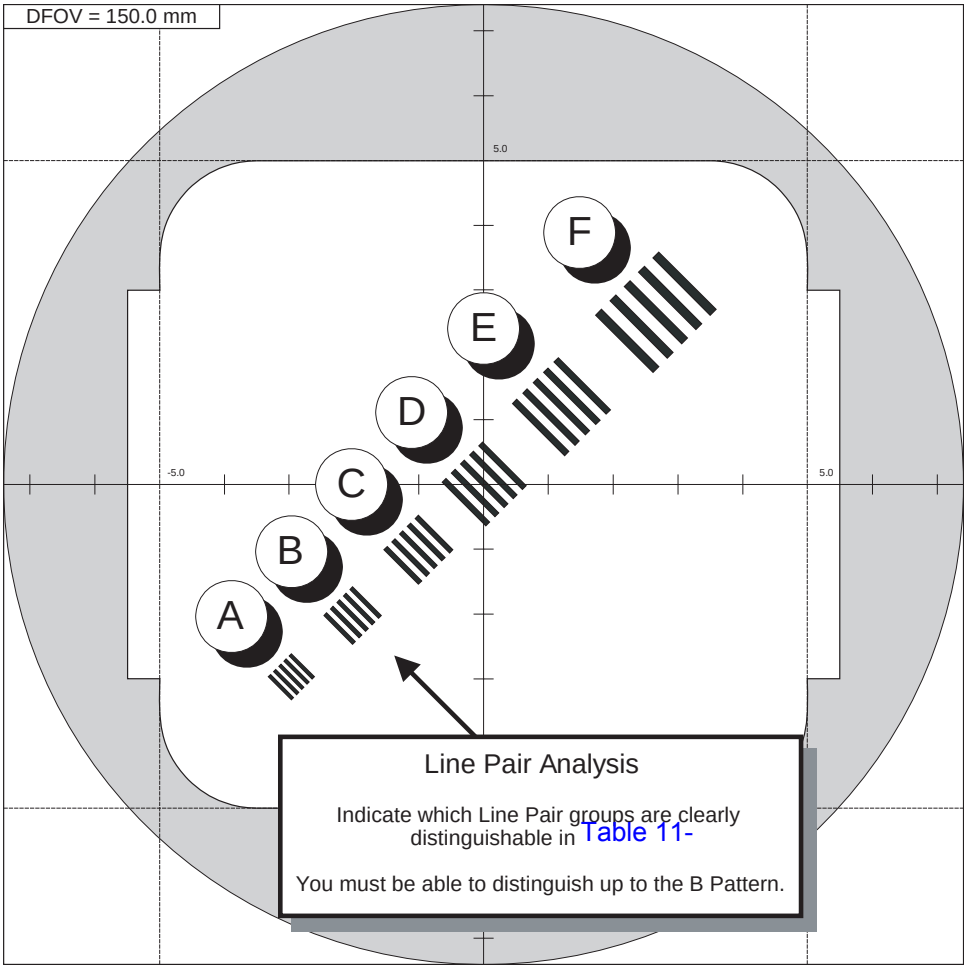

Figure 11-4 20cm QA#1 Phantom High Contrast Spatial Resolution (Visible Line Verification)

2.5.3 Low Contrast Detectability

2.5.3.1 Image Performance Verification

1.) Select the third 20cm QA Phantom image series (QA#2 Holes) from the exam acquired in the previous section.

a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.

b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.

c.) Select the exam and the third series acquired in the previous section.

d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 10 mm x 100 mm reference ROI Box using the Image Works Viewer tools.

a.) Click on the grid button to place a grid on the first image.

b.) Click on the MEASURE button and select the box ROI icon.

c.) Adjust the size of the ROI box to be a rectangle of approximately 10 mm x 50 mm (500 mm2) box.

If required, magnify the image to adjust to proper dimensions. See Figure 11-5 for additional ROI size and placement information.

3.) Collect Mean values for two reference ROI Box positions on four (1st, 3rd, 5th, and 7th) of the eight 20cm QA#2 Phantom images.

If required, magnify the image to adjust to proper dimensions. See Figure 11-5 for additional ROI placement information.

a.) Adjust the Window setting of the image to 20 by simultaneously holding the center mouse button down while dragging the cursor to the left. Adjust level for a viewable image as shown in Figure 11-5.

b.) Position the reference ROI Box built in step 2 on the Plexiglas portion of the QA#2 phantom image without touching the water portion or the hole pattern. See Figure 11-5.

c.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

d.) Click on the MEASURE button and select the box ROI icon to display Box # 2. The system places an ROI box labeled # 2 at the center of the image with the exact same dimensions as Box # 1.

e.) Reposition Box # 2 over the water portion of the QA#1 phantom image and directly above Box # 1 (Box # 2 position in Figure 11-5).

f.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 2 ROI (size and position) on the remaining images.

g.) Record the Mean values of the 1st, 3rd, 5th, and 7th images in the series for each of the two box positions in Table 8.

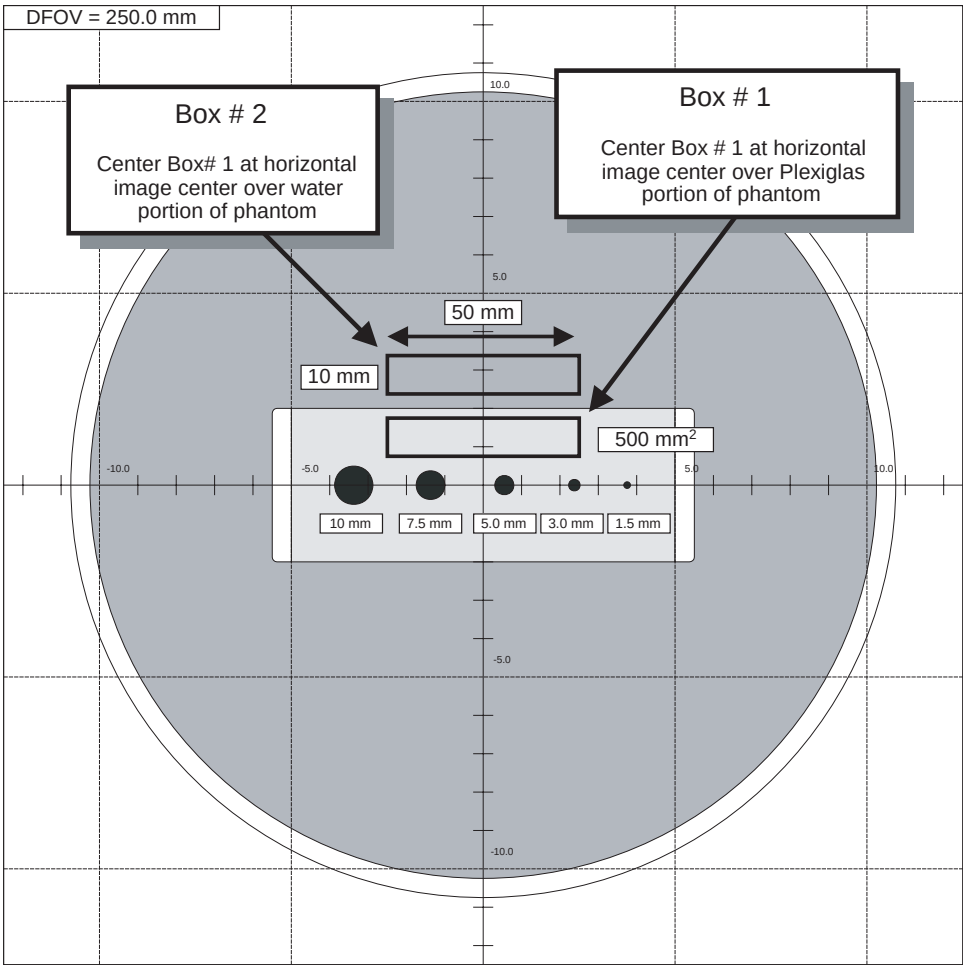

Figure 11-5 20cm QA#2 Phantom Low Contrast Detectability - Building and Placing Reference ROI Boxes

Image	Visible Holes Viewable at Window 20	Box 1 Means (Plexiglas)	Box 2 Means (Water)	Contrast Factor (Box 1 Means – Box 2 Means)	Comments
1					
3					
5					
7					
Specifications	**See Table 11-9**	**n/a**	**n/a**	**2.0 to 12.0**	**n/a**

Table 11-8 20cm QA#2 Phantom Low Contrast Detectability Image Performance Worksheet #1

4.) View the 1st, 3rd, 5th, and 7th images of the QA#2 Holes Series, record the number of visible holes in Table 11-8, and verify each image meets specifications.

a.) While viewing the 1st, 3rd, 5th, and 7th images, indicate in Table 11-8 the number of holes that can be visually distinguished. See Figure 11-5.

b.) Verify Visible Hole visual check meets specifications listed in Table 11-9 for the calculated Contrast Factor and record in the HHS Record Tables.

Contrast Factor Range (Box 1 Means – Box 2 Means)	Visible Number of Holes		Smallest Visible Hole Size
	Lower Limit*	Upper Limit*	
2.00 to 3.99	2	5	7.5mm
4.00 to 7.99	3	5	5.0mm
8.00 to 12.00	4	5	3.0mm
*Required number of visible holes depends on the contrast factor.			

Table 11-9 20cm QA#2 Phantom Visible Hole Specifications

2.5.3.2 Failure Recovery

Specifications

At least two out of the four images of the series must pass the 20cm QA#2 Low Contrast Detectability parameter (Visible Hole Size for a calculated Contrast Factor) for the third series scan parameters specifications.

Recommended Recovery

A.) Check Phantom Alignment (leveling is critical) and repeat this scanning and High Contrast Spatial Resolution Performance Test.

B.) Perform Alignment Procedures (POR Alignment, BOW Alignment, CBF/SAG Alignment, ISO Alignment, and Hot ISO Alignment), perform Full Calibration (Detailed Calibration and Auto CT# Adjust, and repeat this scanning and Low Contrast Detectability Performance Test.

2.5.4 QA#3 Phantom Brightness Uniformity and CT#

2.5.4.1 Performance Verification

1.) Select the fourth 20cm QA#3 Phantom exam acquired in the previous section.
   a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.
   b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.
   c.) Select the exam and fourth (QA#3) series acquired in the previous section.
   d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 31 x 31 pixel reference ROI Box using the Image Works Viewer tools.
   a.) Click on the grid button to place a grid on the first image.
   b.) Click on the MEASURE button and select the box ROI icon.
   c.) Adjust the size of the ROI box to be a square 15 mm x 15 mm (225 mm2) box. Tolerance: 15 mm +/- 1 mm (196 mm2 to 256 mm2).

   If required, magnify the image to adjust to proper dimensions. See Figure 11-6 for additional ROI size and placement information.

3.) Collect Mean values for five reference ROI Box positions on the eight 20cm QA#3 Phantom images.

   If required, magnify the image to adjust to proper dimensions. See Figure 11-6 for additional ROI placement information.

   a.) Position the reference ROI Box built in step 2 directly over the center of the image using

the grid cross-hairs as a guide.

b.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

c.) Click on the MEASURE button and select the box ROI icon to display Box # 2. The system places an ROI box labeled # 2 at the center of the image with the exact same dimensions as Box # 1.

d.) Reposition Box # 2 to the left center portion on the first image (Box # 2 position in Figure 11-2).

e.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 2 ROI (size and position) on the remaining images.

f.) Repeat steps 3.c. through 3.e. for each of the remaining ROI box positions shown in Figure 11-3 (Box # 3 through 5).

g.) Record the Mean values of the eight images in the series for each of the five box positions in Table 11-10.

Each image can only display text for the mean, standard deviation, and box area for three images at a time. To view the data for a particular box, select the box on the image and the system displays the data for the box number selected.

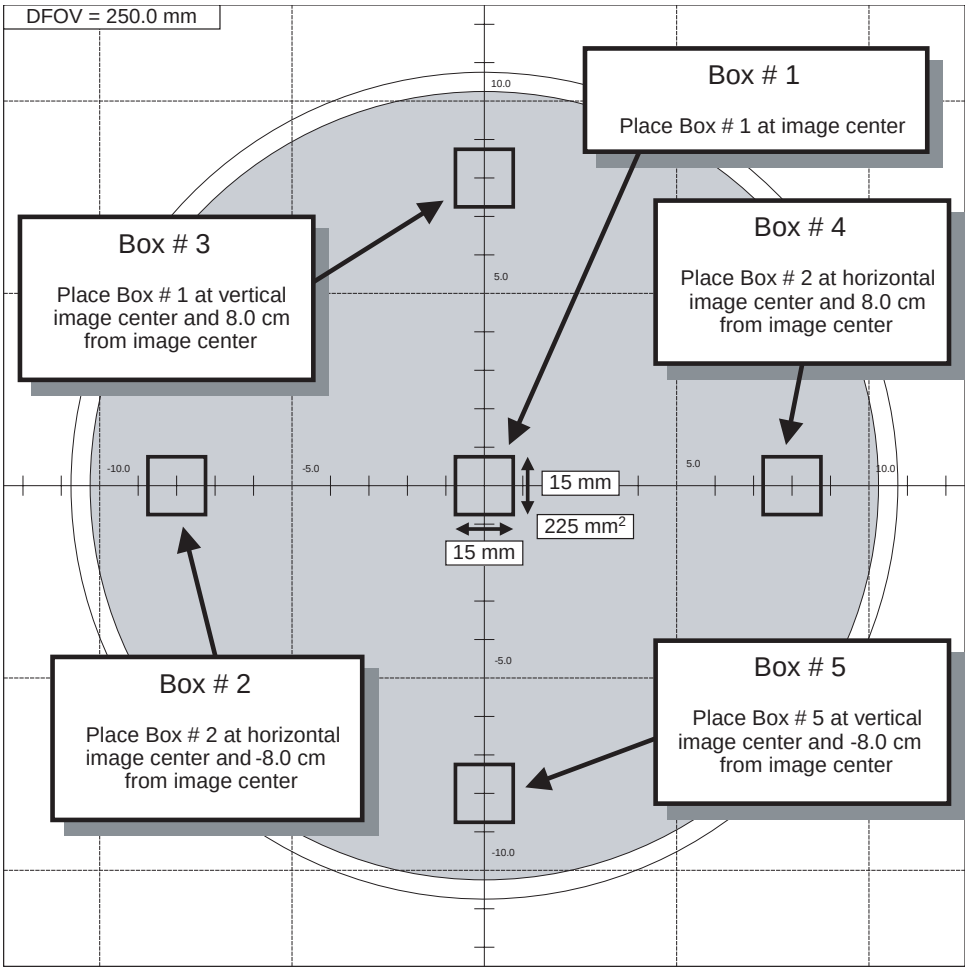

Figure 11-6 20cm QA#3 Phantom Brightness Uniformity & CT# Measurement - Building And Placing Reference ROI Boxes

Image	Box 1 (Center)	Box 2 (Left Center)		Box 3 (Top Center)		Box 4 (Right Center)		Box 5 (Bottom Center)		Outside Boxes Avg	
	Means (Xc)	Means	Std dev	Means	Std dev	Means	Std dev	Means	Std dev	Means (AvXo)	Std dev (AvSDo)
1			n/a		n/a		n/a		n/a		n/a
2			n/a		n/a		n/a		n/a		n/a
3			n/a		n/a		n/a		n/a		n/a
4			n/a		n/a		n/a		n/a		n/a
5			n/a		n/a		n/a		n/a		n/a
6			n/a		n/a		n/a		n/a		n/a
7			n/a		n/a		n/a		n/a		n/a
8			n/a		n/a		n/a		n/a		n/a

Table 11-10 20cm QA#3 Phantom CT# Brightness Uniformity & CT# Image Performance Worksheet

Box Size = 196 mm2 to 256 mm2
15 mm (+/- 1 mm) x 15 mm (+/- 1 mm)
31 (+/- 2 pixels) x 31 (+/- 2 pixels)

Box Positions: Box 1 = 0 mm x 0 mm
Box 2 = 0 mm x -80 mm
Box 3 = 80 mm x 0 mm
Box 4 = 0 mm x 80 mm
Box 5 = -80 mm x 0 mm

Row	Images	Center Box Means (AvXc)	Outer Boxes Means Averages (AvXo)	Outer Boxes Means Averages minus Center Box Means (AvXo - AvXc)	Outer Boxes Standard Deviation Averages (AvSDo)	Comments
2A1A	1, 3, 5, 7				n/a	
1B2B	2, 4, 6, 8				n/a	
Specifications		**0.0 ± 3.0**	**n/a**	**<± 3.0**	**n/a**	

Table 11-11 48cm Phantom CT# Brightness Uniformity & Noise Row Performance Worksheet

4.) Calculate the Brightness Uniformity and CT# values for each image in the series, record values in Table 11-11, and compare to specifications.

a.) Calculate and record the average means values (AvXo) for the four outside Boxes (Boxes 2 through 5) for each of the images and record in Table 11-10.

b.) Calculate and record the average center box (Box 1) means values (AvXc) for each row (2A1A: Images 1, 3, 5, and 7; 1B2B: Images 2, 4, 6, 8) in Table 11-11.

c.) Calculate and record the average outside boxes (Box 2 through 5) means values (AvXo) for each row (2A1A: Images 1, 3, 5, and 7; 1B2B: Images 2, 4, 6, 8) in Table 11-11.

d.) Calculate the Brightness Uniformity (AvXo - AvXc) value for each row and record in Table 11-11.

e.) Verify Brightness Uniformity (AvXo - AvXc) value and the average CT# value (AvXc) for each row meets specifications listed in Table 11-11.

f.) Record the 20cm QA#3 Phantom Brightness Uniformity (AvXo - AvXc) value and average CT# value (AvXc) for each row in the HHS Record Tables.

2.5.4.2 Failure Recovery

Specifications

Each Row (2A1A, 1B2B) of the series must pass 20cm QA#3 Phantom Brightness Uniformity and average CT# specifications:

- AvXo - AvXc: < +/- 3.0
- AvXc: < +/- 3.0

Recommended Recovery

A.) Perform DETAILED CAL.
B.) Perform AUTO CT# ADJUST.
C.) Repeat this procedure to verify 20cm QA#3 Phantom Image Performance.

2.5.5 QA#3 Phantom Noise

2.5.5.1 Performance Verification

1.) Select the fourth 20cm QA#3 Phantom exam acquired in the previous section.
   a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.
   b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.
   c.) Select the exam and fourth (QA#3) series acquired in the previous section.
   d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.
2.) Build a 51 x 51 pixel reference ROI Box using the Image Works Viewer tools.
   a.) Click on the grid button to place a grid on the first image.
   b.) Click on the MEASURE button and select the box ROI icon.
   c.) Adjust the size of the ROI box to be a square 25 mm x 25 mm (625 mm2) box. Tolerance: 25 mm +/- 1 mm (576 mm2 to 676 mm2).

   If required, magnify the image to adjust to proper dimensions. See Figure 11-7 for additional ROI size and placement information.
3.) Collect Standard Deviation values for the single reference ROI Box position on the eight 20cm QA#3 Phantom images.

   If required, magnify the image to adjust to proper dimensions. See Figure 11-7 for additional ROI placement information.
   a.) Position the reference ROI Box built in step 2 directly over the center of the image using the grid cross-hairs as a guide.
   b.) Type **prop a** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.
   c.) Record the Standard Deviation values of the eight images in the series for centered box position in Table 11-12.
4.) Calculate the average Noise values for each image in the series, record values in Table 11-12, and compare to specifications.
   a.) Calculate and record the average Noise values (AvSDc) for the inside Boxes for each of the two rows (2A1A and 1B2B) and record in Table 11-12.
   b.) Verify Noise (AvSDc) values for each row meets specifications listed in Table 11-12.
   c.) Record the 20cm QA#3 Phantom Noise (AvSDc) for each row in the HHS Record Tables.

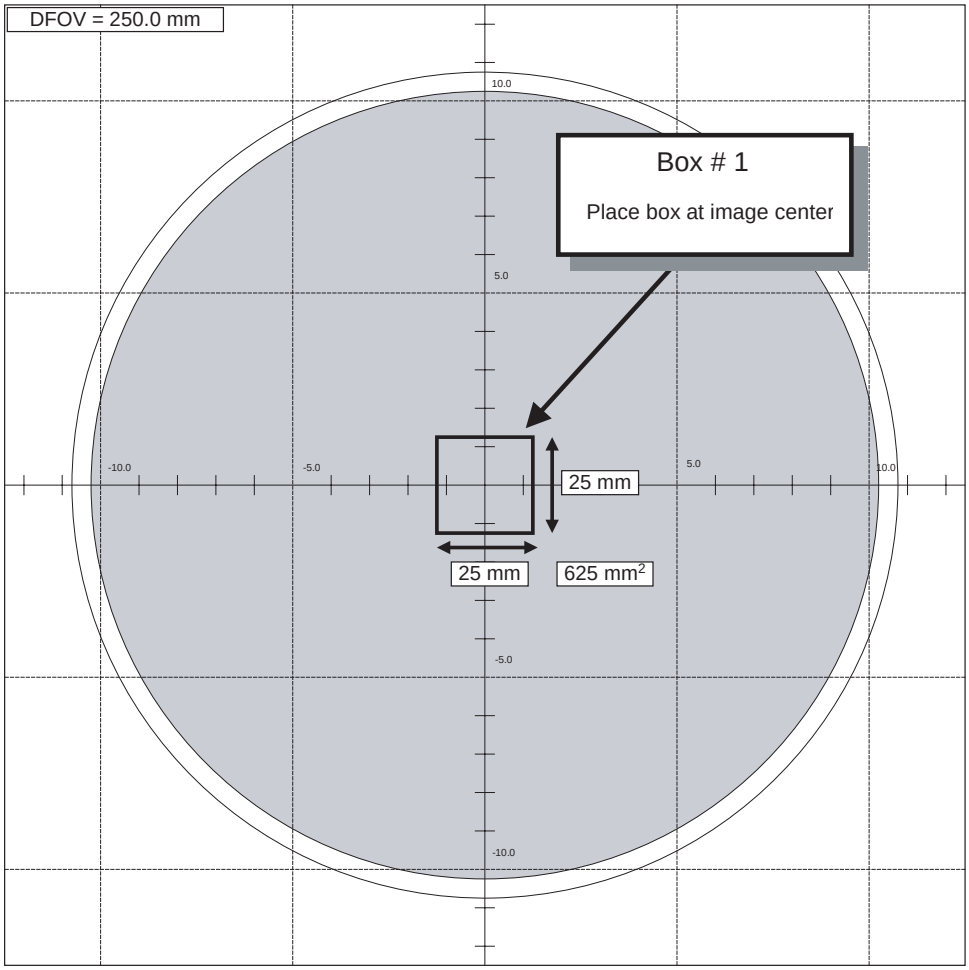

Figure 11-7 20cm QA#3 Noise Measurement - Building And Placing Reference ROI Box

Image	Row	Box 1 Std Dev (SDc)	Average Std Dev (AvSDc)	AvSDc Specifications		Comments
				Systems with less than 5000 scans	Systems with more than 5000 scans	
1	2A1A			3.2 ± 0.3	3.2 ± 0.4	
3						
5						
7						
2	1B2B					
4						
6						
8						

Table 11-12 20cm QA#3 Phantom Noise Performance Worksheet

Box Size = 576 mm2 to 676 mm2
25 mm (+/- 1 mm) x 25 mm (+/- 1 mm)
51 (+/- 2 pixels) x 51 (+/- 2 pixels)

Box Position: Box 1 = 0 mm x 0 mm

2.5.5.2 Failure Recovery

Specifications

Each Row (2A1A, 1B2B) of the series must pass 20cm QA#3 Phantom Noise specifications shown in Table 11-12.

Recommended Recovery

A.) Perform DETAILED CAL.

B.) Perform AUTO CT# ADJUST.

C.) Repeat this procedure to verify 20cm QA#3 Phantom Image Performance.

Section 3.0
Image Quality

3.1 Rings in an Axial Image

Using the Example shown in Figure 11-8, there is a obvious ring in the first image within the group of 4 images. During an Axial series, it is important to know certain parameters about the Scan Prescription. See Table 11-13

SCAN (RX) PRESCRIPTION		COMMENTS
Scan Type	Axial	In a Axial mode, there are several options relative to scanning and displaying images, either 4 x i, or 2 x I (where i = thickness) In a 4 x i mode, images are created from the rows used as indicated by slice thickness. *This mode should always be used to troubleshoot Detector / DAS related artifacts.* In a 2 x i mode Recon actually combines 2 rows of data to produce a thicker slice.
Scan Type	Helical	Images are created using data from all Rows used during data acquisition. (The actual rows being dependent on slice thickness) The amount of data used to reconstruct a image from a row, or row weighting is dependent on table speed.
Head First	Head First	Image 1 consists of the Data in Row 2A, Image 2 consists of the Data in Row 1A Image 3 consists of the Data in Row 1B Image 4 consists of the Data in Row 2B
Feet First	Feet First	Image 1 consists of the Data in Row 2B, Image 2 consists of the Data in Row 1B Image 3 consists of the Data in Row 1A Image 4 consists of the Data in Row 2A
Slice Thickness	4 x 1.25	Uses 4 Center rows of the Detector (D2, D1, D1, D2)
	4 x 2.50	Uses 8 Center rows of the Detector (D4+D3, D2+D1, D1+D2, D3+D4)
	4 x 3.75	Uses 12 Center rows of the Detector (D6+D5+D4, D3+D2+D1, ….)
	4 x 5.00	Uses 16 Center rows of the Detector(D8+D7+D6+D5, D4+D3+D2+D1,…)
Technique	KV vs. Slice Thickness	The DAS Converter boards have 31 pre-amp gains that are selected by selected technique. These gains are not User select-able, however it is important to know if a Artifact only appears at the same pre-amp gain. The pre-amp gain used can be found within the scan header by using Scan Analysis.
Focal Spot Size	Small vs. Large	Technique dependent small spot ≤ 24KW, Large spot > 24KW
Calibration Used	Small vs. Large	Needed to know if artifact may be caused by cal vectors

Table 11-13 Troubleshooting a Ring in an Axial Image

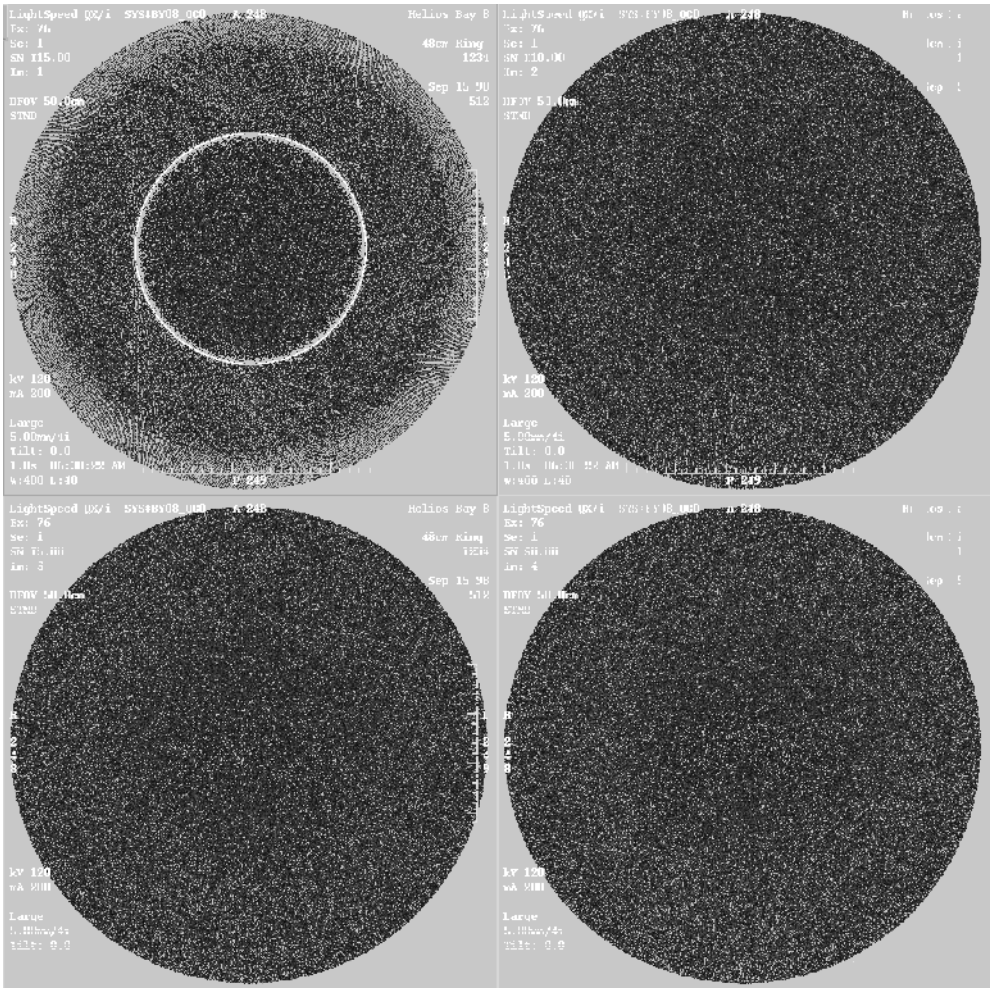

Figure 11-8 Example of Bad Channel in Axial Image Series

Looking at the Example in Figure 11-8, just by knowing the scan series was using Axial 4 x 5.00 Mode and was done Head first (Annotation of image vs. Table position), it can be determined that the Ring is probably in Row 2A of the Scanfile.

To confirm this, use Scan Analysis and plot the Means & Standard Deviations (MSD) of the selected Exam, Series, and Scan Number. From the Service Desktop:

1.) Select UTILITIES.
2.) Select TOOLS.
3.) Select SCAN ANALYSIS.

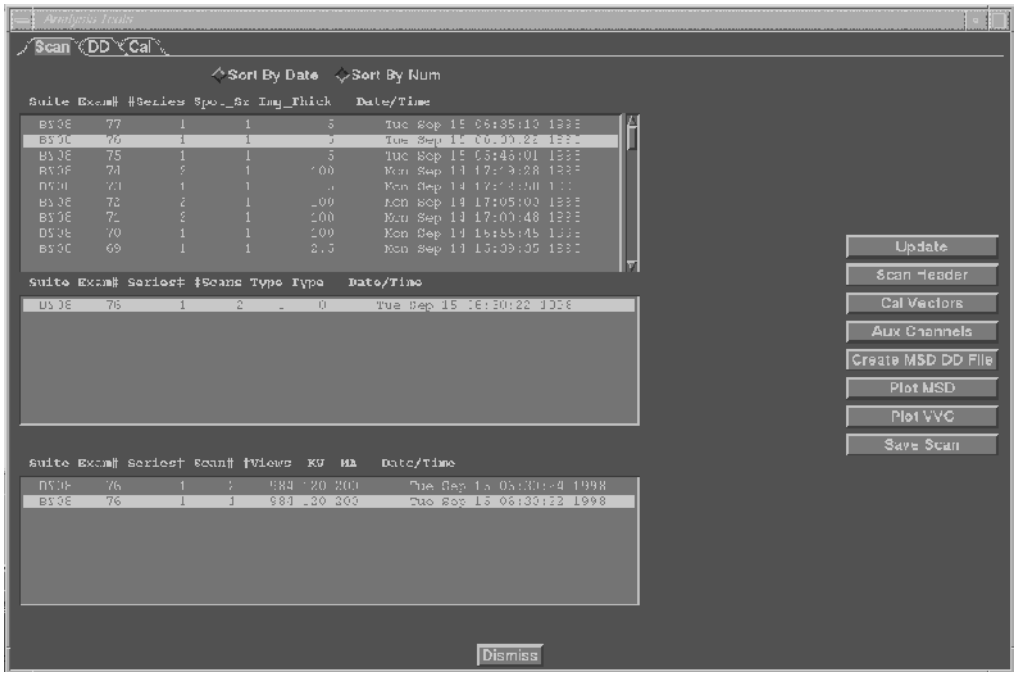

Figure 11-9 Scan Analysis GUI

Select an EXAM NUMBER, SERIES, and SCAN NUMBER. Remember that 1 scan, in a 4 x i mode, is made up of 4 Data sets (or rows), which produces 4 images. In the example, images 1 through 4 are created from scan 1. Once the scan is highlighted, select PLOT MSD.

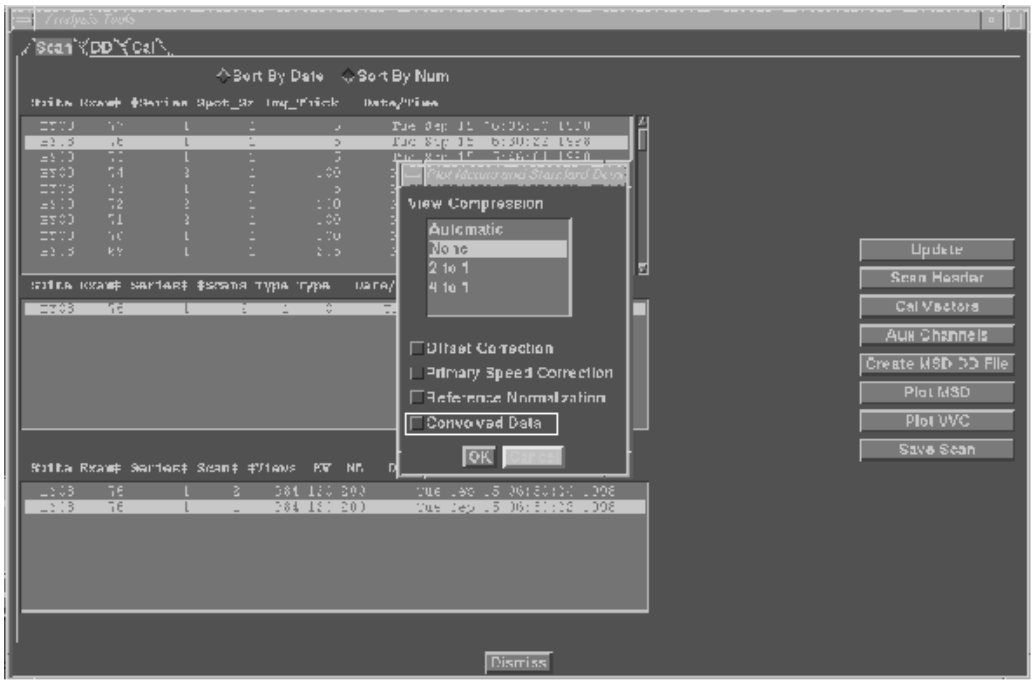

Figure 11-10 Plot MSD GUI

Leave the view compression defaulted to NONE, but choose CONVOLVED DATA, which will identify a ring type artifact better in the resultant plot. Select OK.

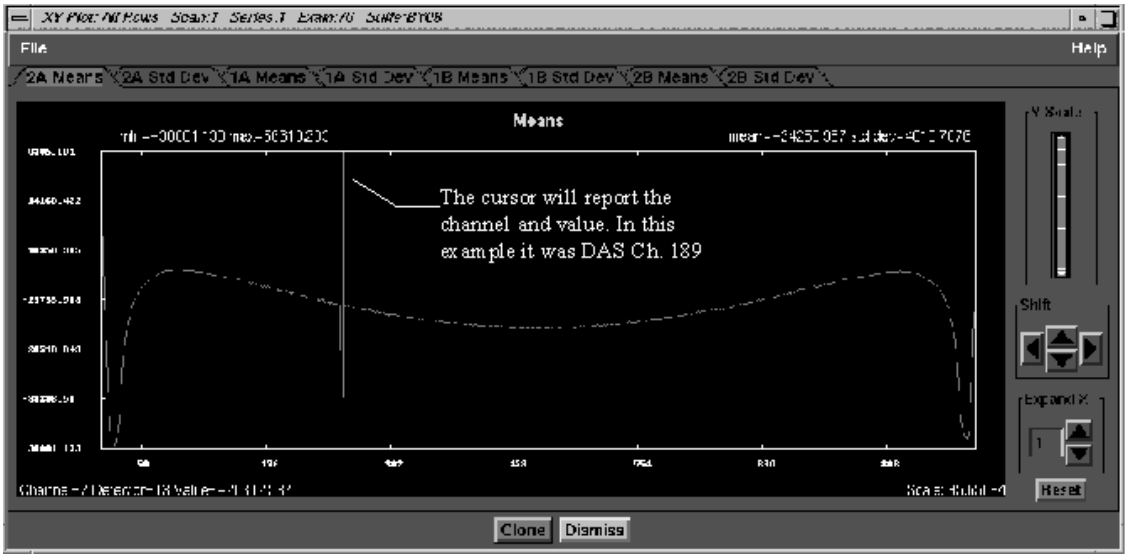

Figure 11-11 Scan Analysis (2A) Means & Standard Deviation GUI

The Scan Analysis Tool will first plot Row 2A. Any of the 4 rows of Means and Standard Deviations can be viewed by selecting the appropriate tabs (see Figure 11-11). Select the tab that indicates the row where the ring is expected based on your initial observations. It maybe necessary to adjust the level to find a spike in the data or view other rows. Look for any abnormal spikes.

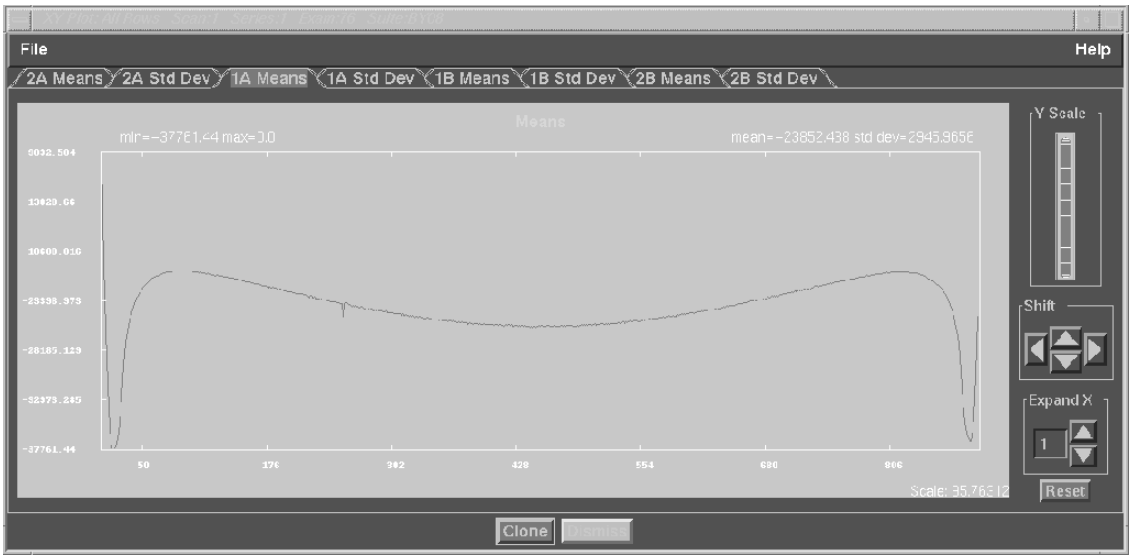

Figure 11-12 Scan Analysis (1A) Means & St. Dev. GUI

In Row 2A (see Figure 11-11), the ring is apparent. Notice the large spike in the data on channel 189. Row 1A (see Figure 11-12) has a small spike on channel 189 that is a result of capacitive discharge from row 2b channel 189. The small spike can be ignored. It is a product of the major spike on row 2B. Rows 1B and 2B look good. See Figures 11-13 and 11-14.

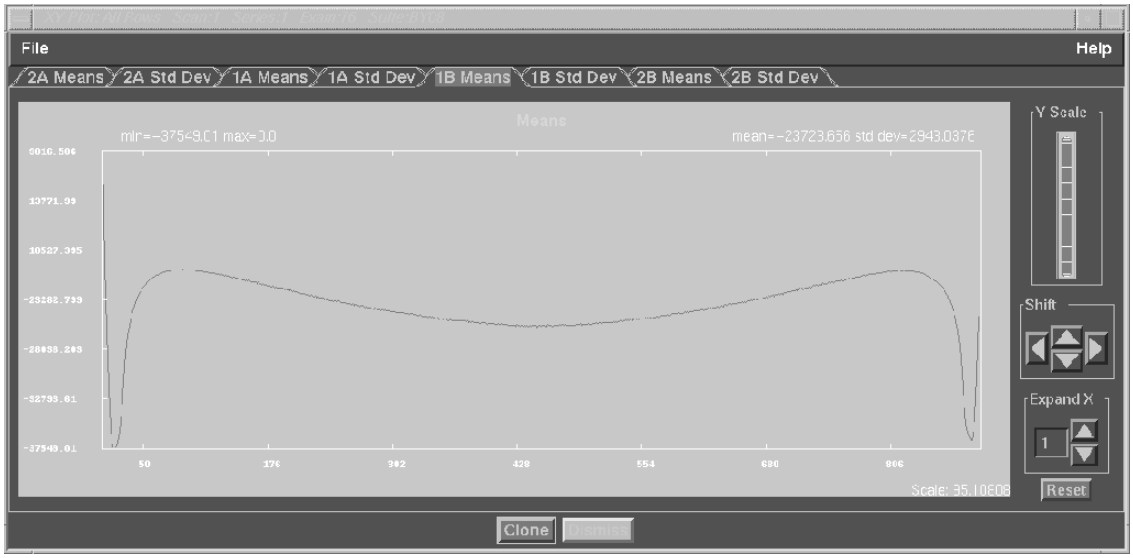

Figure 11-13 Scan Analysis (1B) Means & St. Dev. GUI

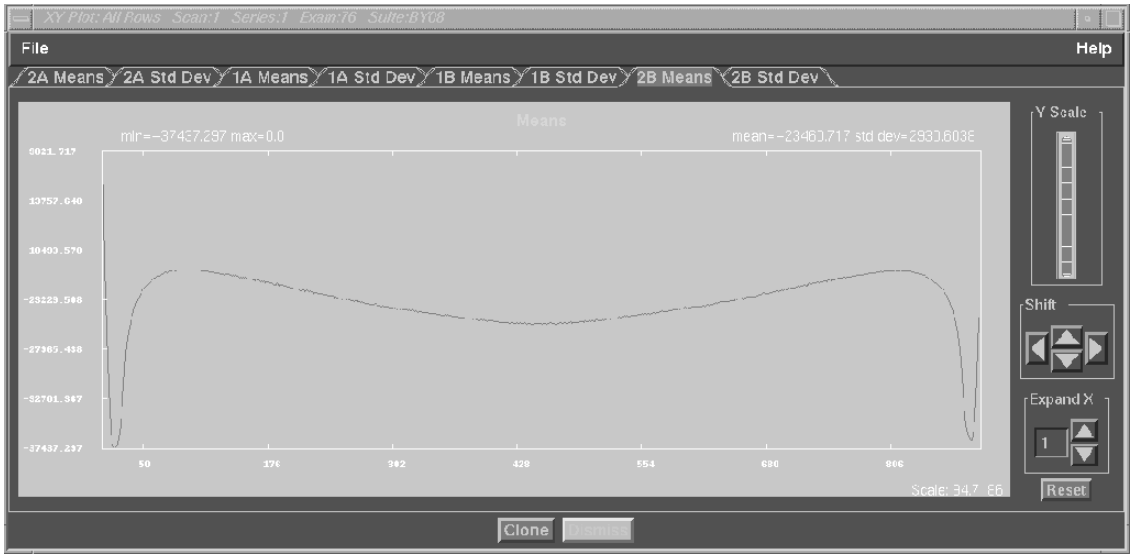

Figure 11-14 Scan Analysis (2A) Means & St. Dev. GUI

Now the Ring has been verified. It is in Row 2B and is on DAS Channel 189.

From within Scan Analysis, Cal vectors can be plotted to see if the bad DAS channel is present.

Determine if the ring is caused by a particular acquisition mode by scanning a phantom using different modes or slice thickness'. The example was scanned in a 4 x 5.00 mode and the ring appeared on Row 2A, therefore, the Detector rows or diodes used were D8+D7+D6+D5. They produce row 2A. If another scan was taken at 4 x 1.25 mode, then the first image, or row 2A data would be acquired from Detector row D2. If the ring is a hard failure (consistent every time) and if after changing slice thickness the ring does away, the ring may have been caused by a suspect detector. *Perform further detector verification before replacing a detector*. If the ring is still present, the problem could still be the detector, but may be a DAS board or elastomer interface connection.

By using the DAS / DETECTOR Architecture Tool, found in the pull-down menu under FILE, select the tool. A TTY window appears and prompts for a Detector Row and DAS Channel. The program will display the associated DAS Converter board, Detector channel, module number, elastomer number, and other important information.Find the associated DAS converter board number. If you have multiple rings, look for patterns (Converter Bd, Row, etc.).

If DAS is Suspect, swap filter Cards and repeat Scan & Analyze.

1.) If bad channel follows bd. replace the bd.

2.) If bad channel stays at same location, problem area could be:

   a.) DAS Backplane

   b.) DAS Backplane to Elastomeric connection point

   c.) Elastomeric to Detector Flex connection point

      1.) Bad Detector (Replace)

      2.) Bad Flex (part of detector, replace Detector)

      3.) Bad Flex to Detector connection point (part of detector, replace Detector)

      4.) Bad Detector Channel (part of detector, replace Detector

      5.) Bad Detector Cell (part of detector, replace Detector)

Troubleshoot Ring Artifacts in a Helical series by duplicating the problem in a Axial Mode. If the Helical data is used to troubleshoot, the bad data can be in any row since all 4 rows of data are used to produce a Helical image and the number of views to produce a helical image are weighted differently based on table speed and pitch.

Note that the Helical images are a result of the same bad DAS Channel as the Above Axial example. The hard ring in the Axial example appears as partial arcs in the Helical images.

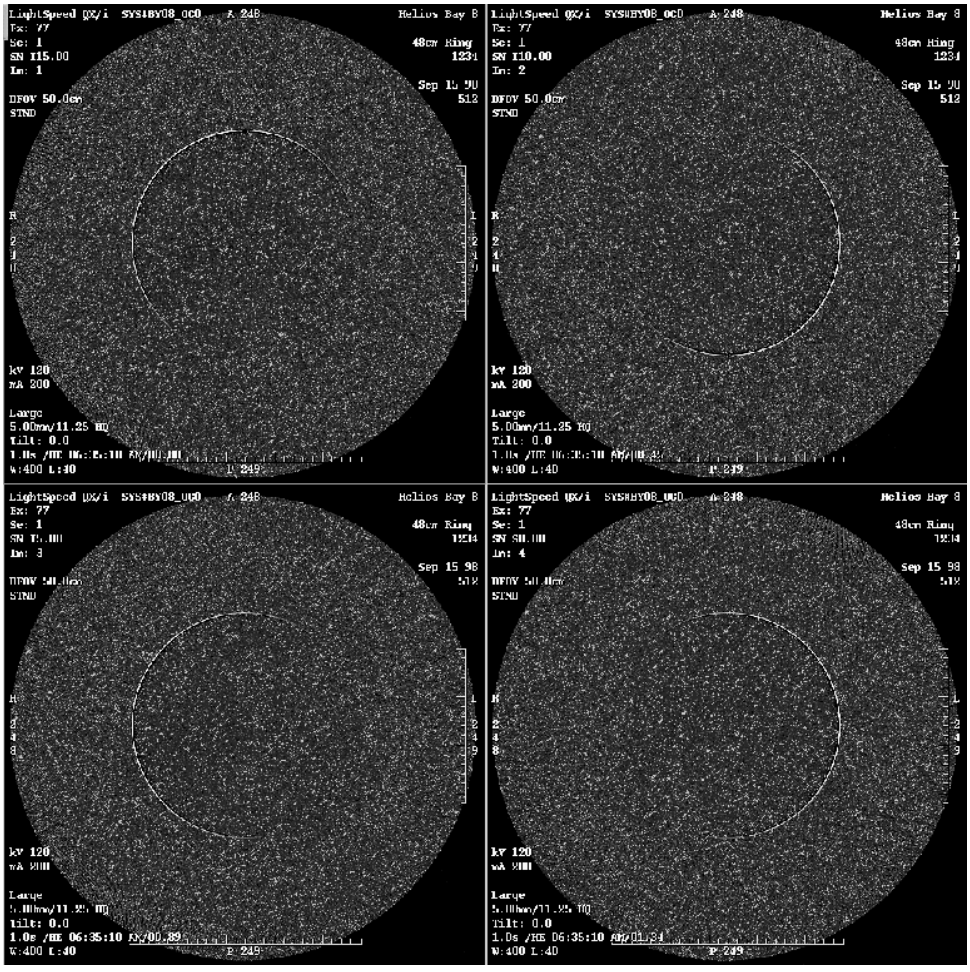

Figure 11-15 Example of Bad Channel in Helical Image Series

3.2 Image Quality Characteristics & Testing Procedures

3.2.1 What to Check for IQ

LightSpeed Plus uses 16 rows of detectors with 4 rows of output, which produces up to four images at one rotation. LightSpeed also utilizes data from all four detectors in helical reconstruction by using different weighting schemes to produce better quality helical images. LightSpeed is also designed to perform longer helical scans at lower mAs. Because of the differences, when checking the image quality (IQ), we need to pay attention to those artifacts/appearance that are unique to the LightSpeed scanner. The following are some of the examples:

1.) Ring/band artifacts may appear as partial or non-uniform ring/band in LightSpeed helical images. When this happens, axial scans may need to be taken to localize the bad DAS channel(s) or detectors.

2.) If artifacts happen in images of one of the outer rows, it may indicate a misalignment of beam in Z-direction (BOW). Again, axial scans may need to be taken to further isolate the problems if the problems happened in the helical images.

3.) LightSpeed uses 16 detectors that cover more space in Z-direction than CT/i. When use thicker slice configurations (5mm/4i), axial images made by the two outer rows are more susceptible to cone beam artifact. An example of a cone beam artifact would be shading off a rib into the liver. Also the use of peristaltic correction can increase the cone beam effect. With our current release, the peristaltic option is turned off for the two thicker axial slice configurations (3.75mm/4i and 5mm/4i). The use of thinner slice configurations (2.5mm/4i and 1.25mm/4i) reduces cone beam artifact. Also, helical mode will help reducing cone beam artifact, with HQ mode having less cone beam artifact that HS mode.

Specifically, the IQ checks may include the following:

1.) Alignment

   a.) MTF with GE Performance phantom, both axial and helical images, comparing with spec.

   b.) Aliasing test, both cold and hot.

   c.) Z-Beam motion.

2.) Noise/Artifacts

   a.) Noise measurement with 20 cm water phantom, comparing with spec.

   b.) Cone beam artifact.

3.) Clever DAS Gain - Confirm that the DAS gains used in the patient scans match those in the cals.

4.) Microphonics - Check image quality (lack of rings, streak and/or center artifacts).

5.) CT Number Uniformity - Check both water and poly phantoms' CT number uniformity, comparing with spec.

3.2.2 How to Check Image Quality

For artifact definitions and numerical measurements, see Installation Manual. For Image Troubleshooting, see Installation Manual. However, if artifacts happened in helical images, take axial scans to further isolate the problems.

3.2.2.1 Alignment

A.) MTF - Values should be similar to those of CT/i.

- Phantom: GE performance phantom (if available). The wire section of the GE performance phantom is not thick enough to have 2 10mm thick images. Two scans need to be done to verify both sides (2A1A and 1B2B) of the detector.

- Data Collection:
  1.) Center the phantom in x-y direction.
  2.) Landmark (in z-direction) at the center of the wire.
  3.) Take scans per Table 11-14.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/440	10mm/2i	Ax/0.8sec	25cm/std. 10cm/edge	S0 - S10	2	0	@S0
small	120/440	10mm/2i	Ax/0.8sec	25cm/std. 10cm/edge	I10 - S0	2	0	@S0
small	120/130	10mm/2i	Ax/2.0sec	25cm/std. 10cm/edge	S0 - S10	2	0	@S0
small	120/130	10mm/2i	Ax/2.0sec	25cm/std. 10cm/edge	I10 - S0	2	0	@S0
small	120/440	5mm/ 7.5mm/ sec	HQ 1sec	25cm/std. 10cm/edge	I5 - S5	4	0	@S0

Table 11-14 Alignment Scan Settings

- Data Analysis: Use the “Image Resolution” button in the “Image Analysis” tool kit to measure system MTF, compare with spec. Use images at S0.

B.) Aliasing - Check ISO alignment, and check if hot ISO was executed correctly.

- Phantom: GE QA phantom, section No. 1.
- Data Collection:
  1.) Fastcal 120 kV, head bowtie.
  2.) Let tube cool 30 minutes after last fastcal or scanning.
  3.) Center the GE QA phantom and take scans per Table 11-15.
  4.) Take heating scans using the protocol for QOEC tube heating.
  5.) Take scans in (4) again.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/200	2.5mm/4i	Ax/1sec	12.8cm/bone	I3.8 - S3.7	1	0	all
small	120/210	2.5mm/4i	Ax/1sec	12.8cm/bone	I3.8 - S3.7	1	0	all

Table 11-15 Aliasing Scan Settings

- Data Analysis: Inspect images visually. Both cold and hot tube images should be lack of aliasing artifacts.

C.) Z-Beam Motion - If artifacts happened in one of the outer rows, it may suggest that the BOW is not aligned correctly.

- Phantom: GE QA Phantom
- Data Collection:
  1.) Fastcal 120kV, head Bowtie
  2.) Let tube cool 1 hour after last fastcal or scanning

3.) Center the QA phantom water section, take scans per Table 11-16.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/200	5mm/4I	Ax/1sec	25cm/std.	I7.5 - S7.5	1	0	all
small	120/100	5mm/4I	Ax/4sec	25cm/std.	I7.5 - S7.5	1	0	all
small	120/200	1.25mm/4I	Ax/1sec	25cm/std.	I1.9 - S1.8	1	0	all
small	120/100	1.25mm/4I	Ax/4sec	25cm/std.	I1.9 - S1.8	1	0	all

Table 11-16 Beam Motion Scan Settings

4.) Scan a series of 30 scans at 4sec with 4sec ISD per Table 11-17.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/200	5mm/4i	Ax/4sec	25cm/std.	I7.5 - S7.5	30	0	None

Table 11-17 Scan Settings (4sec ISD)

5.) Repeat scans in (4) again.

Data Analysis: Check images visually, pay attention to the two outer rows. No failing ring and/or band artifacts should occur

3.2.2.2 Noise

Image noise should meet the spec.

- Phantom: GE QA phantom.
- Data Collection:

1.) Fastcal, 120kV, Head Bowtie.

2.) Center the QA phantom water section, and take scans per Table 11-18.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/260	10mm/2i	Ax/1sec	25cm/std.	I5 - S5	1	0	all
small	120/190	10mm/ 15mm/sec	HE-HQ 1sec	25cm/std.	I10 - S10	2	0	@S0

Table 11-18 Noise Scan Settings

Data Analysis: Place ROI in the center and measure image noise (standard deviation). The spec is 2.7 < Stdv < 3.3 for both axial and helical scans at the above techniques with peristaltic off.

3.2.2.3 Cone Beam Artifact

An example of a cone beam artifact would be shading off a rib into the liver. The greater the cone angle (slice thickness in Z-direction), the more severe the cone beam artifact. Cone beam artifact is typically more pronounced in the images from the two outer rows, where the POR is not as accurate as in the inner rows, especially when using thicker slices. Images obtained using thinner slice configurations should improve image quality in terms of cone beam artifact. Helical reconstruction uses all four detector outputs to minimize cone beam artifacts.

3.2.2.4 Clever DAS Gain

LightSpeed uses a multiple DAS gain scheme to reduce the low signal image noise. For body bowtie, scan techniques (kV/Collimation/Spot Size) are further divided into different mA ranges

based on the detector collimation. For example, for the technique of 120kV/bbt/4x500/LS we have three different mA ranges:

- 210 - 240 mA (gain 17)
- 250 - 300 mA (gain 21)
- 310 - 440 mA (gain 31).

Artifacts (ring, band and center spot) may be caused by a failure of a DAS channel at one of the gains but not all of them. I.E. an image artifact at a certain mA range but not others. Run DAS check to identify or exclude DAS problems.

140KV/380MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	380 (250 - 380)	31	1.19 (lockout @320mA)
4x500	240 (180 - 240)	24	0.97
4x375	380 (250 - 380)	29	0.95
4x375	240 (180 - 240)	18	0.96
4x250	380 (250 - 380)	19	0.96
4x250	240 (180 - 240)	13	0.92
4x125	380 (180 - 380)	10	0.94

Table 11-19 DAS Gains, Body Filter, Large Spot (140kV/380mA)

120KV/440MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	440 (310 - 440)	31	0.96
4x500	300 (250 - 300)	21	0.96
4x500	240 (210 - 240)	17	0.94
4x375	440 (310 - 440)	24	0.94
4x375	300 (250 - 300)	16	0.95
4x375	240 (210 - 240)	13	0.97
4x250	440 (310 - 440)	16	0.92
4x250	300 (210 - 300)	11	0.94
4x125	440 (280 - 440)	8	0.96
4x125	270 (210 - 270)	5	0.95

Table 11-20 DAS Gains, Body Filter, Large Spot (120kV/440mA)

100KV/420MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	420 (250 - 420)	19	0.95
4x375	420 (250 - 420)	15	0.94
4x250	420 (250 - 420)	10	0.94
4x125	420 (250 - 420)	5	0.93

Table 11-21 DAS Gains, Body Filter, Large Spot (100kV/420mA)

80KV/400MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	400 (310 - 400)	9	0.98
4x375	400 (310 - 400)	7	0.96
4x250	400 (310 - 400)	5	0.90
4x125	400 (310 - 400)	3	0.73

Table 11-22 DAS Gains, Body Filter, Large Spot (80kV/400mA)

140KV/170MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	170 (130 - 170)	17	0.95
4x500	120 (10 - 120)	13	0.91
4x375	170 (120 - 170)	13	0.97
4x375	110 (10 - 110)	9	0.91
4x250	170 (120 - 170)	9	0.94
4x250	110 (10 - 110)	6	0.91
4x125	170 (10 - 170)	5	0.85

Table 11-23 DAS Gains, Body Filter, Small Spot (140kV/170mA)

120KV/200MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	200 (150 - 200)	14	0.98
4x500	140 (90 - 140)	10	0.96
4x500	80 (10 - 80)	6	0.92
4x375	200 (170 - 200)	11	0.96
4x375	160 (100 -160)	9	0.94
4x375	90 (10 - 90)	5	0.96
4x250	200 (170 -200)	8	0.87
4x250	160 (10 - 160)	6	0.93
4x125	200 (10 - 200)	4	0.88

Table 11-24 DAS Gains, Body Filter, Small Spot (120kV/200mA)

100KV/240MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	240 (10 - 240)	11	0.92
4x375	240 (10 - 240)	8	0.96
4x250	240 (10 - 240)	6	0.86
4x125	240 (10 - 240)	3	0.85

Table 11-25 DAS Gains, Body Filter, Small Spot (100kV/240mA)

80KV/300MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	300 (240 - 300)	7	0.87
4x500	230 (10 - 230)	5	0.94
4x375	300 (10 - 300)	5	0.90
4x250	300 (10 - 300)	4	0.76
4x125	300 (10 - 300)	3	0.48

Table 11-26 DAS Gains, Body Filter, Small Spot (80kV/300mA)

3.2.2.5 Microphonics

Scan phantom at low signal level to test insensitivity of the DAS, Detector, and interconnect system to noise generated by vibration sources. Sources of vibration could be gantry rotation, tube rotor, fans pumps, etc.

- Phantom: 48cm Poly phantom
- Data collection:

  1.) Fastcal, 120 kV, Body Bowtie

  2.) Center 48cm poly phantom, and take scans per Table 11-27.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
large	120/200	5mm/4i	Ax/1sec	48cm/std	I1.9 - S1.8	30	0	all

Table 11-27 Microphonics Scan Settings

- Data Analysis: Images should have no visible rings/bands, streak and center artifacts

3.2.2.6 CT Number Uniformity

CT number uniformity should be similar to CT/i.

- Phantom: GE QA, 35cm Poly and 48 Poly phantoms.
- Data Collection: Perform 1X series scans.
- Data Analysis: Use the “Series Means” button in the “Image Analysis” tool kit to analyze the CT number uniformity.

3.3 Artifacts Caused by Collimator Grease

Image Artifacts have been generated and reported on some Lightspeed Plus systems due to the contamination of the bowtie and the primary copper filter. This contamination is from the lubricating grease used on the filter positioning drive screw assembly.

The following information may apply in general to all 46-296300G5, 2214768, 2214768-2 and 2214768-3 Collimators.

3.3.1 Inspection Process

The inspection takes less than 5 minutes. It consists of simply examining the Copper primary filter.

3.3.1.1 Required Tool

Bright Flashlight

3.3.1.2 General Inspection Procedure

1.) Remove Mylar Scan Window

2.) Launch Diagnostic Data Collection, DDC, from the Service Desktop.

a.) Select DIAGNOSTICS.

b.) Select DIAGNOSTIC DATA COLLECTION.

c.) Select POSITION TUBE.

d.) Enter **180** and execute.

e.) Select STATIC X-RAY OFF.

i.) Filter AIR.

ii.) Slice Collimation ***Largest Aperture***, 4 x 5.00 for example.

f.) Select ACCEPT RX.

3.) Using a flashlight, inspect the primary copper filter by looking down into the collimator output port. See Figure 11-16.

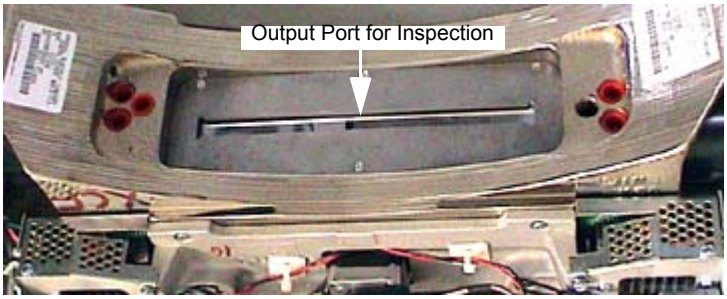

Figure 11-16 Collimator Output Port

Comment: *The copper filter should be clean, dent and scratch free. Discoloration is acceptable.*

Figure 11-17 Extremely Contaminated Copper Filter

If contamination is visible, proceed to Cleaning Process, below.

3.3.2 Cleaning Process

This procedure details the steps necessary to remove the contamination without removing the X-Ray Tube. The entire process will take approximately 3 hours. Tube/Collimator Alignments do not need to be performed. If you wish, you can check the alignments after completing the cleaning process. Any adjustments will require a complete Detailed Phantom Calibration.

Note: If you are at this step during a tube change you must perform a complete Tube Alignment and Detailed Phantom Calibration.

NOTICE **Do not check tube alignments if contamination is present. You will get false results. Perform Tube Alignment checks only after the contamination has been removed.**

3.3.2.1 Required Tools

- 3 mm Hex key for 3/8” drive
- Phillips #0 screwdriver
- Phillips #2 screwdriver
- Vacuum Cleaner or Tape
- Field Torque Wrench Kit 46-268445G1
- ESD Kit 2220482
- Aero Duster Spray 2226685
- Collimator Cleaning Kit 2339299
  Collimator Cleaning Kit contains the following items:
  - Aero Duster Spray System 2335064
  - Alcohol Pads 46-183039P1
  - 91% pure Alcohol 46-183000P164
  - Cleaning Swabs 2339300
  - Loctite 242 10CC 46-170686P2
  - Service Note T-1449 2339305-100

3.3.2.2 Cleaning Procedure Flowchart

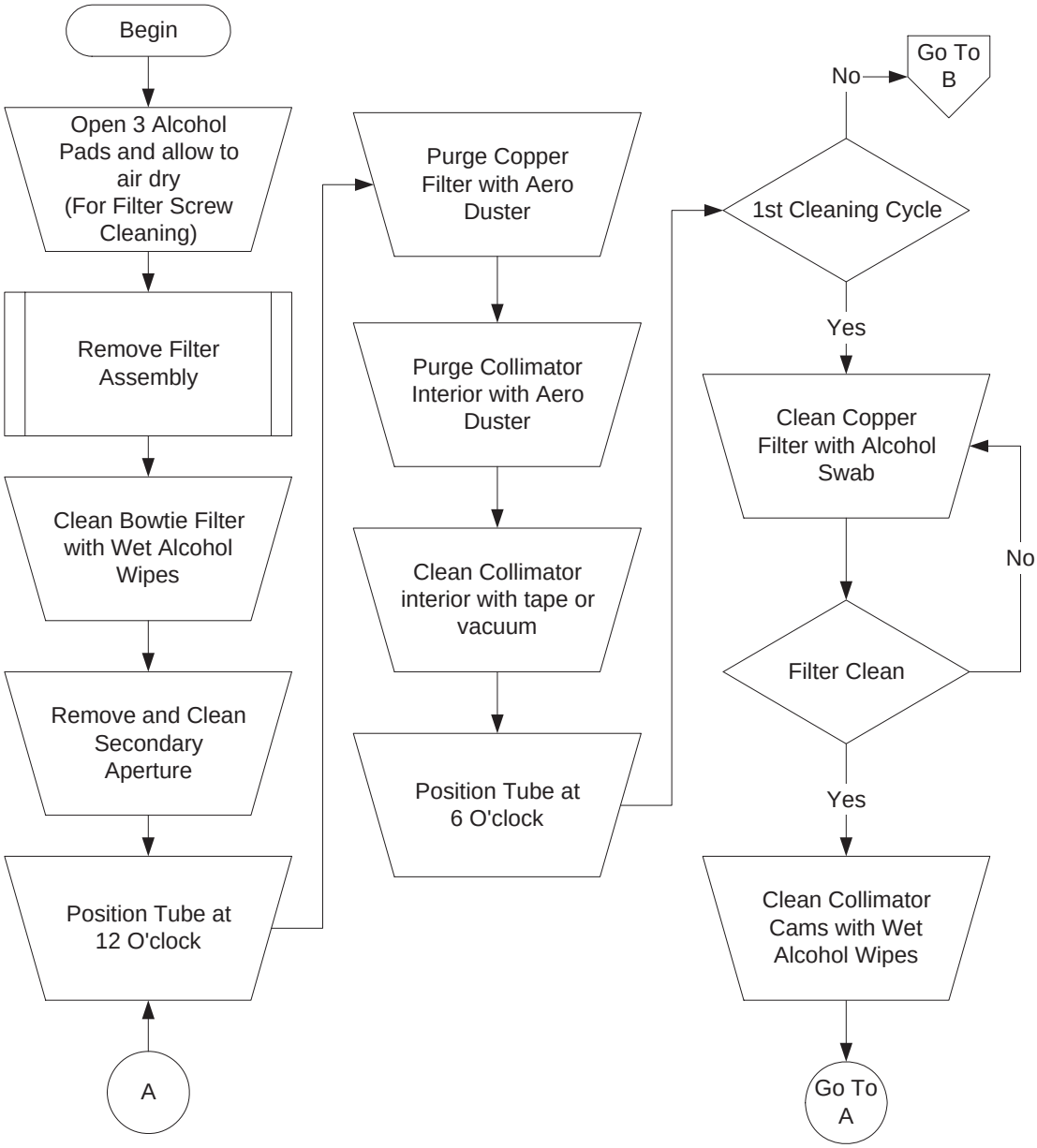

Figure 11-18 Clean Process Flowchart

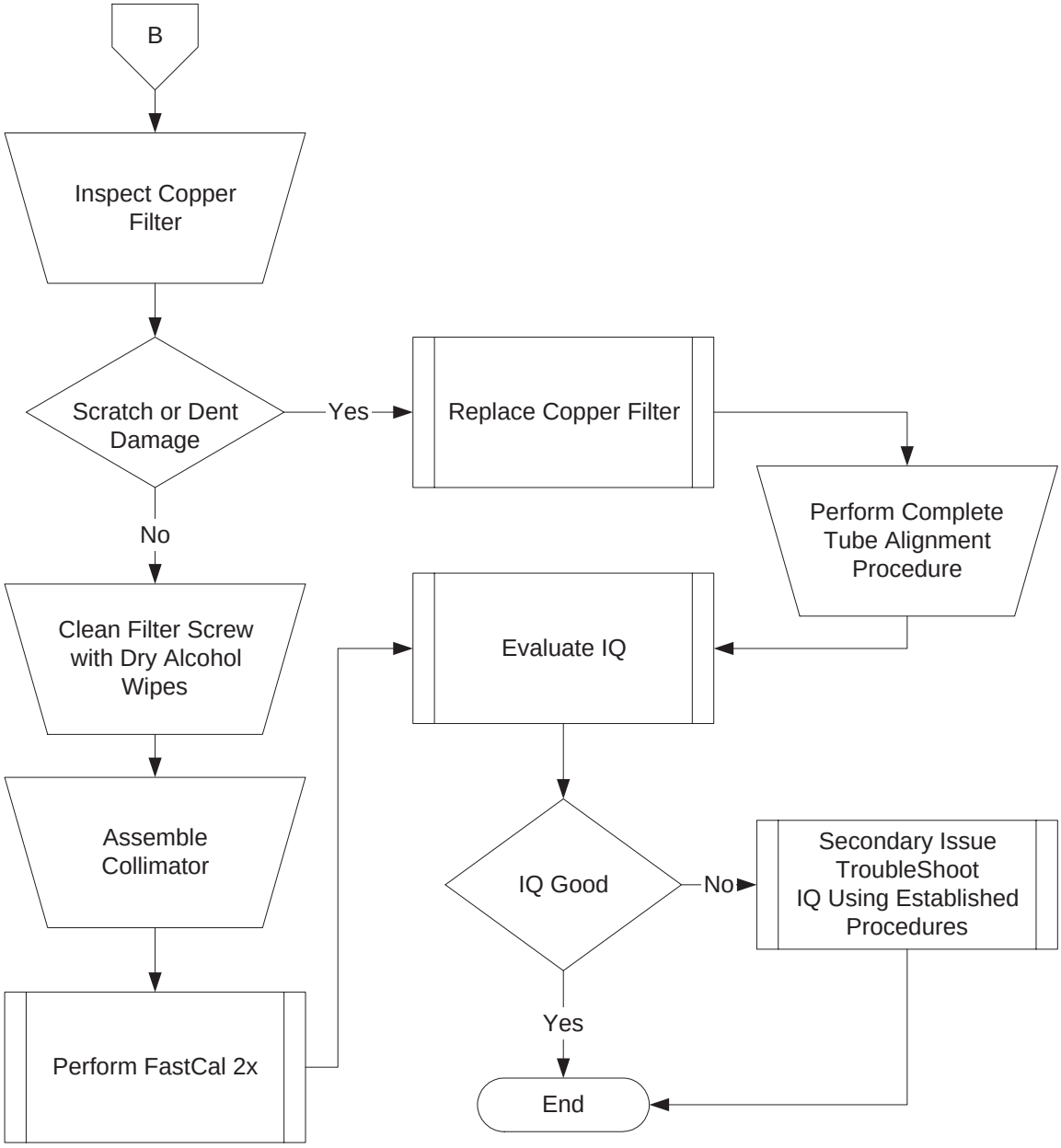

Figure 11-19 Collimator Cleaning Flowchart (continued)

3.3.2.3 Cleaning Procedure Details

1.) Remove the Gantry Covers as needed.

WARNING **RISK OF ELECTRICAL SHOCK. FOLLOW PROPER LOCKOUT/TAGOUT PROCEDURES.**

2.) Perform Gantry Power Lockout/Tagout procedures.

3.) Open three (3) Lint Free Alcohol Pads, unfold and allow to air dry.

4.) Position the gantry with the Collimator at six-o'clock.

5.) Remove Collimator Filter Assembly (see "Filter Assembly," on page 793, for further details).

6.) Clean Bowtie Filter with fresh, wet alcohol pads.
Clean until pads are no longer soiled.

7.) Remove Secondary Aperture and Output Window. See Figure 11-20.

- Take care not to lose the six (6) screws.
- Take care not to damage or nick the lead aperture.

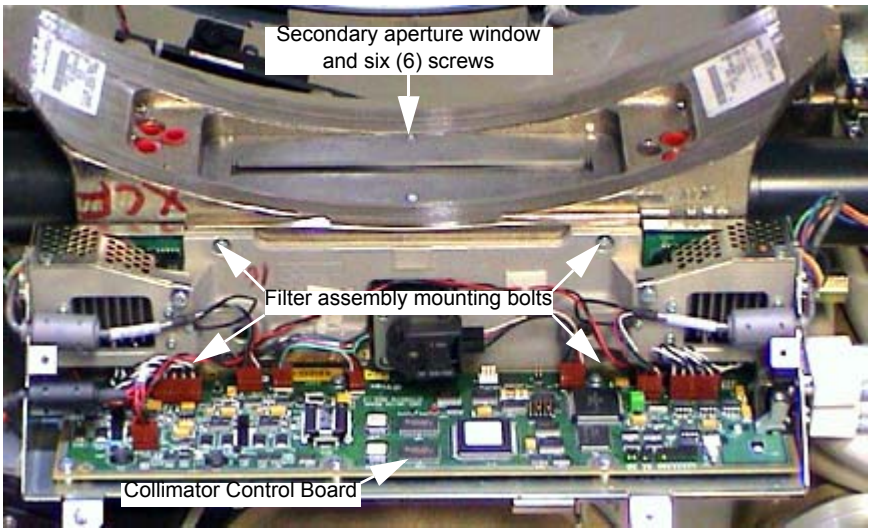

Figure 11-20 Collimator Assembly

a.) Use fresh, wet alcohol pads to clean the window and output port.

b.) Inspect output port and carefully remove any metal or lead that protrudes into the x-ray beam path.

8.) Rotate gantry so collimator is at 6 o'clock. See Figure 11-21.

a.) Using the Aero Duster and nozzle, blow out debris from the Copper Filter chamber.

b.) Using the Aero Duster and nozzle, blow out debris from the Collimator Interior.

c.) Clean collimator interior with vacuum cleaner or tape to remove any attached grease to metal particles.

⚠ **NOTICE**
Potential equipment damage

Do not use the metal end of the vacuum hose. This can scratch the collimator cams. Use non-metallic accessories supplied with the vacuum cleaner.

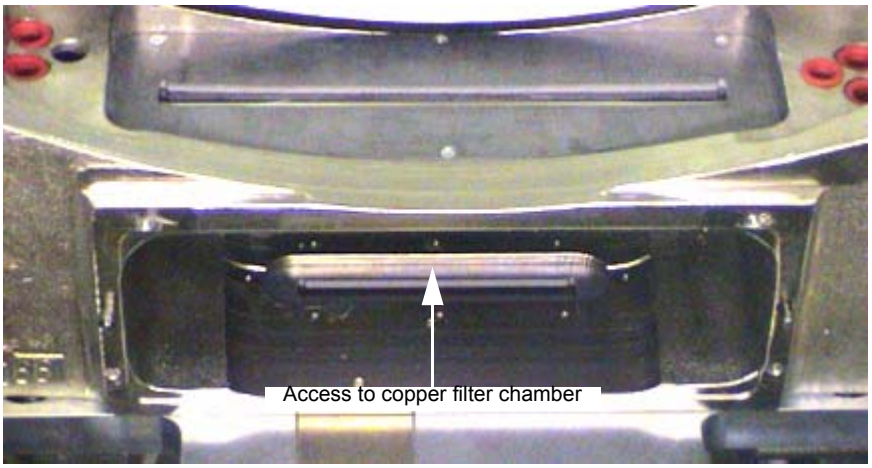

Figure 11-21 Cleaning Collimator Interior

9.) Rotate gantry so collimator is at 12 o'clock and repeat step 8 cleaning.

10.) Rotate gantry so collimator is at 6 o'clock and repeat step 8 cleaning.
This is to ensure all loose particles are removed from Copper Filter Chamber.

11.) Use clean swab, wet with alcohol, to clean the Copper Filter. See Figure 11-22.

a.) Cut swab to 7.5 cm length (3 inches).

b.) Wet lint-free foam head with alcohol. Squeeze excess alcohol from head.

NOTICE
Potential equipment damage

Too much alcohol can dissolve glue that secures lead lining in place. This type of damage will result in intermittent artifacts and require collimator replacement.

c.) Carefully insert swab into copper filter chamber, and wipe filter clean.

NOTICE
Potential equipment damage

Use extreme to care not dent or scratch the copper filter. Such damage will require replacement of the copper filter, resulting in a complete tube change procedure.

d.) Remove swab and inspect copper filter. Repeat with clean swabs as necessary until clean.

Figure 11-22 Swabs, Pure Alcohol and Alcohol Pads

12.) Using fresh, wet alcohol pads, clean the Collimator Cams.
Rotate the Cams using the motor shaft on each side of the collimator.

NOTICE
Potential equipment damage

Use care to not scratch or bend the cams. Do not allow cams to contact each other while rotating by hand. Damage can result in tracking errors or excessive patient dose. This would require collimator replacement.

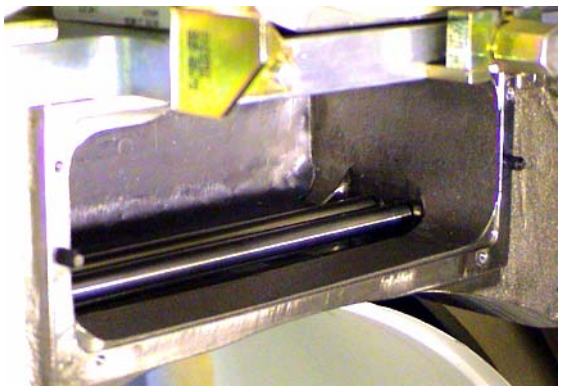

Figure 11-23 Cleaning Collimator Cams

13.) Using the dry lint free alcohol pads from step 3, clean the Bowtie Filter assembly positioning screw. See Figure 11-24.

a.) Remove only excess grease from the drive nut.

* Remove only accumulated grease that may dislodge.
* The grease should lightly coat the screw thread, not fill it.

b.) Position the filter using a flat blade screwdriver.

⚠ **NOTICE**
Potential equipment damage

Do not remove filter off of the positioning drive screw.
Do not crush home switch with filter assembly.
Either action will require replacement of the Filter Assembly.

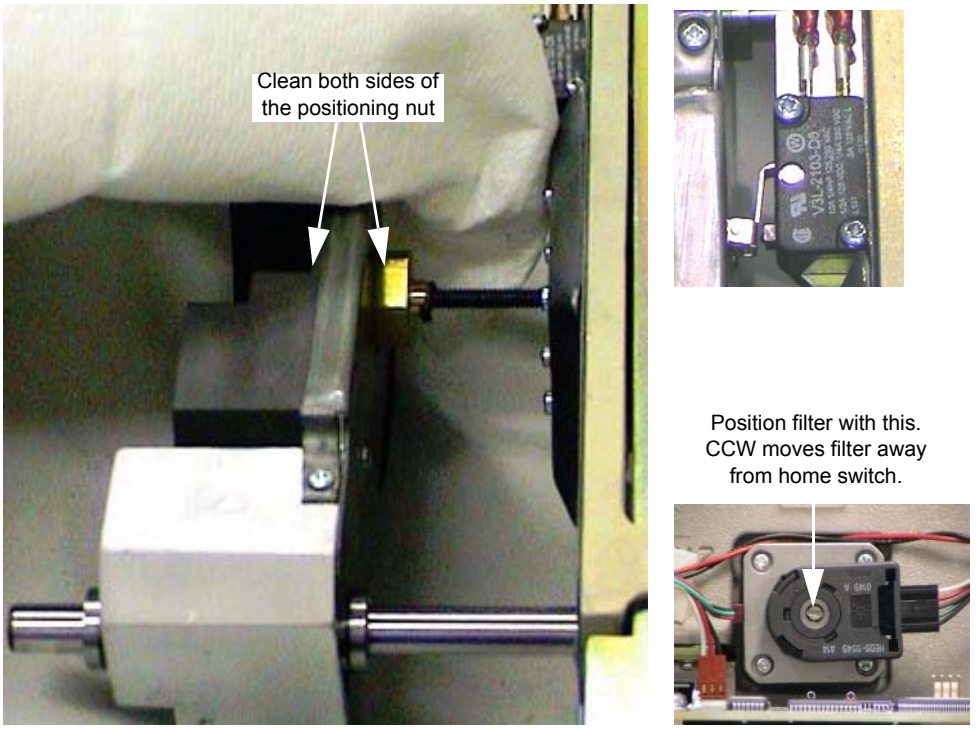

Figure 11-24 Filter Position Screw

14.) Assemble collimator. (Refer to Collimator Filter Assembly replacement procedure, starting on page 793, for details.)

a.) Four (4) Filter Assembly bolts. Torque to 3 ± 0.3 N-m (26.5 lbf-in).

b.) Six (6) Secondary Aperture screws.

Use Loctite 242. Take care not to damage the lead window.

15.) Restore gantry power and perform a hardware reset.

3.3.3 IQ Evaluation

NOTICE **Allow DAS and Detector to warm up for 1 hour.**

1.) Perform Fastcal, twice.
2.) Perform IQ or 1x Image Series, per Section 5.0 of this chapter (beginning on page 913).
3.) Evaluate Image Quality and ensure system meets specifications both numerical and visually.
Perform Ct Number Adjustment if necessary.

3.3.4 Additional Information

Image Quality Testing may fail for one or more of the following reasons:

- Tube Alignments were performed with contamination present.
  - Check and adjust tube alignments as necessary.
  - Perform Detailed Phantom Calibrations and CT Number Adjustment.
- Detailed Calibrations were performed with contamination present.
  Reload Phantom Calibrations from Saved State and perform Fastcal twice or perform Detailed Phantom Calibrations and CT Number Adjustment.
- Beam Obstruction may be present on Tube Output Port or chamber between Tube and Copper Filter.
  Remove Tube and Inspect this area for beam obstructions. Clean or replace parts as needed.
- Component failure within the Image Chain in addition to the collimator contamination.
  Troubleshoot accordingly.

Section 4.0
Detector Artifact Specification

4.1 Scope

The purpose of this document is to specify image artifact tolerances and measurement criteria for those artifacts seen in test phantoms that otherwise pass the LightSpeed Plus Image Performance Specification but contain visually objectionable artifacts.

4.2 Constraints

The system must meet all the conditional requirements and applicable performance document requirements as called out in the LightSpeed Plus Image Performance Specification. Each row of the detector must pass on its own right. Protocols must be consistent so that you do not confuse the rows. Scans should be done in the head first orientation from I to S. This ensures that if images are displayed 4 at a time, row 2a will be in the upper left hand corner, row 1a in upper right, row 1b in lower left, and row 2b in lower right.

4.3 Application

This document applies to those images obtained while performing scans in accordance with the applicable image performance specification. Unless otherwise specified, all artifact criteria contained in this document shall apply to standard algorithm 512x512 image reconstructions.

EXCEPTIONS

The following phantoms are excluded from the artifact requirements, because they are designed to test specific performance parameters, and are not representative of anatomy:

- QA phantom - High contrast resolution bar pattern section.
- QA phantom - Low contrast resolution hole pattern section.

4.4 System Artifacts

4.4.1 Band

DEFINITION

Dark or light circles or arcs concentric with the axis of rotation. Bands are defined as being 3 pixels wide or wider, but may have poorly defined edges. Width is the main distinguishing feature between bands and rings.

SPECIFICATION APPLICATION

Band specs apply to all Standard reconstruction images. They are evaluated by the following:

$$\left|\overline{X}_b - \overline{X}_r\right| \leq T$$

where:

$\overline{X}_b$ is the mean value of the band measured as an arc of no less than 3 pixels in width and no less than 51 pixels area,

$\overline{X}_r$ is the mean value of a reference area measured as the mean value of two arcs measured on either side of the band—each arc shall be no less than 51 pixels in area—and

T is the threshold value for the phantom as defined in “threshold values” section.

MEASUREMENT METHOD

The preferred method of measurement is using the "IABAND" program. Measurement is to be performed on the most intense part of the band. The band measurement should be the entire width of the band.

When near the center or edge of an image, one ROI value may be used to define $\overline{X}_r$. If this is done, the reference area should be at least 102 pixels. Measurements may be taken at any radius and at any angle.

THRESHOLD VALUES

A band is considered a failure for any value greater than the following over the indicated radius:

PHANTOM	4X500	4X375	4X250	4X125	RADIUS
48/L	8.0	8.0	8.0	8.0	0 - 23.5 cm
35/L	2.5	2.5	2.5	2.5	0 - 14.0 cm
35/L	3.5	3.5	3.5	3.5	14.0 - 15.0 cm
35/L	12	12	12	12	> 15.0 cm
20/S	2.8	n/a	2.8	2.8	0 - 8.5 cm
5/S, 65° Slope, BIS, WEQ/WEQ	2.3	2.3	2.3	2.3	0 - 2.0 cm
5/S, 65° Slope, BIS, WEQ/WEQ	2.6	2.6	2.6	2.6	2.0 - 5.1 cm
Note: When using the IA band program, be sure to ignore the outer reference area if its outside 15.0 cm					

Table 11-28 Threshold Values - Band Specifications

Note: When using the IA band program, be sure to ignore the outer reference area if outside of 15.0 cm.

Addendum: For 35/L, if beyond 15.0cm the band is greater than 3.5 counts, scan 4 slices of the muscle fat phantom at the 35/L technique. The phantom must be off centered such that portions of both the muscle and fat regions will be located at the radius of the band in question. Use an ISD of 1 second (or 5 seconds) so that the start angle will vary by 90 degrees from scan to scan. If there is no banding visible at the same radius as the 35/L banding, the 35/L scans are considered to be passing.

For 20/S, if beyond 8.5cm the band is greater than 2.8 counts, scan 4 slices of 25cm phantom on small cal at the same technique that the 20cm was failing. The band should be less than 4 counts on the 25cm phantom.

ALTERNATIVE MEASUREMENT METHOD

Since all bands are not created equal, this method should be used for un usually wide bands, unusually narrow bands, bands that are surrounded by bands of opposing colors, or other cases where the IA band program will give unpredictable results. It can also be used to pass 48cm, 35cm, and 25cm/L images that fail the IA band program.

An alternative to the IA band program that can be performed in the standard display program and allows extra flexibility for the regions of interest is to define the band area or reference area by depositing cursors (circular to outline the inner and outer boundaries of the area, and line cursors to define the upper and lower (or left and right) boundaries of the area. Circular cursors shall be centered at the center of reconstruction. Line cursors shall cross at the center of the reconstruction circle. The reference area(s) shall be bounded by the same line cursors as the band area. All other requirements of section 4.1 remain as previously stated.

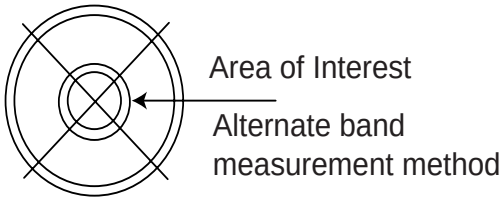

Figure 11-25 Alternative Band Measurement

FAILURE RATE

80% of all slices within a run must meet this specification.

4.4.2 Center Smudge

DEFINITION

Dark or light area of 169 pixels (13 x 13 box) near the center of scan FOV having poorly defined edges. The reference area around the smudge is measured by the ROI of a 41 x 41 ellipse and does not include the smudge area.

SPECIFICATION APPLICATION

Smudge specs shall apply to Standard reconstruction images as specified in the “threshold values” section. It shall be evaluated by the following:

$$\left| AV\{\overline{X}_s - \overline{X}_r\} \right| \le T_s$$

where:

$\overline{X}_s$ is the mean value of the smudge area,

$\overline{X}_r$ is the mean value of a 41 x 41 ellipse and excludes the smudge area,

$AV\{\ \}$ is the Average Threshold value for a minimum of 4 slices on a given row, and

T_S is the threshold value.

MEASUREMENT METHOD

Perform the measurement of the smudge area by depositing a centered circular cursor directly over the most intense portion of the smudge, place the crosshair inside the smudge area and do an ROI. Perform the measurement of the reference area by depositing a circular cursor positioned such that its center coincides with the center of the smudge area, then placing the crosshair cursor inside the reference but outside of the smudge area, do an ROI.

- Smudge cursor size = 13 x 13 ellipse
- Reference cursor size = 41 x 41 ellipse.

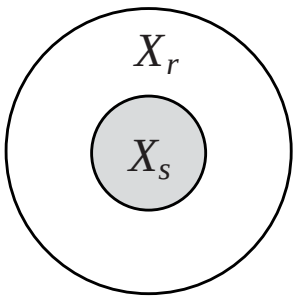

Figure 11-26 Center Smudge Measurement

THRESHOLD VALUES

Smudge specs shall be evaluated using the following threshold values:

PHANTOM	4X500	4X375	4X250	4X125
48/L	14.0	14.0	14.0	14.0
35/L	2.2	2.2	2.2	4.0
20/S	2.2	2.2	2.2	4.0
20/L	3.0	3.0	3.0	4.0
5/S, 65° Slope, BIS, WEQ/WEQ	3.5	3.5	3.5	4.0

Table 11-29 Threshold Values - Smudge Specifications

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis smudge program.

4.4.3 Center Artifact

DEFINITION

A sharply defined small area (usually the center 4 pixels) having mean pixel values that differ more than a threshold value (see below) from the reference area. The average of a four pixel box that includes at least one of the four center pixels must be greater than the specified threshold value to be considered a failure.

SPECIFICATION APPLICATION

The average of the 4 center pixels or the average of any four pixel box that includes any of the four center pixels must be more than 3.5 x σ_r (σ_r = the standard deviation) limits to be considered a center artifact. See thresh old values section.

MEASUREMENT METHOD

Reference area shall be a 41 x 41 pixel box at the center of the image. $\overline{X}_r$ is the mean of the box, and σ_r is the standard deviation of the same box. $\overline{X}_a$ is the mean of any 4 pixel box that includes one or more of the center 4 pixels.

THRESHOLD VALUES

Each of the 4 pixel boxes that includes any one or more of the 4 center pixels must have a mean value, AVXr, within the following limits:

	4X500	4X375	4X250	4X125
35/L	$\overline{X}_r \pm 3.5\sigma_r$	n/a	$\overline{X}_r \pm 3.5\sigma_r$	$\overline{X}_r \pm 3.5\sigma_r$
20/S and 20/L	$\overline{X}_r \pm 3.5\sigma_r$	n/a	$\overline{X}_r \pm 3.5\sigma_r$	$\overline{X}_r \pm 3.5\sigma_r$

Table 11-30 Threshold Values - Center Artifact

where:

$\overline{X}_r$ is the mean value of the 41 x 41 pixel box and

σ_r is the standard deviation of the 41 x 41 pixel box.

AVX is the average of Xr of a minimum of 4 images from the same detector row.

This specification does not apply to phantom and cals not noted in the table above.

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis center artifact program.

4.4.4 Rings - 48cm Phantoms

DEFINITION

- A dark or light circle or arc approximately 3 or less pixels in width. Rings are typically one pixel wide.
- 48/L images: the ring must be greater than or equal to 30 degrees of ARC and have a minimum diameter of no smaller than 1 cm. The ring must also be repeatable at the same radius and image quadrant.

SPECIFICATION APPLICATION

This specification applies to standard reconstruction 48cm and 42cm phantoms.

MEASUREMENT METHOD

Measure the ring using ROI by placing two elliptical arcs surrounding the ring and taking care to include only pixels that are on the ring. The image may be magnified to accommodate this measurement. Next, measure the background mean CT number of the non-magnified image by using a 2cm x 2cm box ROI directly centered about the ring or partial ring.

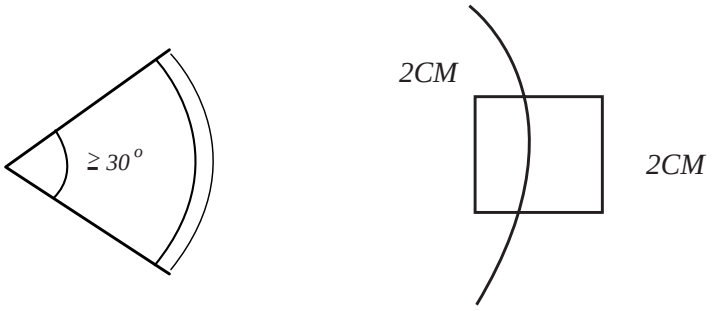

Figure 11-27 Ring Measurement - 48cm and 42cm phantoms

THRESHOLD VALUES

$$\left|\overline{X}_r - \overline{X}_a\right| \leq T$$

where:

$\overline{X}_r$ is the mean pixel value of the ring, and

$\overline{X}_a$ is the mean pixel value of a 2cm x 2cm reference area, and

T is the threshold value for failure as shown in the table below.

	4X500	4X375	4X250	4X125
48/L	36.0	36.0	n/a	n/a
42/L	15.0	15.0	n/a	n/a

Table 11-31 Threshold Values Failure Specifications (Part 1)

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis ring program, adding 20% to the failure threshold.

FAILURE RATE

80% of all slices within 10 contiguous slices.

4.4.5 Rings - All Other Phantoms

DEFINITION

A dark or light circle or partially closed circle approximately 3 or less pixels in width. Rings are typically one pixel in width.

SPECIFICATION APPLICATION

All images.

MEASUREMENT METHOD

Measure the ring using ROI by placing two elliptical arcs surrounding the ring and taking care to include only pixels that are on the ring. The image may be magnified to accommodate this measurement. Next, measure the background mean CT number of the normal or magnified image by using a 2cm x 2cm box ROI directly centered about the ring or partial ring.

Note:
- For 5" images with tight rings located about the center 4 pixels, magnify the image to fill the whole display screen, then apply the method and criteria described in this section.
- On bone detail images, the ring must be $\geq 180°$ arc.

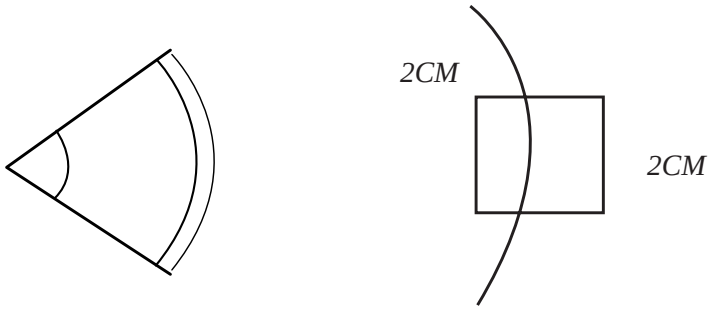

Figure 11-28 Ring Measurement - All other phantoms

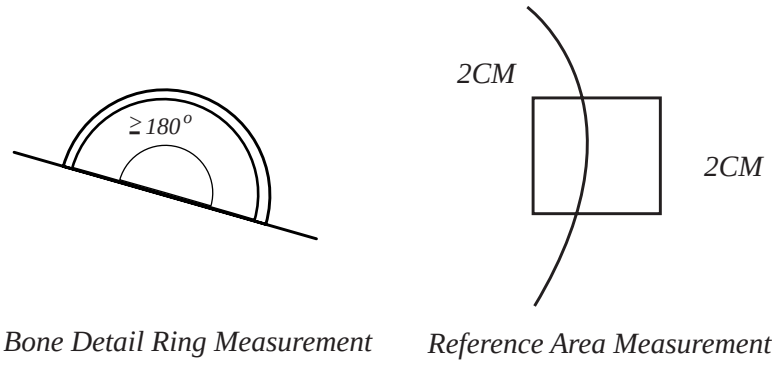

Figure 11-29 Bone Detail Ring Measurement

THRESHOLD VALUES

$|\overline{X}_r - \overline{X}_a| \leq T$

where:

$\overline{X}_r$ is the mean pixel value of the ring, and

$\overline{X}_a$ is the mean pixel value of a 2cm x 2cm reference area, and

T is the threshold value for failure as shown in the table below:

PHANTOM	4X500	4X375	4X250	4X125
35/L	4.8	4.8	4.8	n/a
25/S	4.0	n/a	4.0	4.0
20/S	4.8	4.8	4.8	4.8
5"/S	4.8	4.8	4.8	4.8
65° Slope, BIS, WEQ/WEQ	4.8	4.8	4.8	4.8

Table 11-32 Threshold Values Failure Specifications (Part 2)

ALTERNATIVE MEASUREMENT METHOD

Comment: Reference Only

For reference; may not be available.

Use the Image Analysis ring program, adding 20% to the failure threshold.

FAILURE RATE

No greater than one in 250 slices on a given calibration.

4.4.6 Streaks

DEFINITION

Straight dark or light lines across the images, 3 or less pixels in width. Streaks may be any length.

SPECIFICATION APPLICATION

Streak specs apply to all images.

MEASUREMENT METHOD

Outline the streak by depositing a line cursor on either side of the streak, and bound the ends by depositing a cursor on them. Use ROI inside the streak area. If necessary, magnify the image to accomplish the measurement.

THRESHOLD VALUES

$|\overline{X}_s - \overline{X}_r| \leq 4.0$ counts

where:

$\overline{X}_s$ is the mean value of the streak, and

$\overline{X}_r$ is the mean value of a 41 x 41 pixel reference area, and

ALTERNATIVE MEASUREMENT METHOD

Use the Streak program in Image Analysis.

FAILURE RATE

No more than 1 failing streak out of 50 images.

4.4.7 Clump

DEFINITION

Small light or dark areas at the center of the scan FOV. These must be 3 or more contiguous failing pixels within the center 9x9 pixels. All 3 of the pixels must be on the positive or negative side of the specification to considered a failure.

SPECIFICATION APPLICATION

This specification applies to all 48/L phantom scans.

MEASUREMENT METHOD

Center a 41 x 41 pixel box and determine the mean and standard deviation. Perform a cursor report on a 9x9 pixel box at the center of the image. Search for three or more contiguous pixels that are outside of the limits.

THRESHOLD VALUES

Each pixel in a 9x9 box at the center of the image must be within the following limits:

	4X500	4X375	4X250	4X125
48/L	$\bar{X}_r \pm 3.0\sigma$	$\bar{X}_r \pm 3.0\sigma$	n/a	n/a

Table 11-33 Threshold Values - Clump

where:

$\bar{X}_r$ is the mean value of the 41 x 41 pixel box and

σ_r is the standard deviation of the 41 x 41 pixel box.

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis clump program, making sure to use the proper sigma factor.

FAILURE RATE

80% of all slices within a run must meet this specification.

4.4.8 Center Spot

DEFINITION

Dark or light area near the center of the scan FOV having no defined edges and consisting of up to 25 pixels.

SPECIFICATION APPLICATION

Phantoms: 5", 65º Slope, BIS, and WEQ/WEQ.

MEASUREMENT METHOD

Measure the reference area with a centered 21 x 21 pixel box. Keeping a 5 x 5 box within a centered and deposited 9x9 box (so that the center pixel is always included), search for the 5x5 box with the largest mean value difference from the reference area.

THRESHOLD VALUES

This specifications applied in two parts as follows:

1.) Center spot - The difference in mean values shall be:

$|\overline{X}_s - \overline{X}_r| \leq 3.2$ for 120Kv/10mm and 5mm scans.

$|\overline{X}_s - \overline{X}_r| \leq 3.5$ for 100Kv, 140kV/10mm and 5mm scans, and 80 kV scans.

2.) Max pixel (for white spots only) - A spot is white if it is greater than the surrounding area by:

For 5mm and 10m

$|\overline{X}_s - \overline{X}_r| > 1.5$ for 120 kVp.

$|\overline{X}_s - \overline{X}_r| \geq 1.8$ for 140 kVp, 100kVp.

If the spot is white, the maximum allowable pixel value within the 5x5 box shall be less than a 4 count difference from the reference area.

For 1mm

$|\overline{X}_s - \overline{X}_r| \geq 2.4$ for 120 kVp.

$|\overline{X}_s - \overline{X}_r| \geq 2.9$ for 100 kV, 140kV.

Max pix value = 6.4

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis center spot program.

FAILURE RATE

90% of all slices within a run must meet this specification.

4.5 Clinical Acceptability – Visually Objectionable Artifacts

4.5.1 Artifacts Described within this Document

A system that has a visual artifact described in this document that passes its respective specification shall be considered to be clinically acceptable within the nominal service interval.

4.5.2 Artifacts *Not* Described within this Document

A system that has a visual artifact that does not meet the descriptions of artifacts described in section 4 and determined to be objectionable by Quality Control, shall be brought to the attention of Systems Engineering in order to determine the nature of the artifact. If the system meets the engineering specification and the problem can not be rectified, then Systems Engineering, CT Manufacturing, and CT Applications will jointly take measure to determine the clinical implications of the artifact.

Section 5.0
1X Image Series Outline

Phantom	kVp	mA	Slice	Time	#	# img	CT #	Noise	Unif	MTF	LCD	Ring	Band	Streak	Smudge	Clump	CA
48 Poly	120	340	4x5(4i)	1	4	16	NA	<50	±8.5	NA		*	*	*	*	*	NA
	120	200	4x5(4i)	0.8	4	16	NA	<70	±8.5	NA		*	*	*	*	*	NA
	120	400	4x1.25(4i)	2	4	16	NA	<50	±8.5	NA		*	*	*	*	*	NA
GE	120	440	4x5(2i)	0.8	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
Perfor	120	130	4x5(2i)	2	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
	120	40	4x5(2i)	0.8	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
0.8 sec	120	440	5mm 7.5Q	HE	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
GE QA	120	260	4x5(2i)	1	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
	120	260	4x5(2i)	1	4	4	NA	NA	NA	NA	*	NA	NA	NA	NA	NA	NA
	120	260	4x5(2i)	1	4	8	±3.0	<0.33	±3.0	NA	NA	*	*	*	*	NA	*
	120	200	4x1.25(4i)	2	4	16	±3.0	NA	±3.0	NA	NA	*	*	*	*		
	120	400	4x5(4i)	2	4	16	±3.0	NA	±3.0	NA	NA	*	*	*	*	NA	*
	120	400	4x1.25(4i)	1	4	16	±3.0	NA	±3.0	NA	NA	*	*	*	*	NA	*
lrg SFOV	120	260	4x5(4i)	1	4	16	±6.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
																NA	*
35 Poly	120	400	4x5(4i)	1	4	16	NA	NA	±4.0	NA	NA	*	*	*	*		
	120	200	4x3.75(4i)	3	4	16	NA	<10	±3.0	NA	NA	*	*	*	*	NA	NA
	140	300	4x2.5(4i)	2	4	16	NA	<10	±3.0	NA	NA	*	*	*	*	NA	NA
	120	300	4x1.25(4i)	2	4	16	NA	<17	±3.0	NA	NA	*	*	*	*	NA	NA
																NA	NA
5”	120	240	4x5 (4i)	2	4	16	±5.0	NA	± 4.0	NA	NA	*	*	*	*		
Water	100	200	4x5(4i)	2	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
	120	240	4x1.25(4i)	4	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
	80	170	4x5(4i)	4	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
	140	120	4x5 (4i)	4	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
35cm	120	300	4x2.5(4i)	2	4	16	± 5.0	<25	± 3.0	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA - not applicable
* - see following page for detailed specification

Table 11-34 1X Image Series Outline

ARTIFACT	48CM POLY PHANTOM SPECS	GE QA	35CM POLY	5" WATER
Rings	± 36 cts; 5 mm images only	± 4.8 cts	± 4.8 cts	± 4.8
Clump	< 3.0 sigma; 5 mm images only			
Streaks	± 4.0 cts	± 4.0 cts	± 4.0 cts	± 4.0
Bands	± 8.0 cts (0 to 23.5 cm)	± 2.8 cts (0 to 8.5 cm)	2.5 cts (0-14 cm) 3.5 cts (14-15.8 cm)	2.3 cts (0-2 cm) 2.6 cts (2-5.2 cm)
Smudge	± 14 cts;1.25 mm images only.	± 2.2 cts	2.2 cts	± 3.5 cts
Center Artifact		± 3.5 sigma	± 3.5	

Table 11-35 48 cm Poly Phantom Specs

GE PERFORMANCE PHANTOM

- MTF
  - Small Spot (< 200mA)
    - Standard Algo.
    - 3.8 lp/cm @ 50% Modulation
    - 6.5 lp/cm @ 10% Modulation
  - Large Spot (> 200mA)
    - Standard Algo.
    - 3.8 lp/cm @ 50% Modulation
    - 6.2 lp/cm @ 10% Modulation
- MTF
  - Small Spot (< 200mA)
    - Edge Algo.
    - 8.5 lp/cm @ 50% Modulation
    - 13.0 lp/cm @ 10% Modulation
  - Large Spot (> 200mA)
    - Edge Algo.
    - 7.9 lp/cm @ 50% Modulation
    - 12.1 lp/cm @ 10% Modulation

GE QA PHANTOM

MTF

- Standard Algo.
- MTF 0.65 - 1.0
- Contrast Scale 110 to 130

LCD	CONTRAST FACTOR	# OF HOLES VISIBLE
	2.0 to 3.99	at least 2
	4.0 to 7.99	at least 3
	8.0 to 12.0	at least 4

Table 11-36 GE QA Phantom - LCD

5” WATER PHANTOM

Center Spot

- Max Pixel + 4.0 cts 5mm
  6.4 cts 1.25mm
- Center Spot 5mm only ± 3.2 @ 120kV
  ± 3.5 @ 100, and 140kV

Chapter 12
Tube Replacement

Purpose: This chapter covers the replacement procedure for X-ray tubes. See Figure 12-1 for an overview of this process. The sections within this chapter explain this process.

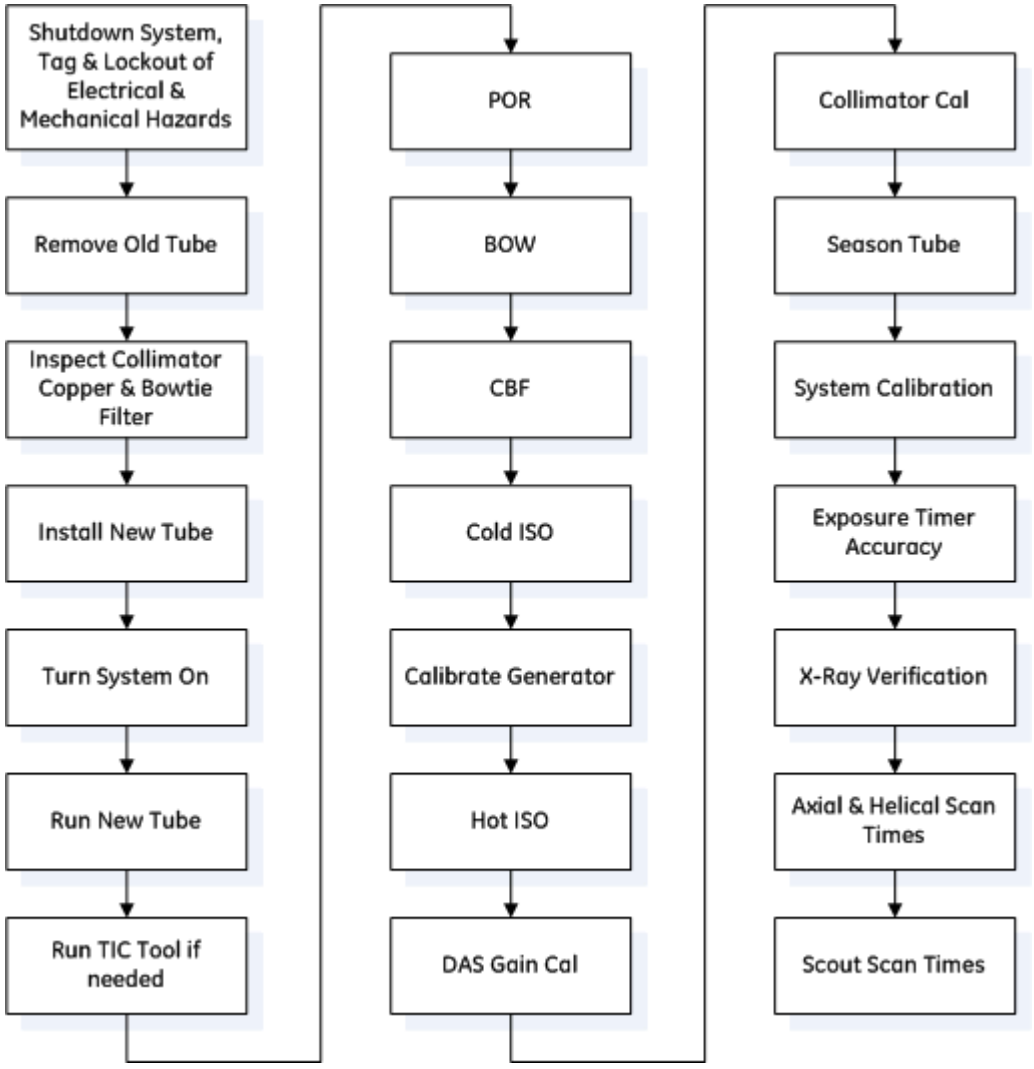

Figure 12-1 Basic Tube Replacement Flow

Section 1.0
Remove Old Tube

Before beginning this procedure, please read the safety information.

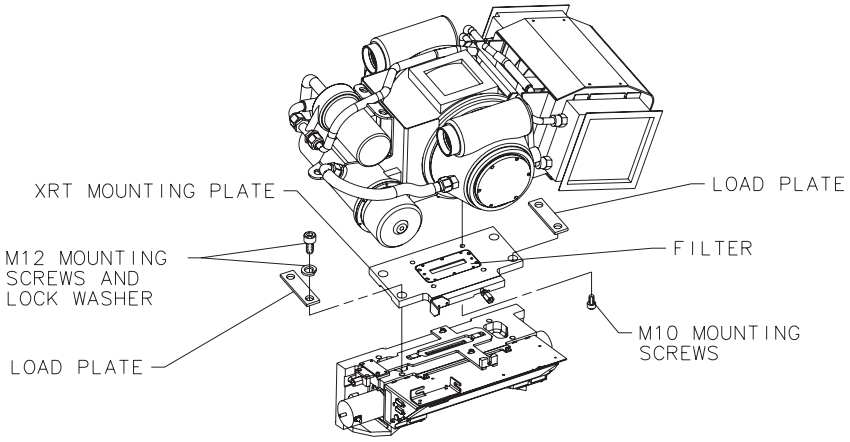

Figure 12-2 Tube Removal Diagram

WARNING **FOLLOW LOCKOUT/TAGOUT PROCEDURES FOR POWER & ROTATIONAL HAZARDS.**

Make sure you engage the locking mechanism before you remove the tube. Failure to lock the gantry could result in injury, should the gantry suddenly move and strike you.

1.) Remove, and set aside, both gantry side covers, top covers, front and rear covers.

2.) Remove the M12 screws from the right front gantry cover mounting bracket, remove and set aside the bracket. Reference Figure 12-3.

NOTICE **It might be necessary to tilt the gantry back to remove the third bolt, which is not normally installed. Remember to tilt the gantry back to zero degrees.**

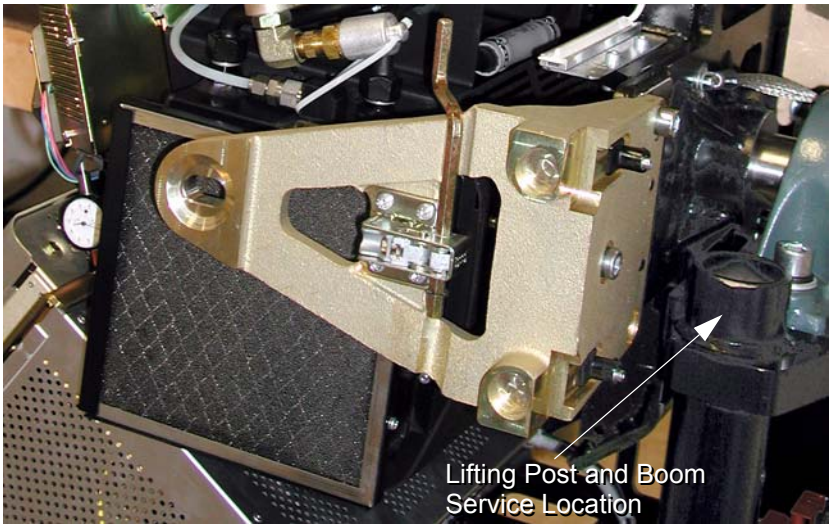

Figure 12-3 Right Front Gantry Cover Mounting Bracket

3.) Turn off facility power to PDU and lockout/tagout.

4.) Turn off the **AXIAL DRIVE ENABLE** and **HVDC ENABLE** service switches.

NOTICE **It may be easier to loosen the M12 tube mounting bolts with the tube at about the 2 o'clock position before locking the tube at the 3 o'clock position. Simply loosen the tube mounting bolts one half (1/2) turn. Do not remove the bolts yet.**

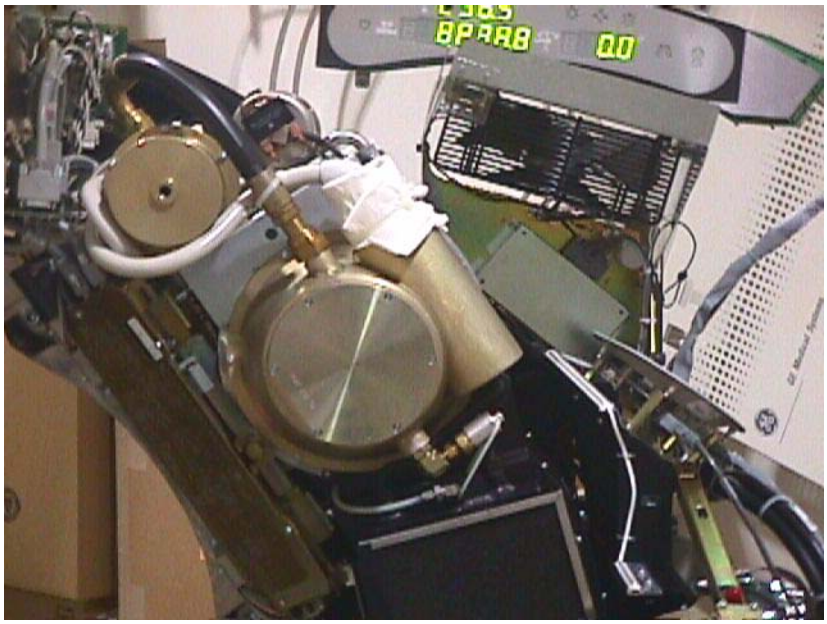

Figure 12-4 Tube Angle to Loosen and Torque M12 Screws

5.) Rotate the Gantry until the failed tube unit reaches the 3 o'clock position.

NOTICE **Make sure the tube is at 90 degrees so the tube hangs at the correct engagement angle for removal and installation.**

6.) Engage rotational lock. Check that the gantry is securely locked by attempting to rotate the gantry by hand.

7.) Insert the lifting post, boom and chain hoist. Reference Figure 12-3.

8.) Disconnect the 12 pin tube I.D. system cable, from the top of the tube unit.

9.) Disconnect the 4 pin mate-n-lock pump and fan power system cable

10.) Disconnect the ground strap from the top of the tube unit

11.) Remove the anode and the cathode cable:

- Carefully cut tie-wraps securing HV cables. Note HV cable routing.
- Loosen each cable's locking ring with the spanner wrench.
- Pull each cable terminal out of its receptacle.
- Ground the end of the cables to the Gantry frame.
- Wipe up any oil that drips from the cable terminal.
- Use paper towels to soak up any oil in the wells.

CAUTION **Remove the mounting bars in the following (lower/upper) order to lessen the risk of injury to your hand. Keep one hand under the bolt and pressure plate while unfastening it. This is to prevent them from falling into the fan that is attached to the tube.**

Note: It may be easier to tape the socket to the extension. This will prevent the socket from being dislodged on the tube radiator assembly

12.) The XRT is attached to the Collimator with a Tube Mount Bracket Assembly (P/N 2128696).

Remove the mounting plate & XRT from the Collimator by removing the four M12 (P/N 46-328416P24) cap screws and lock washers, and two load plates (P/N 2120104), with a hex socket driver. With your hand reach behind the radiator to the screws from either side of the XRT center section while removing the bolts with two 12 inch extensions (24 inch length) on a ratchet. **Throw these M12 screws and washers away, as they should not be reused.**

13.) Carefully swing the tube clear of the gantry.

Note: Be careful not to damage the fragile copper filter or lead shield in the mounting plate for the next step.

WARNING

SEVERE INJURY POSSIBLE.
TUBE CAN SEPARATE FROM GANTRY
DO NOT REMOVE FACTORY INSTALLED MOUNTING PLATE.

14.) If the replacement tube has a mounting plate attached (see Figure 12-5), DO NOT REMOVE IT. Skip steps 15 and 16.

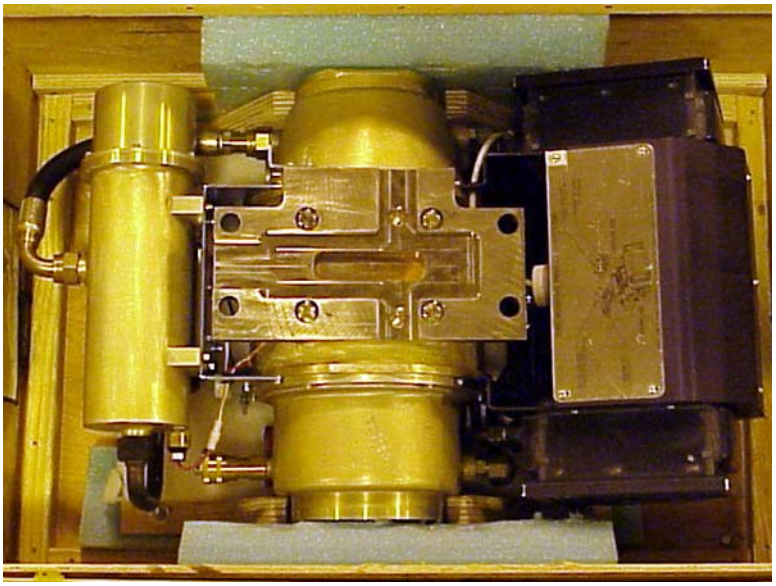

Figure 12-5 Tube Shipped with Mounting Plate Attached

NOTICE
Potential for IQ artifacts

When removing the mounting plate from the tube, be careful with the Copper Filter. It should be free of debris, scratches and dust. Particles create artifacts in the image by affecting the attenuation properties of the copper filter.

15.) If the replacement tube does NOT have a mounting plate attached, remove the mounting plate by removing the four M10 (P/N 46-328416P20) hex head screws. **Throw these bolts and washers away, as they should not be reused.**

16.) If new tube has no mounting plate attached, inspect the copper filter. The copper filter should be clean, dent and scratch free:

- If contamination is visible (see Figure 12-6), clean or replace the copper filter.
- Discoloration is acceptable.

Figure 12-6 Extremely Contaminated Copper Filter

17.) Inspect the Bowtie Filter. It is possible that the Bowtie Filter is contaminated and the Primary Copper Filter is not contaminated.

Note: Perform this inspection before installing the new tube unit. Also look at the tube side of the copper filter when you are swapping the interposer plate.

The following tools are required for this inspection procedure:

- Phillips #2 Screwdriver
- Flat blade Screwdriver
- Bright Flashlight

Inspect the Bowtie Filter as follows:

a.) Remove the Collimator Control Board Sheet Metal Cover. See Figure 12-7.

Figure 12-7 Collimator Control Board Cover, LightSpeed Ultra Shown

WARNING **DO NOT ATTEMPT TO MOVE THE FILTER WITH POWER ON.**

b.) With power removed from the gantry, use a flat blade screwdriver and position the bowtie filter assembly so it is visible through the input port or tube side of the collimator assembly.

* CCW will move the filter into the beam. See Figure 12-8.
* Do not move the filter back to the home position.

NOTICE
Potential for equipment damage

Do not force the filter if it feels stuck. Damage to the limit switch can result.

Do not move the filter more than necessary for inspection. The filter can fall off the drive screw.

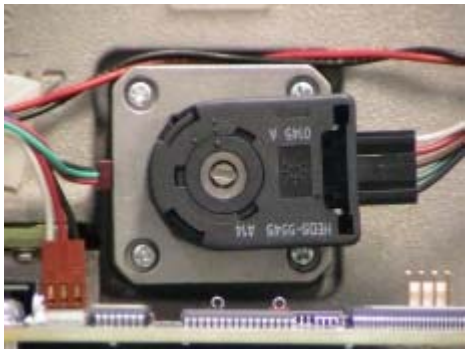

Figure 12-8 Filter Position Adjuster

c.) Using a flashlight, inspect the bowtie filter for contamination.
Look through the input port or tube side of the collimator.
If contamination is visible, clean or replace the filter assembly.

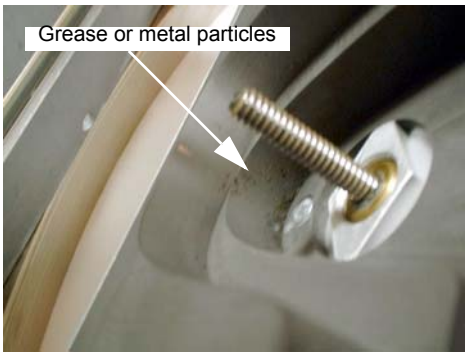

Figure 12-9 Contaminated Bowtie Filter

Section 2.0
Install New Tube

WARNING **SEVERE INJURY POSSIBLE.**
TUBE CAN SEPARATE FROM GANTRY, IF NOT TORQUED CORRECTLY.
ALWAYS USE PROPER TORQUE ON ALL FASTENERS.

WARNING **FOLLOW LOCKOUT/TAGOUT PROCEDURES FOR POWER & ROTATIONAL HAZARDS.**

1.) Allow the tube unit to warm to room temperature before you install it.

WARNING **SEVERE INJURY POSSIBLE.**
TUBE CAN SEPARATE FROM GANTRY
DO NOT REMOVE FACTORY INSTALLED MOUNTING PLATE.

2.) If the new tube has a factory installed mounting plate, DO NOT REMOVE IT. Skip to Step 4.

3.) Attach the mounting plate from the old tube using **four new M10 x 25mm bolts** that come with the tube. **Do NOT use Loctite**.

- Finger tighten all four (4) bolts
- Set all four (4) bolts to the following pre-load torque specification:

15 lb-ft.	**20 N-m**	**180 in-lbs**	**210 kg-cm**

This seats each bolt, enabling you to visually ensure that the mounting holes are not stripped while applying final torque.

WARNING **SEVERE INJURY POSSIBLE.**
IF YOU TURN THE TORQUE WRENCH MORE THAN 90º (¼ TURN) WHILE APPLYING FINAL TORQUE, THE MOUNTING THREADS ARE STRIPPED.
DO NOT USE THIS TUBE.

- Set final torque on all four bolts:

30 lb-ft.	**41 N-m**	**360 in-lbs**	**420 kg-cm**

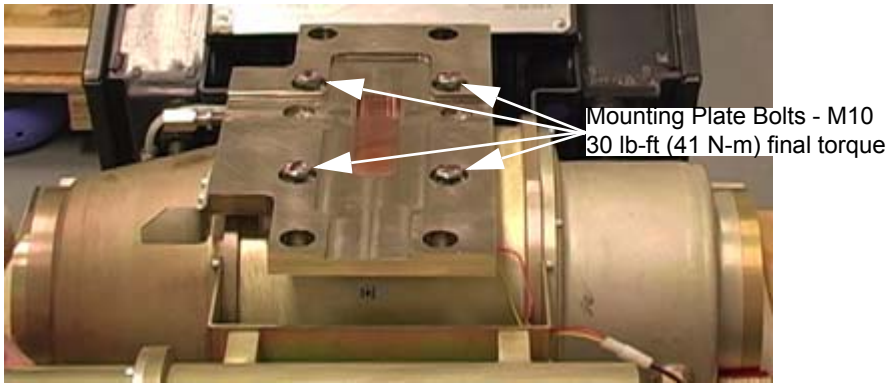

Figure 10 - Tube and Mounting Plate

NOTICE
Potential for IQ artifacts

When attaching the mounting plate on the tube, be careful with the Copper Filter. It should be free of debris, scratches and dust.The reason is particles create artifacts in the image by affecting the attenuation properties of the copper filter.

4.) Re-check facility power and make sure it is off.

WARNING

SEVERE INJURY TO PATIENT COULD OCCUR.

USING THE WRONG BOLTS COULD PLACE STRESS ON BOLTS, CAUSING TUBE TO SEPARATE FROM GANTRY.

USE PROPER BOLTS.

5.) Use the hoist to lift the new tube unit:

a.) Position the tube on the gantry: The “crosses” on the mounting plate and on the collimator should fit in perfectly when the tube is aligned properly.

Note:

* To ease installation, fasten the top pressure plate to the rotating structure first. Then attach the bottom pressure plate.
* **Use new bolts and washers from tube crate. Make sure to select the proper bolts. There are instructions in the crate, and on the tube itself.**

b.) Fasten the lower and upper and pressure plates to the rotating structure with the four M12 (50 mm) bolts, and set **pre-load torque to**:

25 lb-ft.	**33 N-m**	**295 in-lbs**	**340 kg-cm**

c.) Set final torque to:

49 lb-ft.	**66 N-m**	**590 in-lbs**	**680 kg-cm**

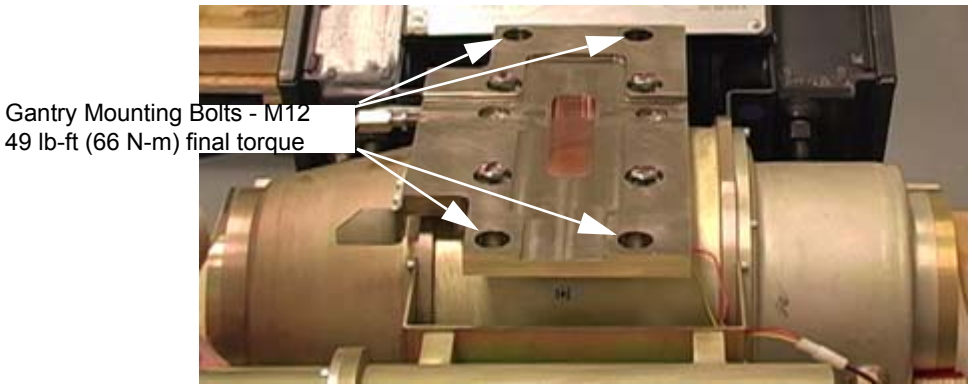

Figure 11 - Tube and Mounting Plate

6.) Attach the tube I.D. cable to the 12 pin mate–N–Lock connector on top of the tube.

7.) Attach the tube pump and fan power cable to the 4 pin mate–N–Lock connector.

8.) Fasten the grounding strap to the 1/4–20 ground stud on top of the tube unit.

9.) Remove the plastic cap plug from each cable receptacle on the tube unit.

Note: Take care not to lose the rubber quad rings for the High Voltage cables.

10.) Lightly wet the new rubber quad ring with transformer oil (917).

11.) Return the quad ring to its slot at the top of the receptacle retaining ring.

12.) Pour transformer oil (917) into the receptacle to a depth of 10 mm (0.375 in).

NOTICE **Incorrectly routed or secured HV cables will result in damage to the HV cables and/or other parts of the gantry.**

13.) Be sure to route the HV cable as shown in Figure 12-12.

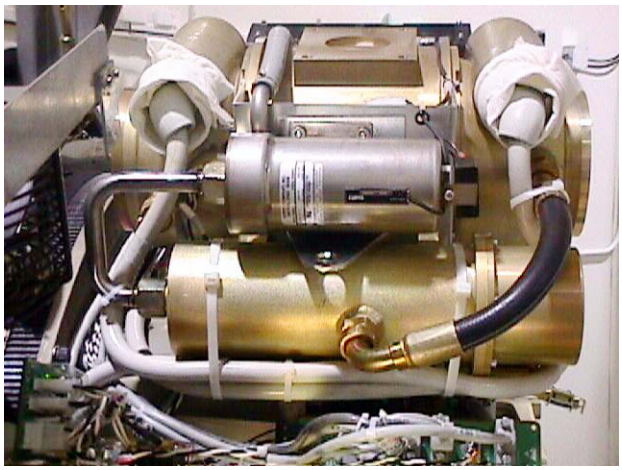

Figure 12-12 HV Cables Properly Routed and Secured

14.) Align the cable terminal orienting key with the notch in the receptacle.

15.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.

- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

NOTICE **IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW**

16.) Carefully wipe up all excess oil.

17.) Secure HV Cables using Large tie-wraps, as shown in Figure 12-12.

18.) Disconnect hoist from tube and boom.

19.) Remove the post and boom from the gantry. Reference Figure 12-3, on page 916.

20.) Check for oil leaks:

- Wrap rags or paper towels around the cable horns, and tape them into place.
- Manually rotate the tube to the 6 o'clock position.
- Return the tube to the 3 o'clock position
- Remove the toweling and wipe up all excess oil.
- Wipe off the cable horns, locking rings, and strain reliefs with a rag dampened with alcohol.
- Repeat with a dry rag.
- Wrap the cable strain reliefs and locking rings with a single layer of absorbent paper tissue.
- You can use two inch wide strips cut from a paper napkin.
- Wrap the bottom edge of the paper around the top end of the cable horn, and tape it into place.
- Extend the top edge of the paper over the top of the locking ring, and tape it to the plastic cable strain relief.
- Remove paper after leak check.

21.) If oils leaks are found, tighten the locking ring slowly until there is no leakage, paying attention to not over tighten.

22.) Install the right gantry front cover bracket. Reference Figure 12-3, on page 916.

23.) Restore system power at the main disconnect panel.

24.) Turn on gantry **120 VAC**, **HVDC POWER** and **AXIAL DRIVE ENABLE** at the STC backplane. Wait at least 10 minutes to warm up the filament.

25.) After restart of software, begin entering the new tube information.

26.) Select SERVICE DESKTOP.

27.) Select CALIBRATION.

28.) Select GENERATOR CALIBRATION.

29.) Select INSTALL NEW TUBE.

30.) Perform Tube Installation Certification. (See “SmarTube™ Setup” on page 925.)

31.) Verify tube types match before proceeding.

Figure 12-13 Install New Tube Configuration Check

Section 3.0
SmarTube™ Setup

Note: If the tube in your system has a Tube ID Board, the software automatically selects the tube identity and sets it to “GE Performix Tube”; there is no action needed by service personnel. For all other systems or if the software does not automatically select the tube identity, follow the procedure below.

3.1 Personnel Requirements

REQUIRED PERSONS	PRELIMINARY REQUIREMENTS	PROCEDURE	FINALIZATION
1	None	30 Minutes	None

3.2 Overview

The SmarTube software includes a number of enhancements. One of the enhancements that affects the tube change procedure is an enhancement known as Secure Tube Identification. We have included this feature to confirm that a tube with “system-known” operating characteristics is installed so GE can assure that all system elements will perform as designed. This feature allows positive identification of the GE CT tube in use so that the interaction between the tube and the system operating characteristics may be optimized for best performance.

In contrast, if a non-GE supplied tube is used there can be operating impact on the system. For instance—mechanical stability, life expectancy of other components, calibration differences, the accuracy of dose reporting and image quality may be affected. GE does not test non-GE supplied tubes for suitability, and therefore GE cannot assure system performance for systems utilizing a non-GE supplied tube. If a non-GE supplied tube is installed the SmarTube software displays a message for the CT Operator on the console indicating that fact. No features will be disabled if a non-GE supplied tube is detected; however, advisories will be posted to alert the user of the possibility for performance discrepancies. The advisories are purely informational. The CT equipment users benefit by having a mechanism to quickly and effectively confirm the configuration of their systems without having to perform a physical inspection. This is a phased release for the following three software platforms:

- FMI 25363 - GOC1 Irix/Pegasus systems (HiSpeed QX/i, LightSpeed 2.X, 3.X and 4.X)
- FMI 25364 - GOC2 Linux/Pegasus systems (HiSpeed QX/i, LightSpeed 2.X, 3.X and 4.X)
- FMI 25365 - GRE console systems, Pathfinder 1.5 (all systems from LightSpeed 1.X)

Among the new features enabled by SmarTube are the following:

- Tube Identification – allows positive identification of the GE CT tube in use so that the system may be optimized for the particular tube’s operating characteristics (discussed above)
- Enhanced Tube Management – results in an average 7% to 20%+ improvement in GE tube life depending upon system platform type (not available on H1 based LightSpeed QX/I system).

  Note that Enhanced Tube Management is provided with GE-supplied tubes subject to an included license. A license for systems not using GE-supplied tubes is available for a fee. However, Enhanced Tube Management has been exclusively developed and designed for use with GE-supplied tubes. GE has conducted no testing for any other tube configuration, makes no representation concerning, and assumes no responsibility for compatibility with non-GE-supplied tubes.
- Enhanced Dose Reporting – facilitates saving of patient dose data in a format that will allow

easy communication and storage

- Enhanced Data Capture – allows development of improved proactive remote diagnostic capability and additional features planned for future implementation.
- Enhanced Advisory Messaging—communicates exception information in situations where system performance may be affected by the use of a non-GE supplied tube

There are two basic tube types related to this topic.

- GE Supplied Tubes
- Non-GE Supplied Tubes

When installing a new tube it will be necessary to utilize the new Tube Install Calibration (TIC) tool. The tool is in Common Service Desktop under Configuration. Follow the process shown in the Process Flow section of this document. You will need to select Tube Identity (“GE Medical Systems Performix Tube” or “All Others”) using the Tube Install Certification Tool. It will be necessary to insert the GE Employee Service Key (Class M) in order to permanently authenticate the tube as a GE supplied tube.

If “All Others” is chosen, advisory messages will be posted on systems with Non-GE-Supplied tubes during Fast Cal indicating that Fast Calibration techniques are designed specifically for GEHC Performix tubes and that the performance of the system cannot be guaranteed with unrecognized tubes. In addition, a message will be posted on the Dose Report screen save image indicating that GE cannot assure the accuracy of reported dose information for any configurations that include tubes other than GE Medical Systems Performix Tubes.

If the installed x-ray tube is a GE-Supplied tube and the field service engineer did not have all the appropriate information to complete verification, a message will be displayed indicating verification needs to be completed. If the GE-Supplied tube is installed by either an in-house or 3rd party service provider, the same message will be displayed and the customer will need to call to have a GE Service Representative dispatched to verify the identity of the tube. A message will be displayed for 30 days or until the field service engineer is able to complete tube installation verification within the 30-day window. If verification is not complete within 30 days then the system will revert to “All Others” status and operate accordingly.

If the tube is a GE-Supplied tube and if the tube has been properly authenticated with a GE Employee Service Key (Class M) then the warning messages are not necessary and will not be posted.

3.3 Preliminary Requirements

3.3.1 Tools and Test Equipment

ITEM	QTY	EFFECTIVITY
Class M Service Key (See Note)	1	Linux Based Operating Systems

Note: This tool is only available to GE Healthcare service personnel.

3.3.2 Safety

Potential Tube damage or explosion if a non-GE Tube is classified as a GE Tube.

3.3.3 Required Conditions

Applies to any system that does not support Smart Tube ID.

Class M Service key required to effectively record Tube type when the following events occur. (This tool is only available to GE Healthcare service personnel.)

- Tube is changed

- After Load From Cold (LFC) software install
- When performing Beam on Window
- When performing Hot or Cold ISO alignment

3.4 Procedure

3.4.1 Tube Selection

For all tube changes, the following must be performed.

1.) Select the [Tube Install Certification Tool] in the Common Service Desktop under [Configuration].

Note: Do not double click the [Tube Install Certification Tool]. This will cause more than one tool screen to be displayed, one with message service key information not available. If this happens, delete screens and try again. If this happens more than once, reboot the system and try again.

2.) (For GE Healthcare service personnel only) Insert the Class M Service Key.

3.) Verification of GE Medical System Performix tube: This can be verified by checking the tube insert model number that can be found on tube rating plate.

4.) In the Tube Install Certification Tool, Change Tube Identity field, select [GE Medical Systems Performix Tube] or [All Others] as appropriate. See Figure 12-14.

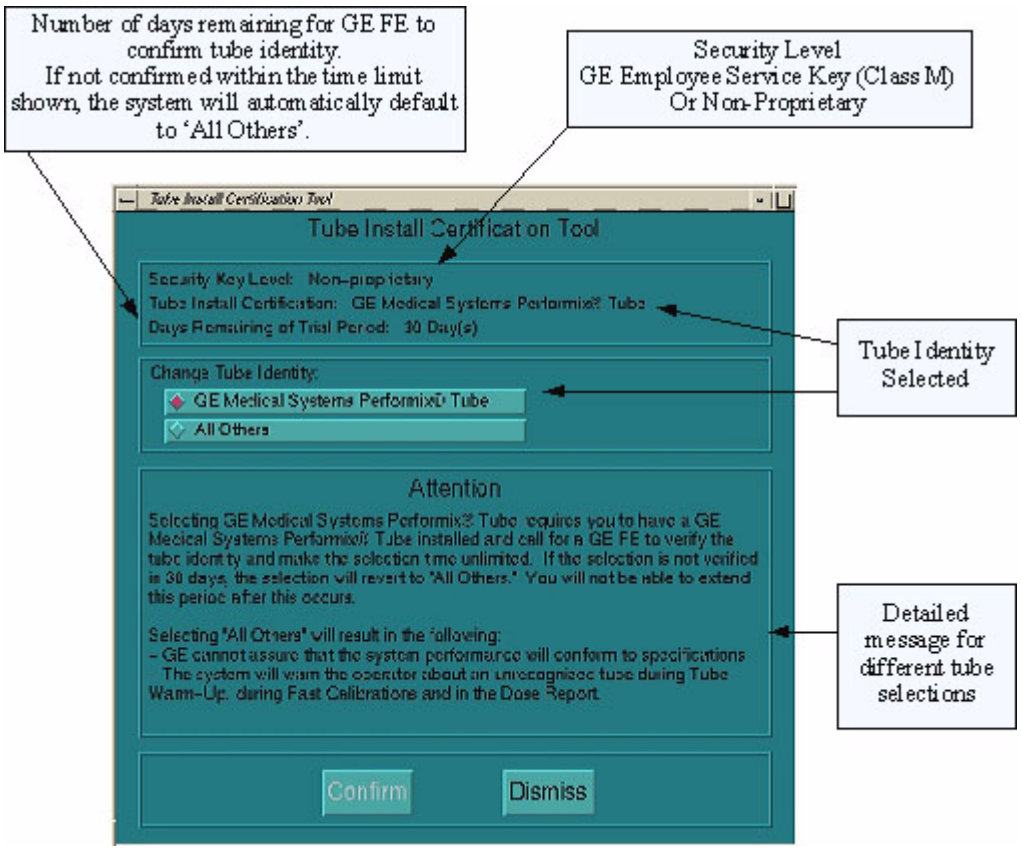

Figure 12-14 Tube Install Certification Tool Screen

5.) Select [Confirm]. A confirmation screen is displayed.

6.) On the confirmation screen, select [Accept].

7.) Exit the Tube Install Certification Tool by selecting [Dismiss].

8.) (For non-GE service personnel) Additionally for a GE Medical Systems Performix Tube, follow

the process shown in Figure 12-15.

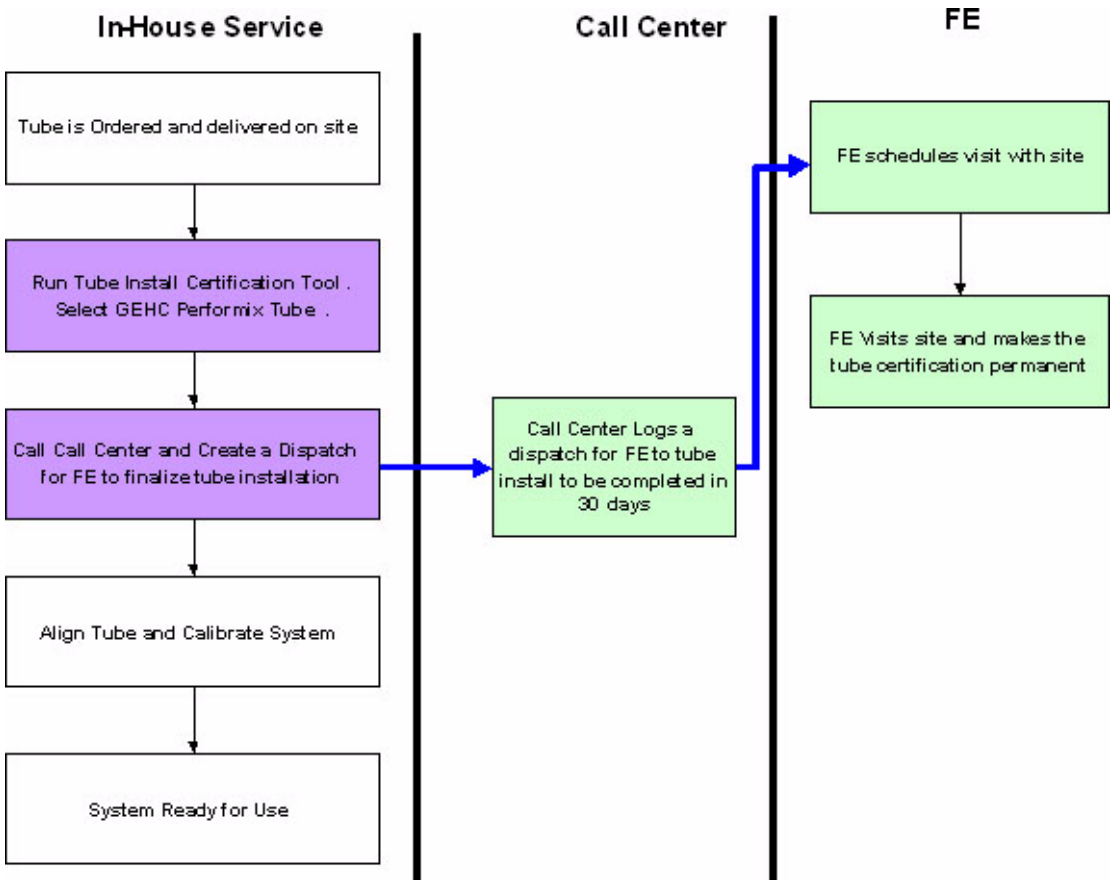

Figure 12-15 Tube Authentication Process

3.4.2 Tube Installation Certification (TIC) Customer Messages

The Tube Installation Certification (TIC) functional flow is displayed in Figure 12-16. The installation path determines if the customer will see any popup windows or Dose Reporting qualifiers as shown in Figure 12-17, Figure 12-18, and Figure 12-19.

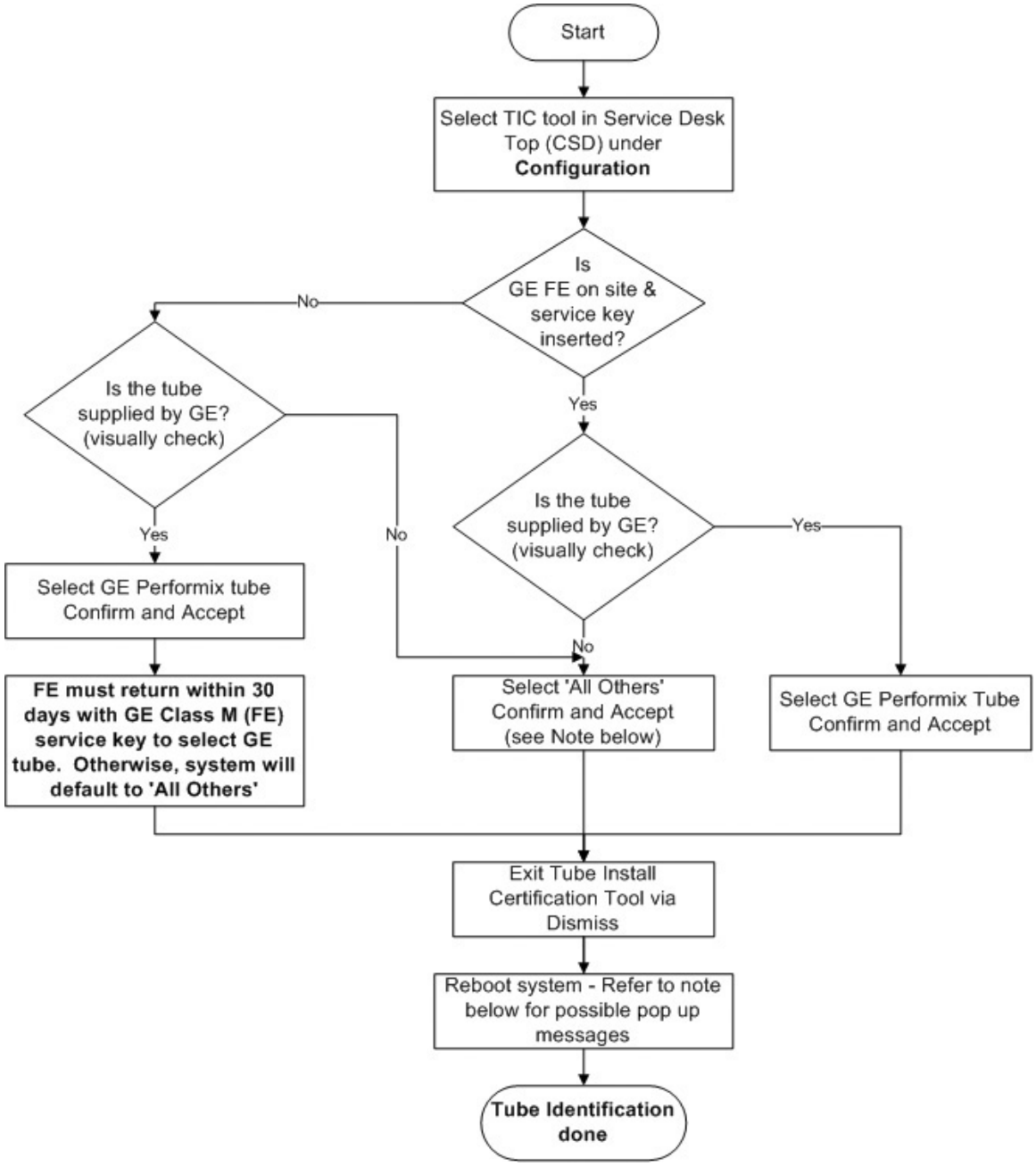

Figure 12-16 Tube Identity Selection and Messages Flowchart

Note: Possible popup messages at startup:

- If the tube selection is GE tube without time limit, no popup messages relating to tube identity are shown on boot-up.
- If the tube selection is GE with time limit, a message with days remaining for GE FE to verify tube is shown on boot-up until GE FE removes the time limit with service key (see Figure 12-17). If not verified by GE FE within the time limit, the system defaults to “All Others'.

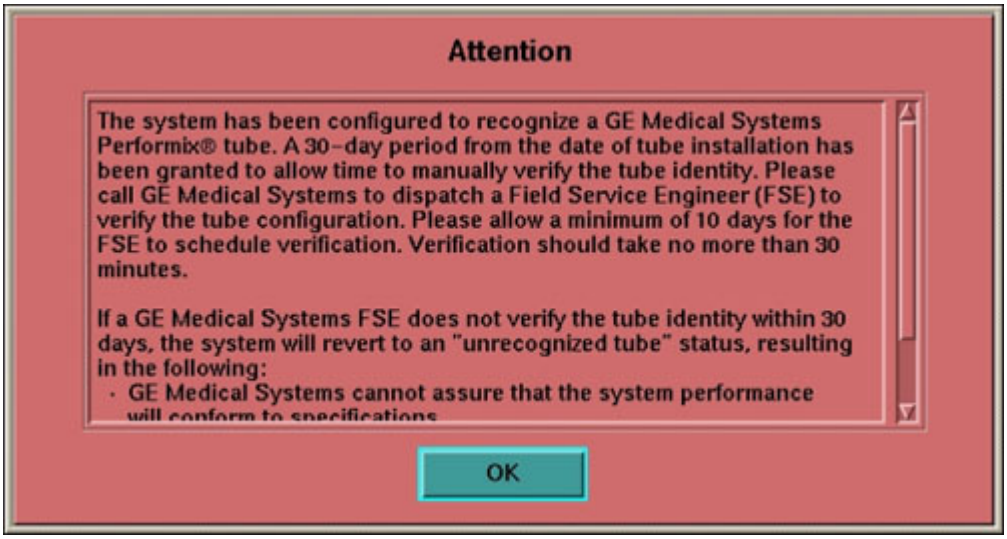

Figure 12-17 30 Day Configuration Install Message

- If the tube is set to 'All Others', unrecognized x-ray tube installed message is always shown at boot-up (see Figure 12-18).

Figure 12-18 Unrecognized X-Ray Tube Installed Message

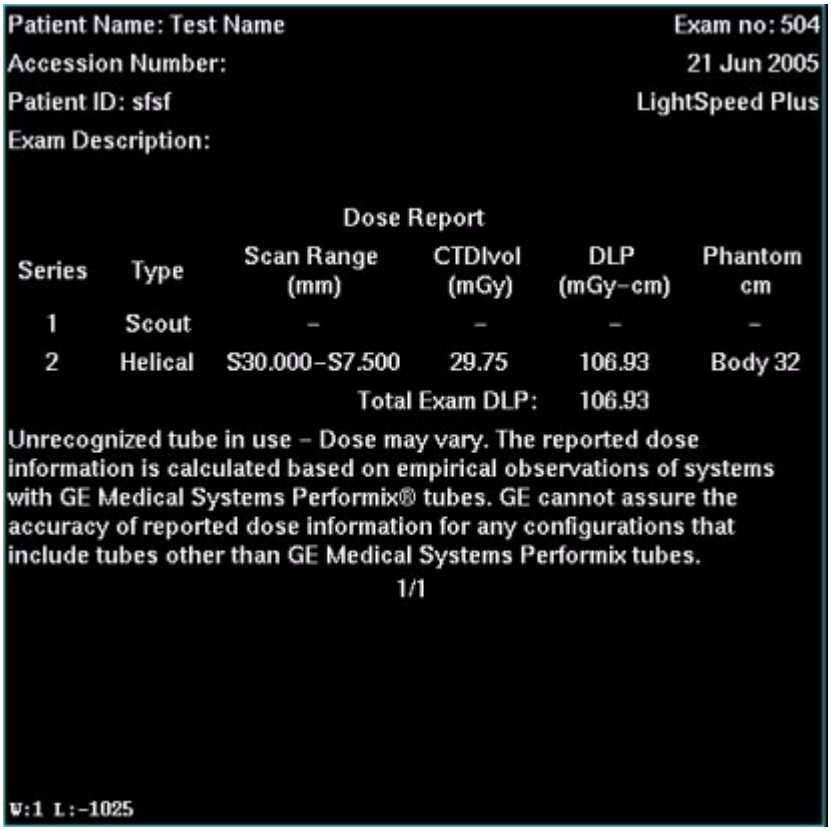

Figure 12-19 Unrecognized X-Ray Tube "Dose" Message

3.5 Finalization

No finalization required.

Section 4.0
Plane of Rotation (POR)

4.1 Overview

The purpose of Plane of Rotation measurement/alignment is to put the X-ray tube in the correct physical relationship to the detector and verify it. This is normally only necessary when the X-ray tube has been replaced or moved.

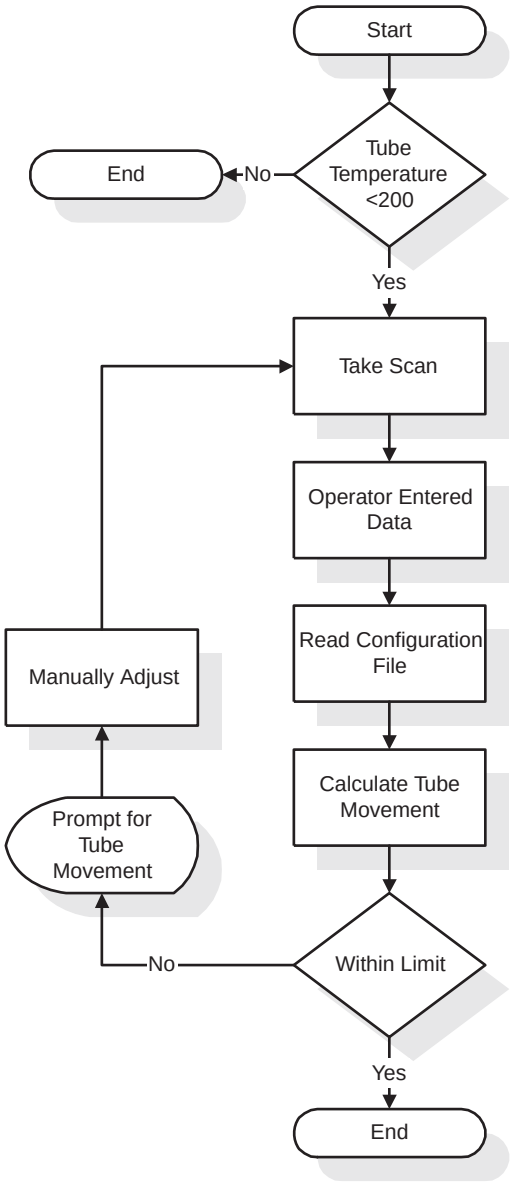

Figure 12-20 POR Procedural Flow

4.2 Tools Required

Figure 12-21 Vernier Caliper & Dial Gauge Indicator

- Calibrated Vernier Caliper (millimeters or inches)
- Dial gauge Indicator (millimeters or inches)
- Type 52 Polaroid Film (see Figure 12-24, on page 935)
- Type 52 Polaroid Film Developer

4.3 Procedure

4.3.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

NOTICE **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (gesys_suite.log)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.

This entry is created when Cancel is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.

Start Tube Alignments when 200.00 degrees Celsius is reported.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.

8.) Repeat steps 3 through 5 as necessary to generate updates in the gesyslog.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

4.3.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

4.3.3 Start the POR Software

Note: Make sure the tube is cold before alignments.

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select POR ALIGNMENT

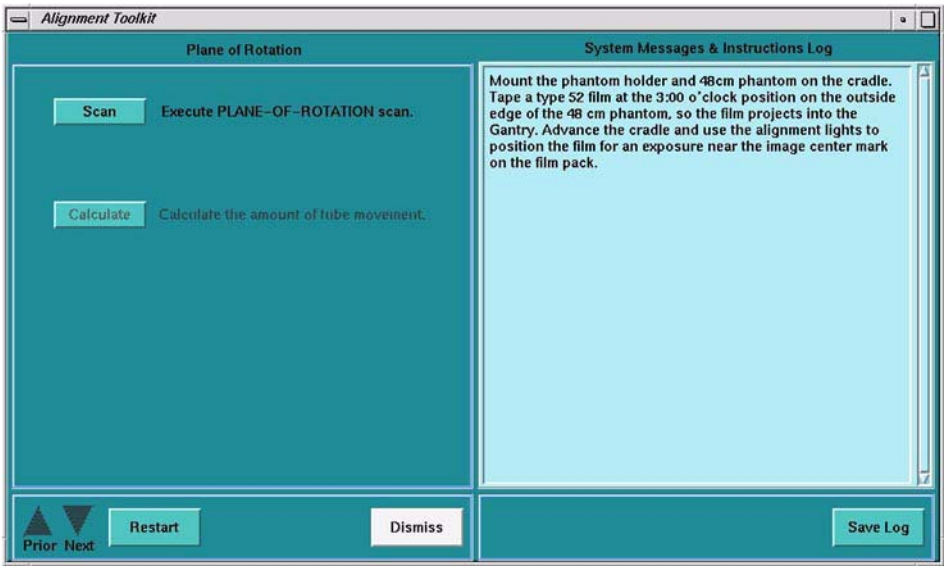

Figure 12-22 Plane Of Rotation Alignment Screen

4.3.4 Measure Tube Alignment

1.) Mount the Dial Indicator onto the Collimator / Tube Assembly as shown Figure 12-23. *Make sure you zero the dial indicator, when it is securely in place*.
2.) Loosen the (4) M-12 bolts that secure the tube. (½ turn out is all that's necessary and not any more.)

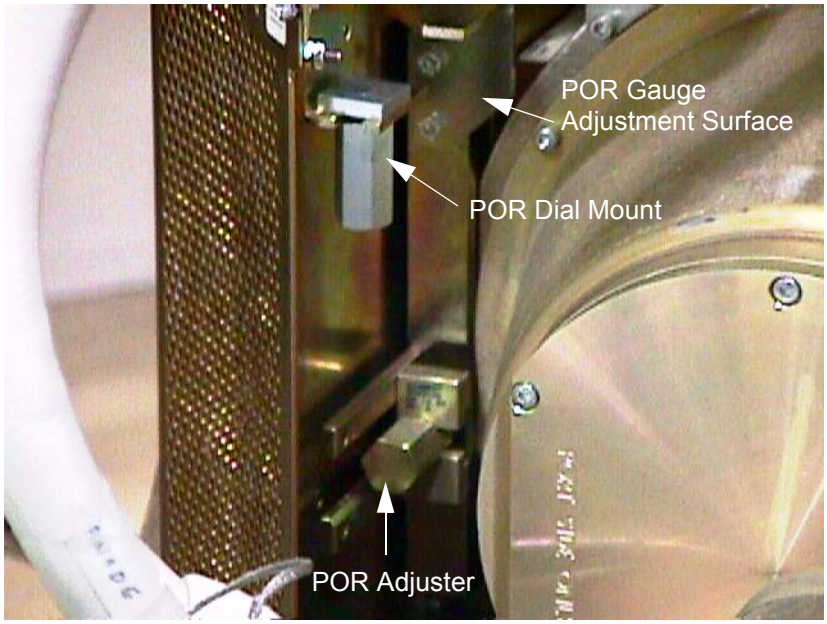

Figure 12-23 POR Gauge Mount and Adjuster.

3.) Get the system's phantom holder and its 48cm phantom onto it.

4.) Attach (1) "*Polaroid type 52*" film on the outside edge of the 48cm phantom, at the 3 o'clock position.

Note: Only the film should be projecting into the Gantry bore when complete. The phantom is used only to position and hold the film in the gantry bore, Figure 12-26.

Orient the side of the film side marked "**This side toward lens"** towards iso center, see Figure 12-24. When exposed and developed later, the film will show the alignment of the x-ray beam with respect to the table, as viewed from the X-Ray tube in the 3 o'clock position.

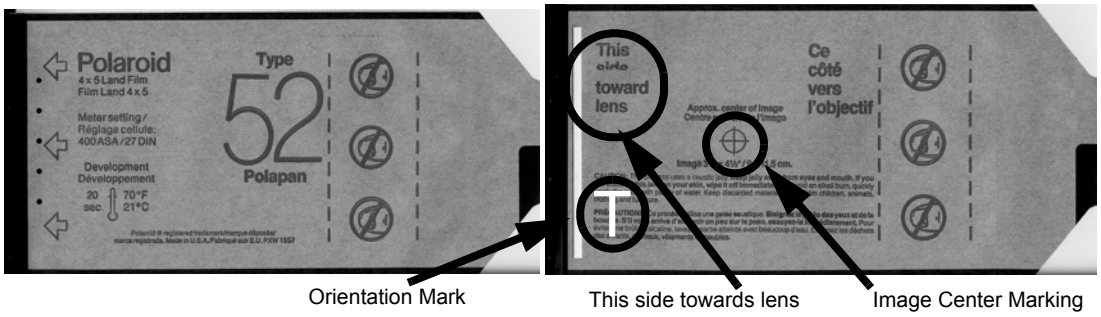

Figure 12-24 Polaroid Film, Type 52

5.) Advance the cradle and rotate the phantom if necessary, while using the alignment lights, to position the film's center marking on the alignment light marks.

6.) Take a scan.

7.) Remove the exposed film and immediately mark the outside of the film nearest the table. For example, use a pen and print the letter "T" on the film nearest the table, Figure 12-24. Go and develop the exposed film. After the film is developed, transfer the table marking to the film itself while keeping the orientation correct, Figure 12-26.

8.) Verify that:

- The film's narrow (white beam) slit lies within (between) the wider (gray) X-Ray slit.
- The film's edges in both Z direction are equally well defined by the exit slit of the collimator. The edges of the narrow beam should be much sharper than the wide beam. If a difference in edge definition exists, check for gross Z misalignment. (*Mis-alignment of the slit in the*

tube's collimator adapter is a common cause of fuzzy film edges.)

9.) Refer to Figures 12-25 and 12-26 during the following instructions. Use a Vernier Calipers to measure the width of the 2 wider (dark gray) slits. They're the dark gray slits that extend past the edges of the narrower (off-white) slit and to the blackest part of the film.

a.) Take 3 measurements to obtain an average value for X_F. X_f is the side of the film closest to the table. Using the same film measurement tool, take (1) X_f measurement at the top of the film, another near the middle and another near the bottom. Add these (3) X_f distances together and divide this sum by 3 or "n". *Where,*

$$X_F = (X_{f1} + X_{f2} + X_{f3})/(n)$$

Note: It is important that you take multiple measurements. The more measurements you take, the more accurate the measurement. There is less likelihood of a measurement error and you will increase the accuracy of the alignment.

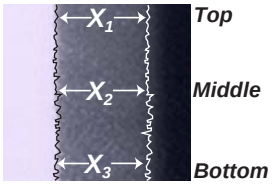

Figure 12-25 XF and XR measurement points

b.) Now take 3 measurements to obtain an average value for X_R. Take (1) X_R measurement at the top of the film, another near the middle and another near the bottom of the film. Add these 3 values together and divide the sum by 3 to obtain an average for X_R.

$$X_R = (X_{r1} + X_{r2} + X_{r3})/(n)$$

c.) Use the values obtained for X_F (front distance) and X_R (rear distance) in the calculation that follows.

10.) Click on the **CALCULATE** button, Figure 12-22, on page 934. Enter the values for X_F and X_R obtained in the steps above. The software will do the distance calculation.

The specification limits are 0.059 - 0.082 inches or 1.50 - 2.083 millimeters.

11.) Check the results.

- If the tube is out of specification, move the tube as indicated by the program. If adjustment is necessary, clockwise rotation (in) of adjustment bolt moves the tube towards the table side. Repeat Steps 3 through 11 again if you have moved the tube, to check accuracy of adjustment. See Figure 12-26 for more details.
- If the tube is within specification, tighten the four (4) M-12 Bolts bolts on the tube and torque them to 49 ft-lbs (66.4 Nm) and you're done.

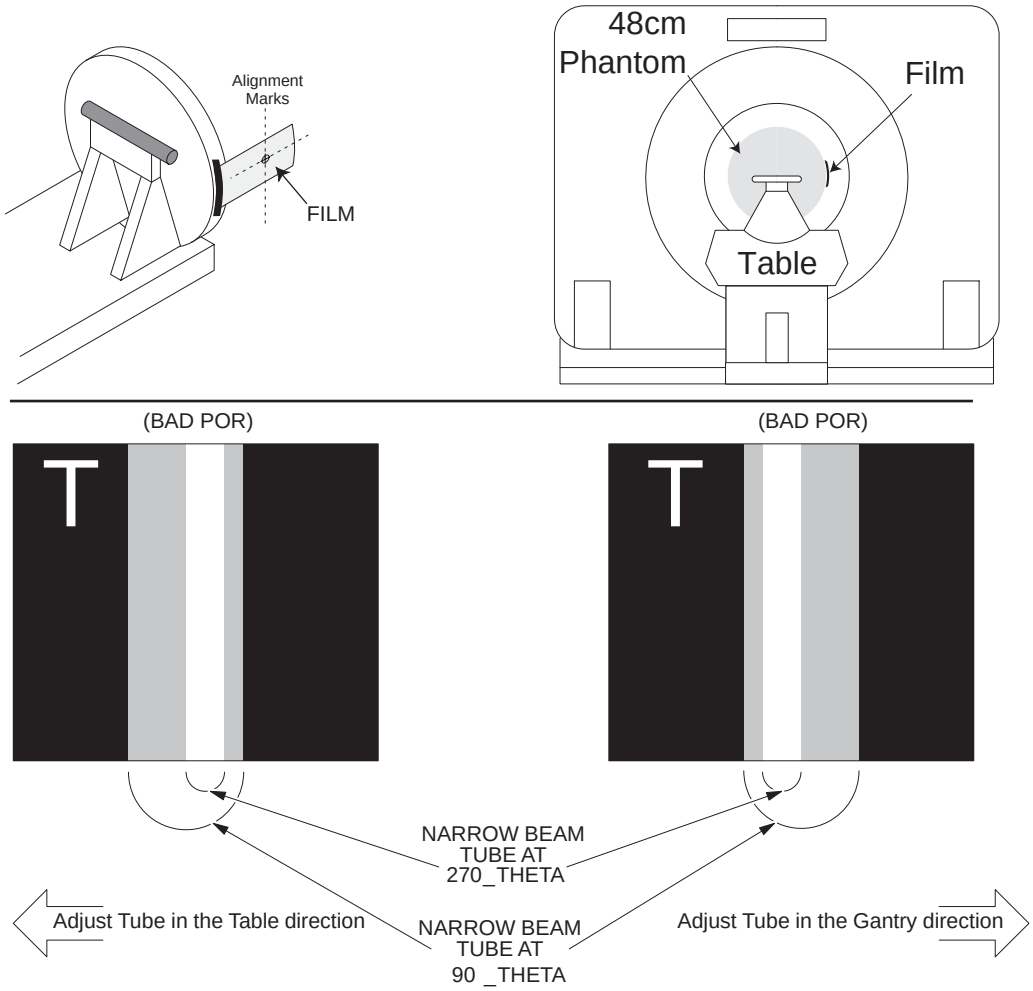

Figure 12-26 Plane of Rotation Film Interpretation

Section 5.0
Beam on Window Alignment (BOW)

Purpose: The objective is to put the Detector in the correct position, assuming the tube is already in the correct position. This makes sure the X-ray Flux does not miss the Detector.

Note: Perform Tube Installation Certification, if necessary. (See “SmarTube™ Setup” on page 925.)

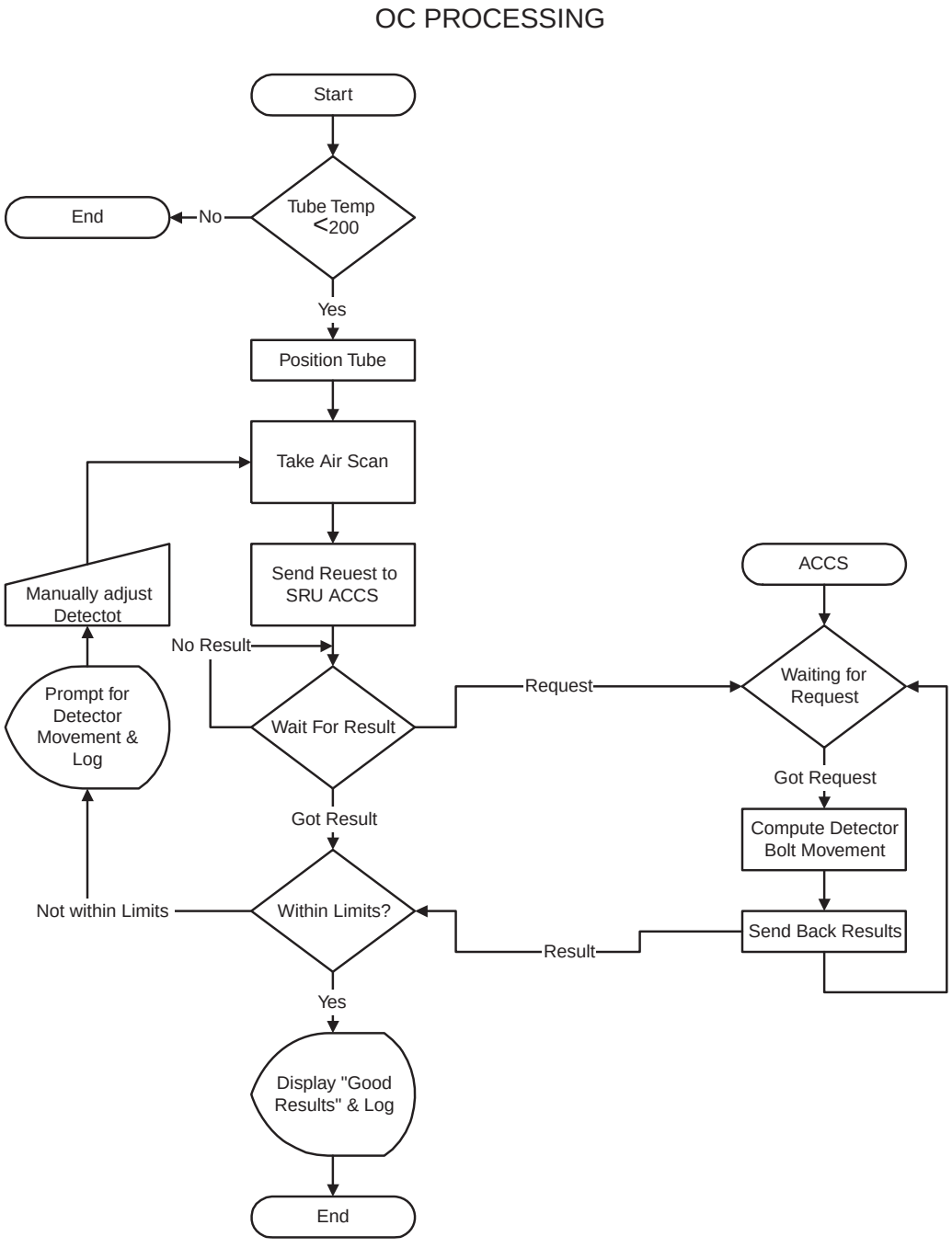

Figure 12-27 BOW Alignment Process Flow

5.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

NOTICE **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (gesys_suite.log)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.

This entry is created when Cancel is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.

Start Tube Alignments when 200.00 degrees Celsius is reported.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.

8.) Repeat steps 3 through 5 as necessary to generate updates in the gesyslog.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

5.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

5.3 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select BOW ALIGNMENT

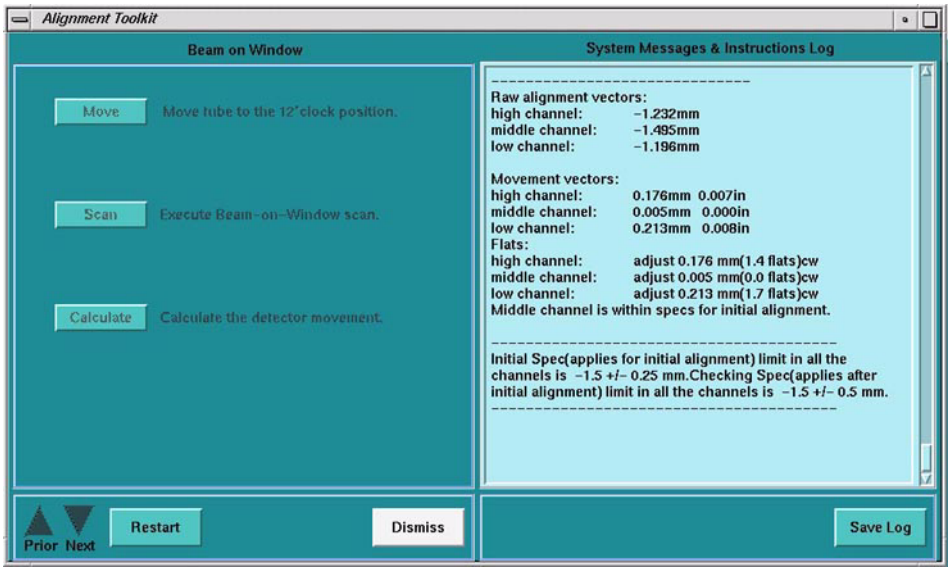

Figure 12-28 Screen Shot for Beam on Window Alignment

5.4 Adjustment Procedure

1.) Select MOVE to send the tube to the 12 o'clock position.
2.) Acquire a Beam on Window Scan.
3.) Select CALCULATE and make adjustments as indicated by the program.
4.) Remove the rear gantry cover if necessary.
5.) Refer to Figure 12-29. Loosen the M-6 caphead screws, located at each end of the detector (total of two caphead screws).
6.) Loosen the middle nut (jam nut) with a 10 mm wrench. Make adjustments as requested by software.
7.) Acquire a Beam on Window Scan, then select CALCULATE.
8.) If the adjustments pass the calculation, proceed to step 9, otherwise return to step 2.
9.) Tighten all three screws. (Torque to 120 inch-lbs, 13.5 Newton Meters).

Note: The specs for BOW are checked by the software. If an adjustment is needed for the first BOW scan, make adjustments per procedure. In the verification scan, the spec is different than the software version because the tube is warm. The spec is -1.5 ± 0.5mm.

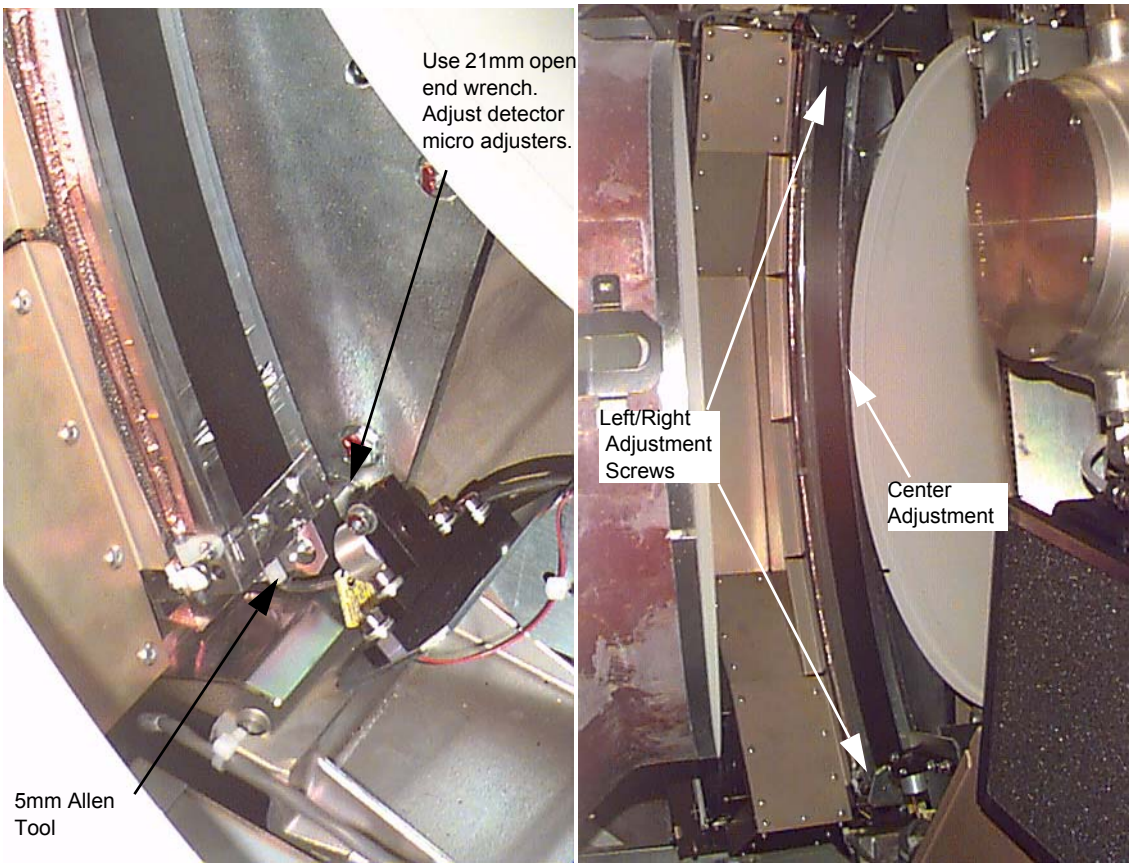

Figure 12-29 Detector Cap-head Screws

Note: CW (clockwise) turns move the detector toward the mounting plate. CCW (counter-clockwise) turns move the detector away from the mounting plate. Right=Low Chnl, Center=Medium Chnl, Left=High Chnl.

Section 6.0
CBF / SAG Alignment Process

Purpose: CBF/SAG Alignment ensures the focal spot is accurate, the bowtie filter is centered and center of rotation is in a straight line.

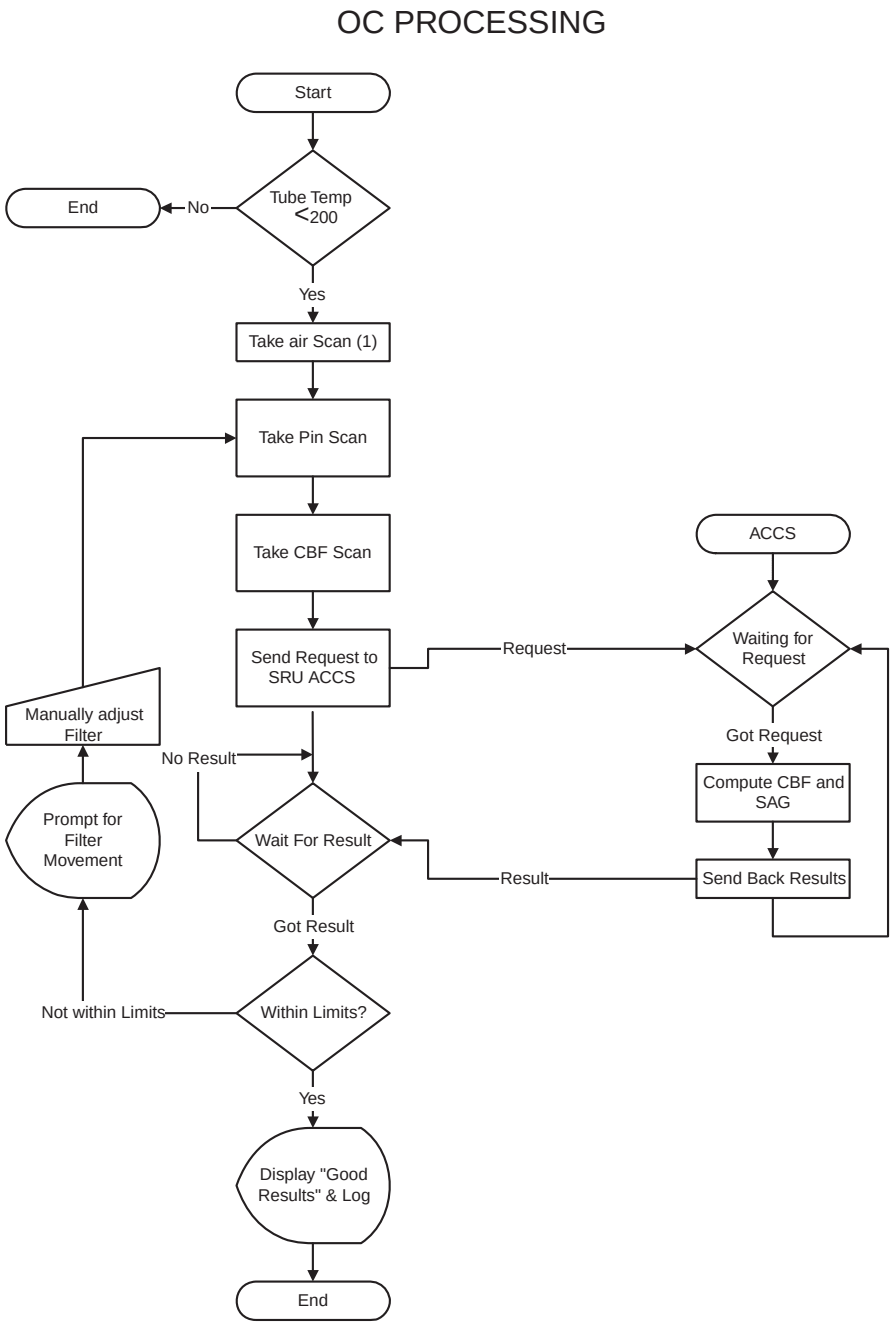

Figure 12-30 CBF Procedural Flow

6.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

NOTICE **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (gesys_suite.log)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.

This entry is created when Cancel is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.

Start Tube Alignments when 200.00 degrees Celsius is reported.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.

8.) Repeat steps 3 through 5 as necessary to generate updates in the gesyslog.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

6.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

6.3 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select CBF AND SAG ALIGNMENT

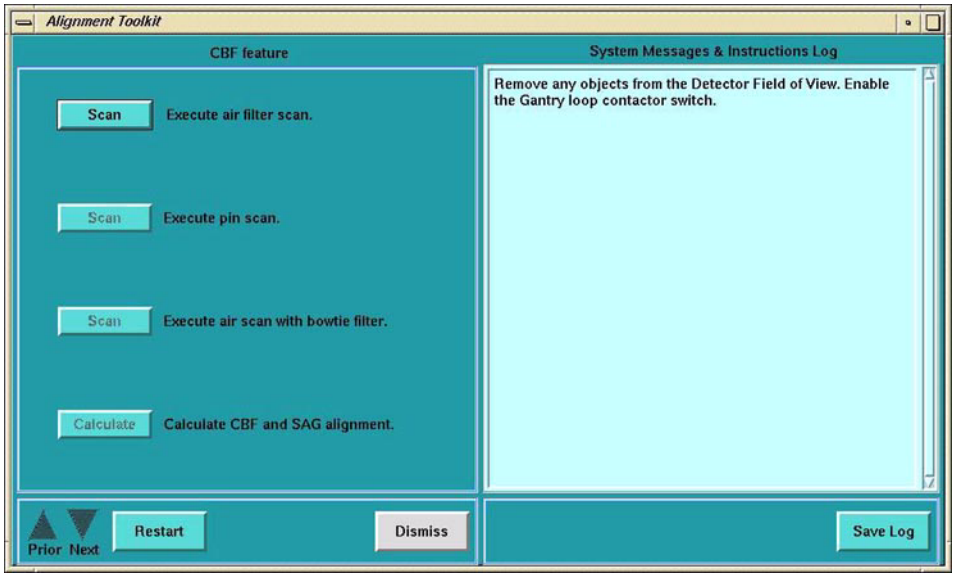

Figure 12-31 CBF / SAG Alignment Program Screen

6.4 Adjustment Procedure

1.) Click on the **SCAN** button to execute air filter scan.
2.) Place the 1/8 inch screw driver on the phantom holder (should be pointing into the Z direction).
3.) Execute pin scan.
4.) Execute air scan with bow-tie filter.
5.) Click on the **CALCULATE** button to calculate the CBF and SAG alignment.
6.) Mount indicator onto the HEMRC (Figure 12-32). *Make sure that you zero the Dial Indicator.*

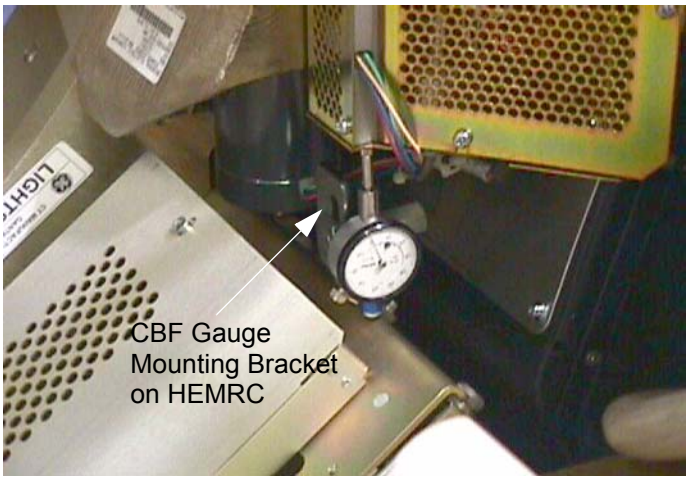

Figure 12-32 CBF Dial Indicator

7.) Loosen the six (6) M12 collimator cap screws. Four (4) cap screws on the front side of the collimator. (One cap screw is behind the cable connections. Use a swivel adapter for ratchet wrench.) Two (2) cap screws on the rear. Reference Figure 12-33.

NOTICE **Two (2) cap screws on the rear through the rotating base casting.**

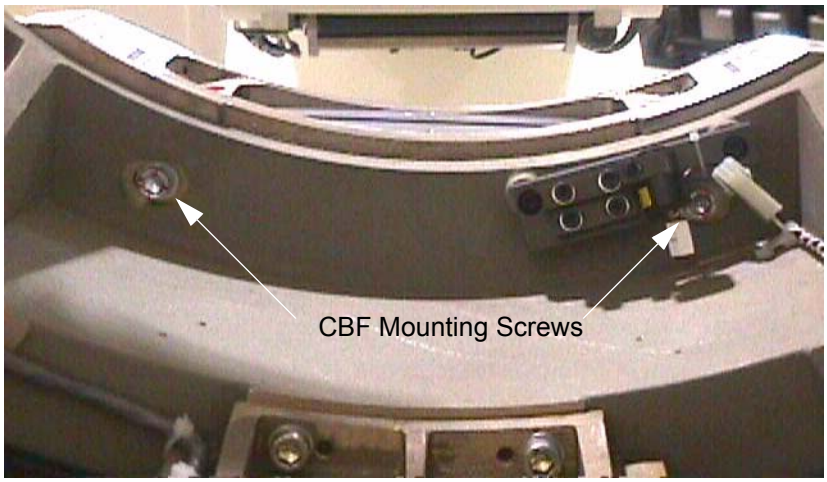

Figure 12-33 Collimator CBF Rear Mounting Screws

8.) Adjust the Collimator as indicated by the results of the calculation. (Ignore the negative sign in front of the adjustments.)

9.) Tighten the Collimator.

10.) Rescan and calculate.

11.) Proceed to the next step if the adjustment is within limit, otherwise jump to step 7.

12.) Torque all six (6) M12 cap screws to 49 ft/lbs (66.4 Nm)

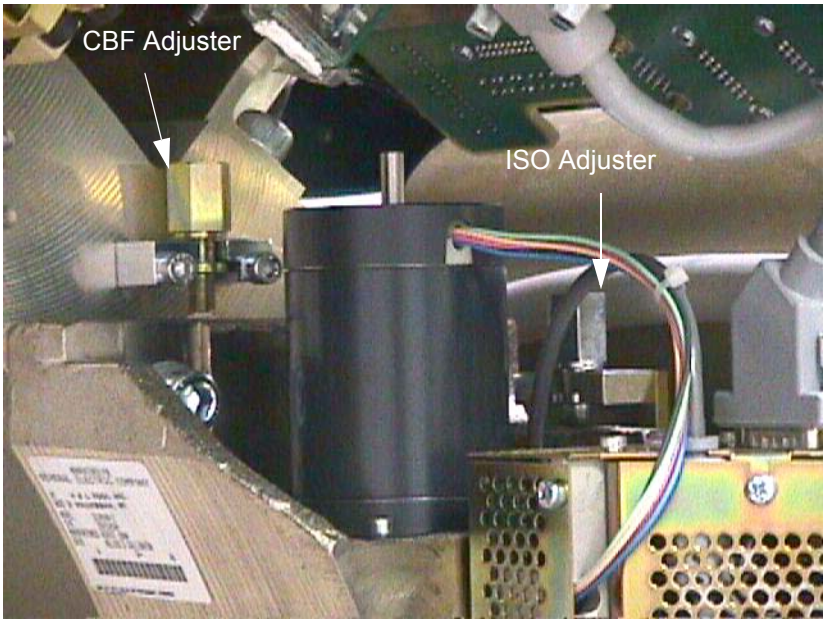

Figure 12-34 CBF Adjuster Location

Section 7.0
ISO Alignment

Cold ISO Alignment is done before the tube is heated by Generator calibrations. Hot ISO is done later. For details on Hot ISO, see Figure 9.0, on page 962.

Note: Perform Tube Installation Certification, if necessary. (See “SmarTube™ Setup” on page 925.)

7.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

⚠ **NOTICE** **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (gesys_suite.log)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.

This entry is created when Cancel is clicked.

bay57 dailyPrepRx
StateMachineEventNotify.c 411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.

Start Tube Alignments when 200.00 degrees Celsius is reported.

bay57 dailyPrepRx
StateMachineEventNotify.c 418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.

8.) Repeat steps 3 through 5 as necessary to generate updates in the gesyslog.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

7.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

7.3 Overview

The geometry of ISO alignment is shown in Figure 12-35. The following computational software are required for ISO alignment:

1.) Centroid calculation program as used by CT/I.

2.) ISO and CBF computation.

The scans required for ISO are the following:

A.) Air scans:

1.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture /4 sec/small spot/air filter/ rotating

2.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture/4 sec/large spot/air filter/ rotating

B.) Pin scans:

3.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture/4 sec/small spot/air filter/ rotating

4.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture/4 sec/large pot/air filter/ rotating.

For all above ISO/CBF scans, DAS gain should be set to its default level for that technique. After the scans are taken, the following computational steps should be carried out:

1.) Normalize scan data 3 & 4 using air scans 1 and 2 respectively.

2.) Compute centroid using data from scans 3 and 4 and average over all rows.

3.) Average the two numbers obtained in step 2 for large and small spots. This is our average centroid value.

4.) If the average value is at DAS Channel 389.75 ±.02 channels, the adjustment is done. Else move the tube by the following: move = (average value - IsoChan) *dischan* (FO/OD) mm

- Where: IsoChan = 389.75
- Dischan = channel to channel distance 1.0239 mm
- FO = source to iso center distance 541 mm
- OD = Iso center to detector distance 408 mm

Take scans 3 and 4 and repeat centroid computation. Please note that if the computed ISO channel is out more than 1 channel, all four scans must be taken for each successive iteration.

Please note that the ISO values for small and large focal spots must be saved for use by the reconstruction process.

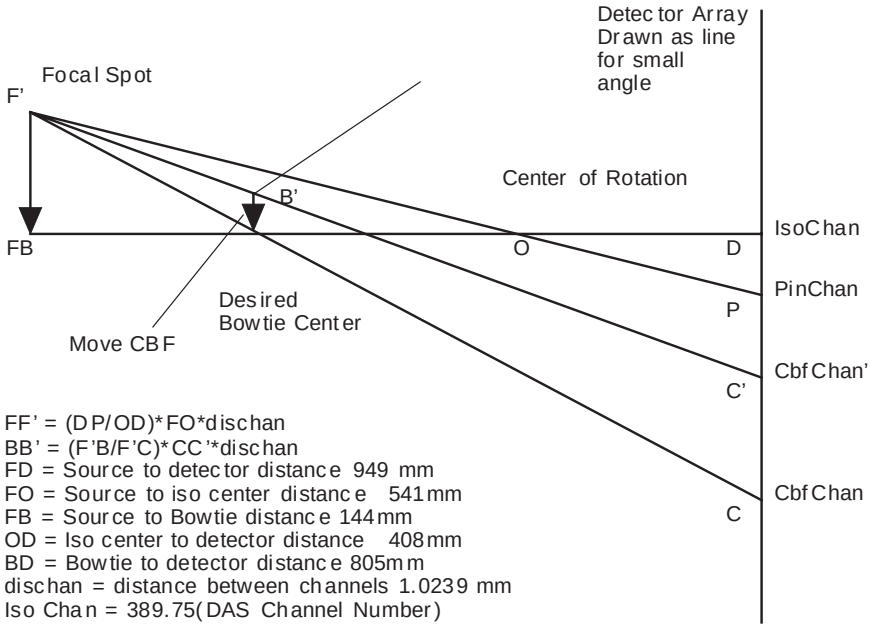

Figure 12-35 Geometry for CBF/ISO Adjustment

7.4 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select ISO ALIGNMENT

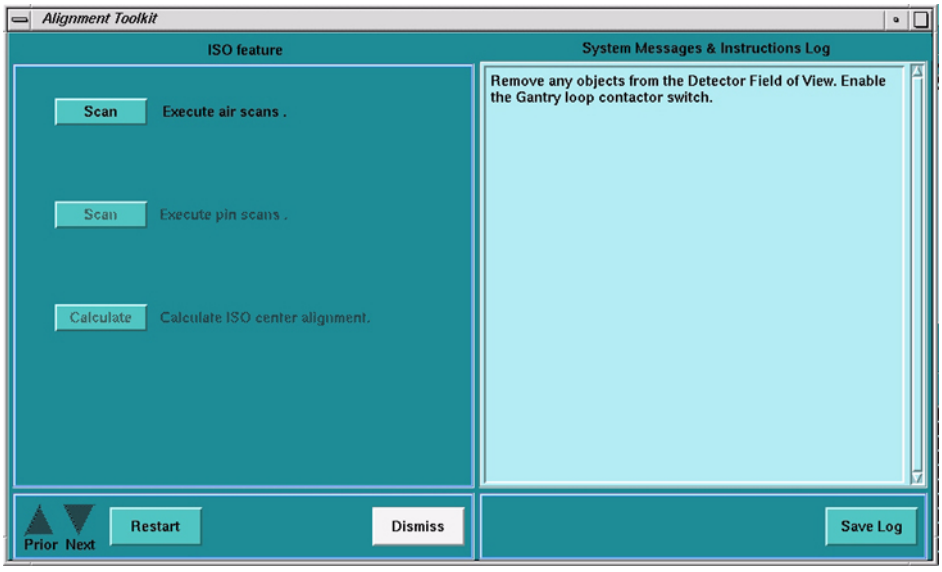

Figure 12-36 ISO Alignment Menu

7.5 ISO Adjustment Procedure

1.) Execute Air scan (small spot).
2.) Execute Air scan (large spot).
3.) Place the 1/8 inch screw driver on the phantom holder (should be pointing into the Z direction).
4.) Execute pin scan (small spot).
5.) Execute pin scan (large spot).
6.) **CALCULATE** ISO center alignment.
7.) Mount the dial indicator on the tube assembly. (Figure 12-37.) Make sure that you zero it.

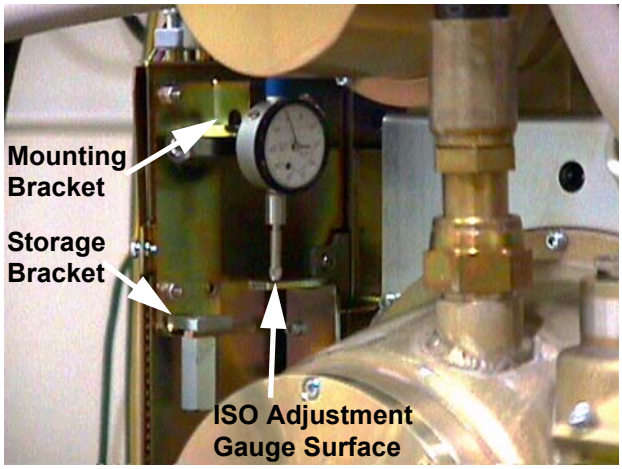

Figure 12-37 ISO Dial Gauge Mounting Location

8.) Loosen the 4 M-12 bolts on the tube assembly.
9.) Adjust the tube UP / DOWN as indicated by the calculation. The adjustment bolt is located on the top of the tube - Please see Figure 12-38.

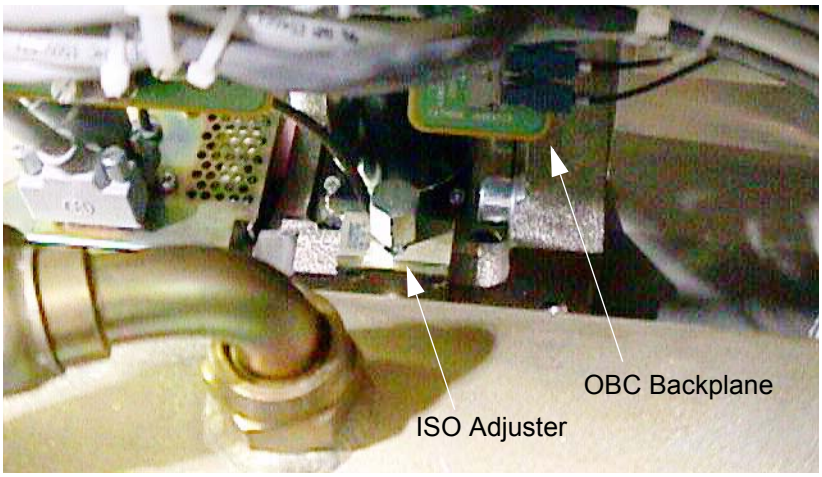

Figure 12-38 ISO Alignment Adjuster

10.) Tighten the four (4) M12 bolts and verify dial gauge still reads the correct adjustment value.
11.) Repeat steps 1 through 6.
12.) If the adjustments are within limit proceed to the next step, otherwise go to step 9.
13.) Tighten the four (4) M12 bolts. Torque to 49 ft-lbs (66.4 Nm).
14.) Wait 15 minutes, then recheck BOW to verify that the Beam-on-Window values are within the

drift spec of -1.5mm ±0.5mm.

- If BOW is within spec, DO NOT adjust anything
- If BOW is out of spec, alignments must be done, starting with POR and ending with BOW recheck.

Section 8.0
Calibration - High Voltage

8.1 Access HV Maintenance through Service Desktop

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.

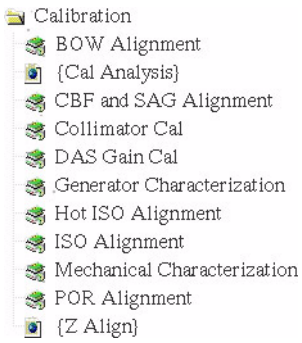

Figure 12-39 Calibration Menu Screen

8.2 Generator Characterization

Use the Generator Characterization Program to update the “small spot” and “large spot” characterization files, to provide a starting point for the closed loop mode of the generator. This iterative process requires several scans at a different KV/MA/spot size. It calculates corrections, repeats the scan until the results fall within tolerance, then updates the characterization file.

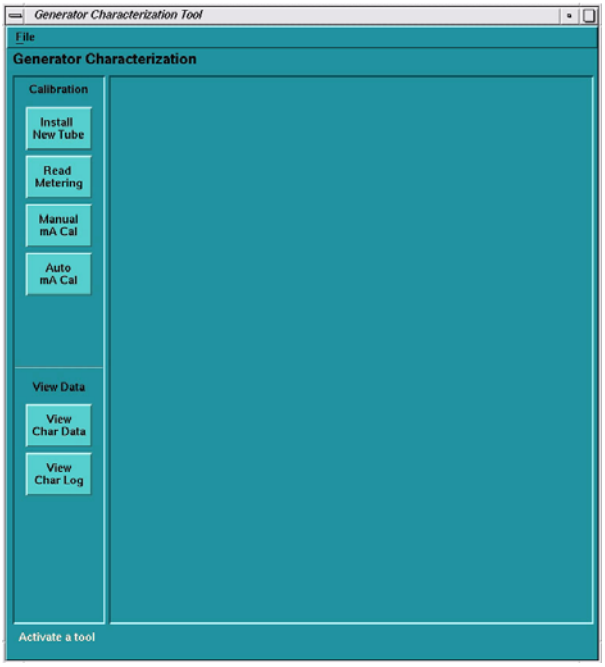

Figure 12-40 Generator Characterization Menu Screen

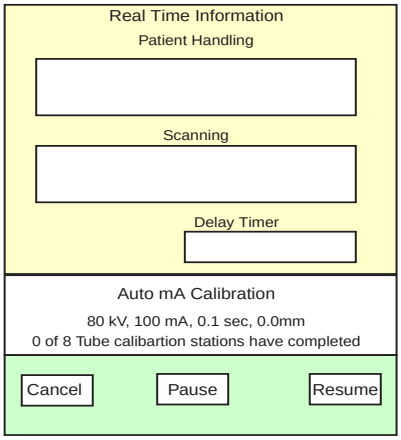

Figure 12-41 Auto mA Calibration Status Screen

8.3 Verify kV Meter

This section describes the calibration check of system internal kV metering circuits.

1.) Select READ METERING.

2.) Select RUN to start the test. During the test, the firmware reads the metering circuits in the OFF state, then reads the metering circuits in the ON state, and finally reports the readings to the display.

3.) Compare the data in the “Delta” column on the Read Meter screen (Figure 9-4) to the data in the “Limit” column.

Note: “Delta” = DVM - A/D

CIRCUIT "OFF"	CIRCUIT "ON"
Anode kV = 0 ± 0.5	Anode kV = 50 ± 7.5
Cathode kV = 0 ± 0.5	Cathode kV = 50 ± 7.5
Total kV = 0 ± 0.5	Total kV = 100 ± 15.0

Table 12-1 Generator Characterization Test Specifications

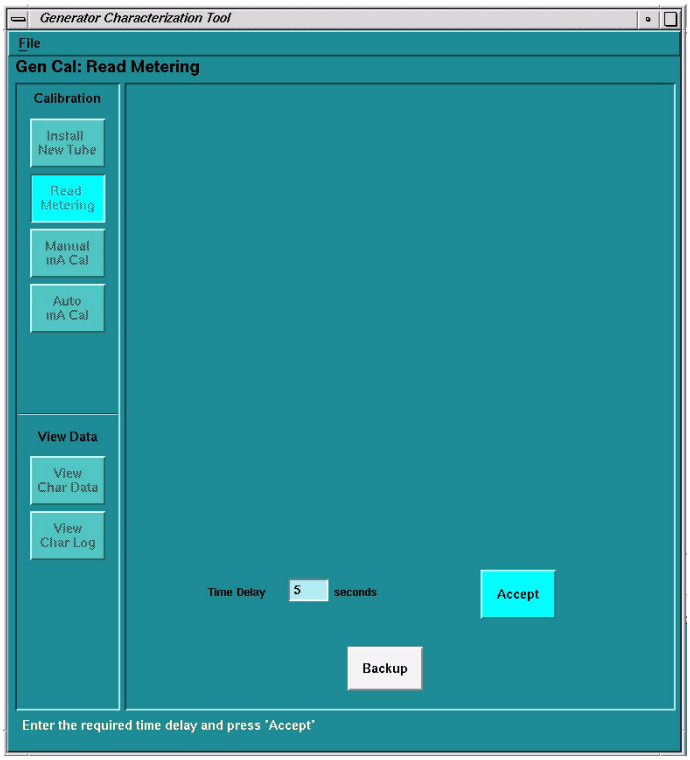

Figure 12-42 Read Metering Screen

8.4 Verify mA Meter

WARNING **WHEN SERVICING THE GANTRY:**

- **NEVER PUT ANY BODY PART INTO THE GANTRY WITHOUT FIRST DISABLING THE AXIAL DRIVE AND RE-VERIFYING (CHECK TWICE) THAT IT IS DISABLED.**
- **ENSURE THAT THE DRIVE STATUS LED (Figure 12-43) IS NOT LIT. DO NOT SERVICE THE GANTRY IF THIS LED IS ON.**

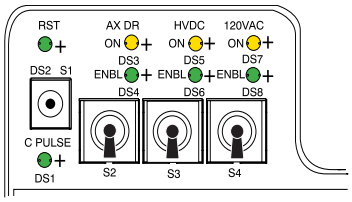

Figure 12-43 STC Backplane Service Switches

This section describes the calibration check system internal mA metering circuits.

1.) Inside the Gantry:

a.) Switch OFF the **HVDC ENABLE** on STC backplane.

b.) Switch OFF the **AXIAL DRIVE ENABLE** on STC backplane.

c.) Rotate the Anode tank to the 2 o'clock position.

d.) Engage the gantry rotational lock.

2.) Select SERVICE DESKTOP.

3.) Select CALIBRATION.

4.) Select GENERATOR CHARACTERIZATION.

5.) Select READ METERING.

Note: On the display, type/enter a time delay in seconds, to provide enough time for you to walk from the console to the DVM, and record the reading. The test will not begin until this time delay expires.

Once it begins, the test enables the meter circuit for only 4 seconds.

6.) Use a DVM as an mA meter; connect it to the hardware on the anode side:

a.) Connect the black lead to TP8 (ACAL1) on the mA board.

b.) Connect the red lead to TP11 (ACAL2) on the mA board.

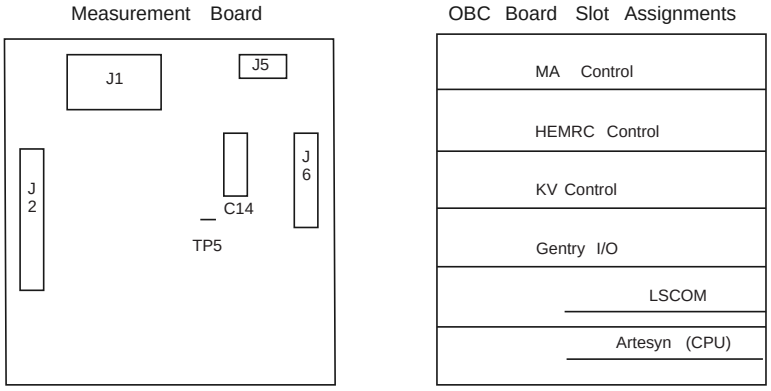

Figure 12-44 Tank Measurement Board

7.) On the Display, select the ACCEPT button.

8.) Record the displayed, and measured, Anode mA values for "Circuit OFF" and "Circuit ON".

Note: Your system has the test wire to TP5 included in the harness, the Cathode side should read approximately 19 mA during "Circuit On".

9.) Disconnect the test equipment from the Anode side, if used.

Note: When you exit Generator Characterization, this test may generate

kV board tube spit counter = x error messages.

10.) Use a DVM as an mA meter:

a.) Connect the black lead to TP9 (CCAL1) on the mA board.

b.) Connect the red lead to TP14 (CCAL2) on the mA board.

11.) On the Display, Select the ACCEPT button.

12.) Record the displayed, and measured, Cathode mA values for "Circuit OFF" and "Circuit ON".

Note: Your system has the test wire to TP5 included in the harness, the Anode side should read approximately 20mA during "Circuit On".

13.) Disconnect the test equipment from the Cathode side if used.

Note: When you exit Generator Characterization, this test may generate

kV board tube spit counter = x error messages.

8.5 KV Gain Pots Adjustment

8.5.1 Install HV Divider

1.) Inside the Gantry on the STC backplane:

a.) Switch OFF the **HVDC ENABLE**.

b.) Switch OFF the **AXIAL DRIVE ENABLE**.

c.) Rotate the Tube to the 3 o'clock position

d.) Engage the gantry rotational lock.

e.) Switch OFF the **120 VAC GANTRY POWER**.

f.) Install the HV Divider between Tube and Tanks.

Note: Place the HV Divider on a table or tube hoist, so the cables reach the tube.

2.) Add a ground wire (minimum size of AWG 12) from Tube ground to bleeder ground. Refer to Figure 12-45.

CAUTION Potential Electrical Hazard

Performix tube unit MUST be grounded to the gantry during testing.

3.) Switch ON the **120 VAC GANTRY POWER**.

4.) Switch ON the **HVDC ENABLE**.

5.) Press the button, on the gantry control panel, turning ON the drives power.

Note: If the gantry covers are removed press the **RESET BUTTON** on the STC backplane to turn ON Drives power.

6.) Reset the hardware.

NOTICE Potential for tube damage

Incorrect installation of anode and cathode HV cables can destroy the Performix tube unit.

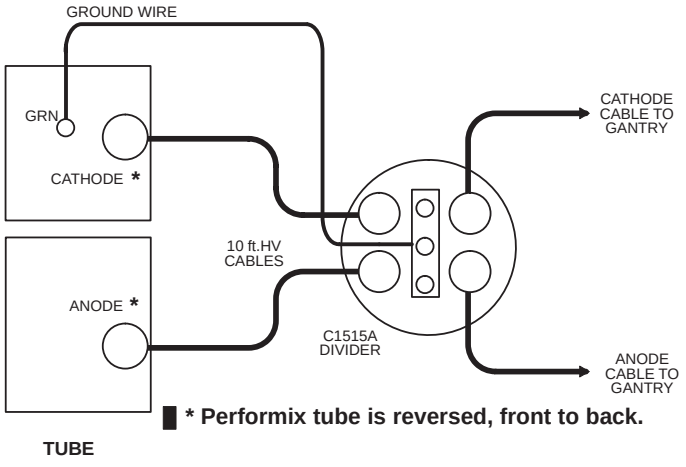

Figure 12-45 HV Divider Installation

8.5.2 Setup Instrumentation

Use an oscilloscope with 10X probes

1.) Use the Gantry Service Outlet to provide 120 Vac power for the scope. This will reduce noise

on the scope waveform.

2.) Connect **channel one** to the **anode** output of the divider. Connect scope ground to bleeder ground.

3.) Connect **channel two** to the **cathode** output of the divider. Connect scope ground to bleeder ground.

Note: In order to minimize bleeder-induced ripple on the kV waveform, connect a 30 foot Belden shielded twisted pair cable between the scope probes and the bleeder.

4.) Trigger channel one, positive, DC couple, trigger mode normal.

5.) Channel one and two, 10v/div, time base 200ms.

6.) Invert Channel two.

8.5.3 Calibrate the Cathode

1.) Select SERVICE DESKTOP.

2.) Select REPLACEMENT.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select BLEEDER SETUP and LOAD.

6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON — Interscan Delay **2.00**
- **1 SECOND** — DAS Gain **31**
- **1 SCAN** — Gantry Tilt **0.0**
- FOCAL SPOT LARGE — Trigger Rate 984
- **100 KV** — Filter BLOCKED
- **50 MA** — Calibration Vector NONE
- MONITOR ENABLE

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV equals 50 ± 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Cathode pot on the kV board, until the scope reading for the Cathode kV, and the displayed reading for the Cathode kV in the message log, fall within ±0.5kV of each other.

9.) Use the pot, labeled CAKV, R316, on the kV board, to adjust the scope reading.

- CCW decreases the scope kV.
- CW increases the scope kV.
- 1/2 turn equals approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

8.5.4 Calibrate the Anode

1.) Select SERVICE DESKTOP.

2.) Select REPLACEMENT.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select BLEEDER SETUP and LOAD.

6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON — Interscan Delay **2.00**
- **1 SECOND** — DAS Gain **31**
- **1 SCAN** — Gantry Tilt **0.0**

- FOCAL SPOT LARGE Trigger Rate 984
- **100 KV** Filter BLOCKED
- **50 MA** Calibration Vector NONE
- MONITOR ENABLE

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV is 50 ± 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Anode pot on the kV board, until the scope reading for the Anode kV, and the displayed reading for the Anode kV in the message log, fall within ±0.5kV of each other.

9.) Use the pot, labeled ANKV, R318, on the kV board, to adjust the scope reading.
- CCW decreases the scope kV.
- CW increases the scope kV
- 1/2 turn is approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

8.5.5 Measure Total kV

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following DDC parameters:
- STATIC X-RAY ON Interscan Delay **2.00**
- **1 SECOND** DAS Gain **31**
- **1 SCAN** Gantry Tilt **0.0**
- FOCAL SPOT LARGE Trigger Rate 984
- **100 KV** Filter BLOCKED
- **50 MA** Calibration Vector NONE
- MONITOR ENABLE

7.) Change the oscilloscope to add ch.1 and ch.2, to read total kV from the HV divider.
8.) Channel one and two, 20v/div, time base 200ms, trigger channel. one, positive.
9.) Select ACCEPT RX.
10.) Record the scope reading, and the Average. kV displayed in the message log, in **FORM 4879**.
11.) Display the Generator Characterization menu.
12.) Toggle the soft-key MONITOR ENABLE **OFF**, so the message log no longer displays kV and mA readings.

8.5.6 Verify kV Meter

Use this procedure to verify the calibration of the internal kV metering circuits.

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.
4.) Select READ METERING.

5.) Select ACCEPT.
- The test begins after the time delay expires.
- Once the test begins, the software enables the meter circuit for 4 seconds.

6.) Record the displayed Anode kV, Cathode kV and Total kV values in the **FORM 4879** "Circuit OFF" and "Circuit ON" table.

7.) Select BACKUP.

8.5.7 Remove the External HV Divider

1.) Press the button, on the gantry control panel, turning **OFF** the drives power.

Note: If the gantry covers are removed, proceed to step 2.

2.) Inside the Gantry on the STC backplane:

a.) Switch OFF the **HVDC ENABLE**.

b.) Switch OFF the **AXIAL DRIVE ENABLE**.

c.) Switch OFF the **120 VAC GANTRY POWER**.

3.) Remove the HV Divider between the Tube and Tanks (Figure 12-43, on page 952).

4.) Reconnect the HV cables for normal operation.

NOTICE **Incorrect installation of anode and cathode HV cables can destroy the Performix tube.**

5.) Re-apply paper toweling around tube locking ring to absorb excess oil.

6.) Disengage the gantry rotational lock.

7.) Inside the Gantry on the STC backplane:

a.) Switch ON the **HVDC ENABLE**.

b.) Switch ON the **AXIAL DRIVE ENABLE**.

c.) Switch ON the **120 VAC GANTRY POWER**.

8.) Press the button, on the gantry control panel, turning ON the drives power.

Note: If the gantry covers are removed, press the **RESET BUTTON** on the STC backplane to turn ON Drives power.

9.) Reset the hardware.

8.5.8 Install New Tube Program

Use this program to complete Auto mA Cal on a new tube. *Run this program only on a new tube.*

Refer to Figure 9-5.

1.) Select SERVICE DESKTOP.

2.) Select CALIBRATION.

3.) Select GENERATOR CHARACTERIZATION.

4.) Select the INSTALL NEW TUBE.

Note: The system automatically warms up the tube.

5.) The system prompts you with the tube type. Verify the number corresponds to your tube type; answer **Y** or **N**.

SOFTWARE TOKEN	HOUSING NUMBER	INSERT NUMBER
12-MX_135CT	46-274800G1	46-274600G1
13-MX_165CT	46-309500G2	46-309300G1
14-MX_165CT_I	46-309500G2	46-309300G2
15-MX_200CT	2137130-2	2120785

Table 12-2 Tube Type Table (SW tokens for various Housings and Inserts)

6.) Press **START SCAN** when it flashes, to automatically run the program and update the display:
seed filament current shift scans

8.5.9 Auto mA Calibration

Run this program when you replace the X-Ray tube, or the system requires re-calibration.

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.
4.) Select AUTO MA CAL.

Note: The software automatically warms up the tube.

5.) Press **START SCAN** when it flashes, to automatically run the program and update the display:
– Ductility warm-up -
– Auto mA Cal -
6.) The system displays the final filament currents on the screen.

8.5.10 KV Rise and Fall Times

1.) In the OBC, connect a scope to the KV board.
- Channel 1: Exposure Command EXCM, TP5. Scope ground to LGND, TP3, 2v/div
- Channel 2: Total kV KVTB, TP11. (At this test point KV = 20KV per volt.)
  Scope ground to AGND SGND, TP12, 1v/div

2.) Set the Scope Time base to 200 usec.
Positive or Negative trigger as required.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select RISEFALL and LOAD.

TECHNIQUE		RISE		FALL	
kV	mA	**Record** Delay ms	Limit	**Record** Delay ms	Limit
80	400		0 +1.9 ms	Test not required.	N/A
140	40	Test not required.	N/A		-0 +0.5 ms

Table 12-3 kV Rise and Fall Time Record Table

Note: See Figure 12-46, on page 959, and Figure 12-47, on page 960, for measurement clarification.

8.5.11 Measure Rise Time

1.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	DAS Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **80 KV**	Filter BLOCKED
- **400 MA**	Calibration Vector NONE

Note: Measure rise time only on the 80kV/400mA scan.

2.) Select ACCEPT RX.

3.) Select PAUSE after the start of scan, to prevent the scope from displaying the fall time.

4.) After you record the rise time, select the RESUME to initiate the fall time scan.

5.) Record the delay between the rise of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).

- Do not include the waveform overshoot.
- The 75% point for 80kV equals 60kV.

Note: Refer to Figure 12-46 for measurement clarification.

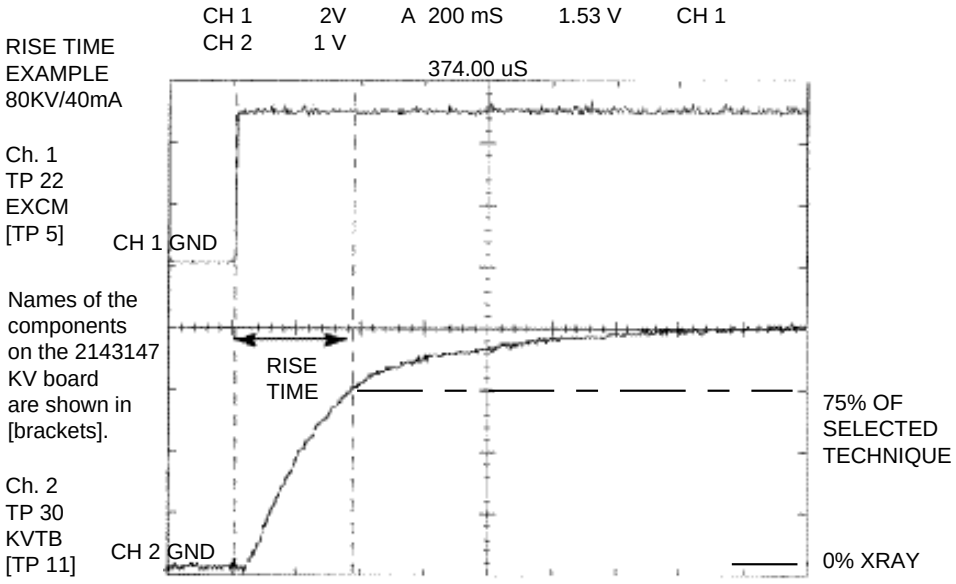

Figure 12-46 Rise Time Measurement

Note: The 75% point for:

- 80kV equals 60kV
- 100kV equals 75kV
- 120kV equals 90kV
- 140kV equals 105kV

8.5.12 Measure Fall Time

1.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	DAS Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**

- FOCAL SPOT LARGE — Trigger Rate 984
- **140 KV** — Filter BLOCKED
- **40 MA** — Calibration Vector NONE

Note: Measure fall time only on the 140kV/40mA scan.

2.) Record the delay between the fall of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).

- Do not include the waveform overshoot.
- The 75% point for 140kV equals 105kV

Leave the scope connected for the next test.

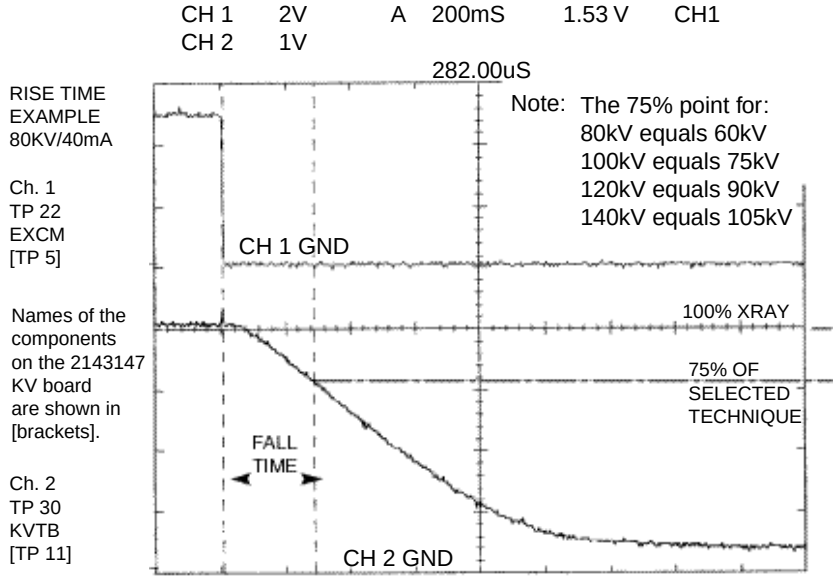

Figure 12-47 Fall Time Measurement

8.5.13 Verify Internal Scan Timer

1.) Select DIAGNOSTIC DATA COLLECTION (DDC).
2.) Select PROTOCOL NAME.
3.) Select SCANTIMER and LOAD.
4.) Toggle the softkey MONITOR ENABLE to **ON**, to display the scan time in the message log.
5.) In the OBC, connect a scope to the kV board, as follows:

a.) Channel 1, Exposure Command (EXCM, TP22). Scope ground to TP3, 2v/div
b.) Channel 2, Total kV, TP11. Scope ground to SIG, TP12, 1v/div
c.) Set the Scope Time base to 200msec, positive trigger.

6.) Verify/Set-up the following DDC parameters:

- STATIC X-RAY ON — Interscan Delay **2.00**
- **1 SECOND** — DAS Gain **31**
- **1 SCAN** — Gantry Tilt **0.0**
- FOCAL SPOT LARGE — Trigger Rate 984
- **100 KV** — Filter BLOCKED
- **40 MA** — Calibration Vector NONE

7.) Record the measured scan time from the oscilloscope and the displayed scan time from the message log. Spec limits are as follows:

Note: Scope Exposure Duration = 0.96 to 1.04 s.
Displayed Exposure Duration = 0.99 to 1.02 s.

8.) Toggle the softkey MONITOR ENABLE **OFF**, to stop the scan time display in the message log.
Failure to turn the MONITOR ENABLE **OFF** results in the system message log filling with exposure information.

9.) Disconnect the scope from the kV board.

10.) Replace the OBC cover**.**

Section 9.0
HOT ISO Alignment

9.1 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select HOT ISO ALIGNMENT.

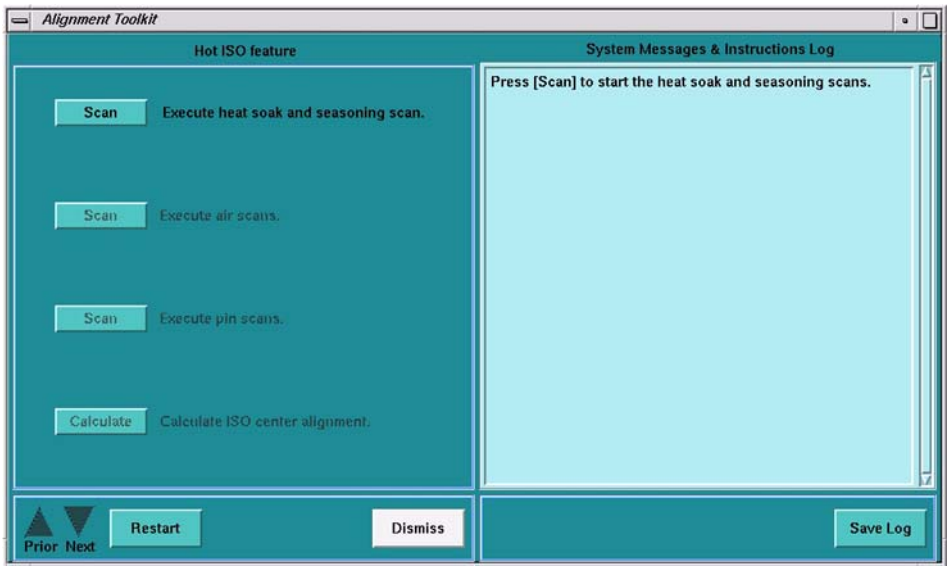

Figure 12-48 HOT ISO Screen

9.2 Adjustment Procedure

1.) Execute the Heat Soak and Seasoning scan.
2.) Execute Air Scan (small spot).
3.) Execute Air Scan (large spot).
4.) Place the 1/8 inch screw driver on the phantom holder (should be pointing into the Z direction).
5.) Execute Pin Scan (small spot).
6.) Execute Pin Scan (Large spot)
7.) Calculate correction factor with Calculate button.

Note: No movement of the tube is required. This is a software correction done automatically.

8.) Perform Tube Installation Certification, if necessary. (See “SmarTube™ Setup” on page 925.)

Section 10.0
DAS Gain Calibration

1.) Perform DAS Gain Calibration by selecting the function from Scanner Utilities (**left head**).
2.) Select SCANNER UTILITIES, and Select DAS GAIN CALIBRATION**.**
3.) Ensure that there is nothing in the x-ray beam and continue.
4.) The system will now perform a Mylar window check and provide the appropriate messages if the window should need cleaning.
5.) Upon completion of the Mylar window scans the system will now take 31 scans and save the results in the Calibration Data Base. The system will provide the appropriate messages if the calibration should fail.

Section 11.0
Collimator Calibration

1.) Perform Collimator Calibration by selecting the function from Scanner Utilities (**left head**).
2.) Select SCANNER UTILITIES, and Select COLLIMATOR GAIN CALIBRATION.
3.) Ensure that there is nothing in the x-ray beam and continue.
4.) The system will now perform a Mylar window check if needed and provide the appropriate messages if the window should need cleaning.
5.) Upon completion of the Mylar window scans the system will now take 8 scans and save the results in the Calibration Data Base. The system will provide the appropriate messages if the calibration should fail.

Section 12.0
Calibration Process

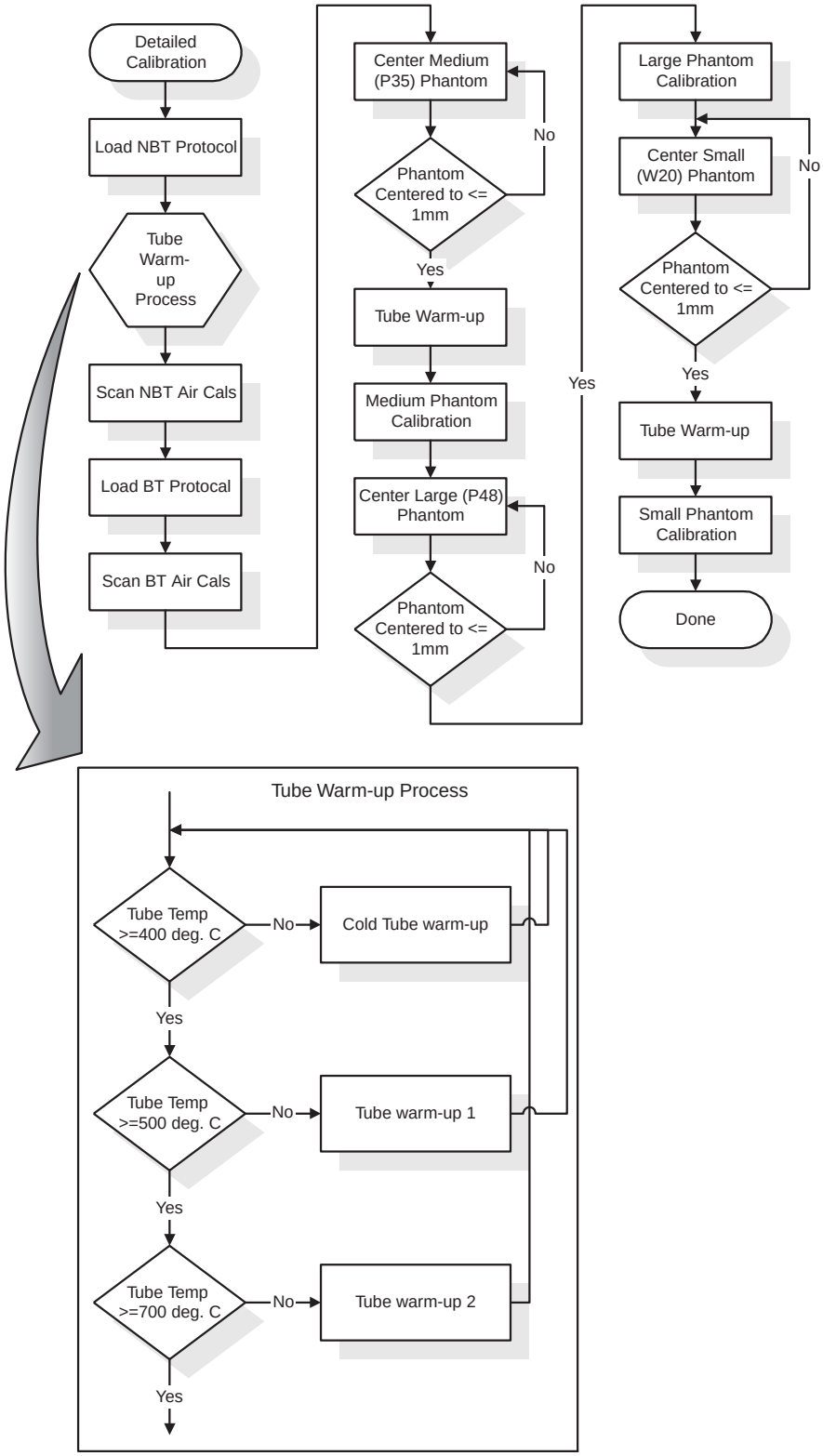

Figure 12-49 Calibration Flowchart: Non-Bow-tie, Bow-tie and Phantom Centering

1.) Bringing up the main menu: It is represented as an icon located on the bottom of the screen labeled as “Scanner Utilities”. Click the on-screen SCANNER UTILITIES button (**left head**).

2.) The Main menu consists of the following three button selections:

- Detailed Calibration - Brings up the Detailed Calibration screen.
- Adjust CT Number - Not implemented at this time
- Quit - Exits the application

3.) Detailed Calibration menu (refer to Figure 12-50)

Click the on-screen button DETAILED CALIBRATION. The Detailed Calibration screen consists several rows of toggle buttons that can be selected to build the desired techniques needed to perform detailed calibration processing. These buttons are located on the top left area of the screen.

- kV toggle button selections: 80 kV, 100 kV, 120 kV, and 140 kV.
- SFOV toggle button selections: Small/Head and Large/Body
- Slice Collimation toggle button selections: 4x1.25, 4x2.50, 4x3.75, and 4x5.00.
- Focal Spot toggle button selections: Small and Large.

Comment: *The defaults select all techniques and aperture settings. The customer has the option to select specific kVs that are used most often. It is preferred to calibrate all kV stations. All aperture settings must be calibrated or they cannot be used for scanning.*

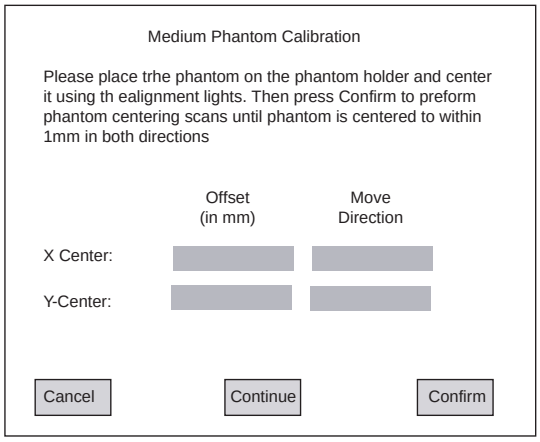

Figure 12-50 Phantom Centering & Calibration Screen

Note: There is also an option to perform new non-bow-tie air calibrations whether data from previous non-bow-tie calibrations exist in the CAL database or not. New non-bow-tie air calibration data can be created by selecting the option button labeled as “Acquire Non-Bow-tie Air Scans” on the GUI. If this button is not selected, then the application performs a series of checks to determine whether non-Bow-tie air scans are necessary. Click the on-screen button CONFIRM.

4.) Activation (Scan List) Screen

Initially, the scrolled window on this screen displays a list of all scans that is performed for one of the following processes:

- Tube Warm up processing: Cold Warm up, Warm up 1, or Warm up 2
- Non-Bow-tie Air Calibration processing
- Bow-tie Air Calibration processing

The Activation screen title changes dynamically to indicate which process is currently being executed.

If for any reason a problem is detected, the current scan and processing aborts and the last scan be reacquired. When a problem is detected, the Activation screen’s “Pause” button

becomes a “Resume” button, scanning and processing of the current scan is aborted, and an error message may be displayed on the log.

At this point, selecting the “resume” button is recommended to re-acquire the last scan in order to continue the detailed calibrations. This logic is implemented for all air and phantom scanning and processing.

5.) Phantom Centering and Calibration Screen (Figure 12-50)

This screen is displayed automatically after the air calibrations complete successfully. For each Phantom there are two functions that must be accomplished on this level of processing: phantom centering and phantom calibrations. Medium, Large and Small phantom centering and calibrations are accomplished respectively using this GUI window.

FOLLOW THESE STEPS:

a.) Place the correct size phantom on the phantom holder of the Gantry.

b.) Align the phantom manually on the gantry by using the alignment lights as a guide.

c.) On the small water phantom, make sure the alignment lights are centered on the water section. The black markers on the phantom are centered on the resolution section and the center of the water section is 60mm (2-3/8 inches) in front of the markers.

d.) Select the CONFIRM button to calculate the accuracy of the alignment. A list of scans needed for phantom centering is displayed and executed. When this process completes, the Activation screen disappears and the x and y coordinate values are displayed in the “Offset” fields provided for the “X-Center” and “Y-Center” rows. These fields are located directly below the instructions field.

e.) If either x or y coordinate value is greater than 1mm, repeat steps 2 and 3 until both values are less than or equal to 1 mm. The values in the field “Move Directions” indicate where to move the phantom on the gantry to help in aligning the phantom more accurately.

f.) Once x and y coordinates are less than or equal to 1mm, the phantom is centered and ready to be calibrated. Select the “Continue” button to begin calibrations.

g.) The “Cancel” button may be selected at any time while scanning is not in progress. This brings down the window and re-displays the Detailed Calibration screen.

Note: As soon as the CONTINUE button is selected, the application checks the X-ray tube temperature to determine whether the tube needs to be warmed up before scanning can begin.

WARNING **THERE IS A REQUIREMENT THAT THE PHANTOM CENTERING PROCESS MAY NOT EXCEED A TOTAL OF 10 MINUTES TO COMPLETE. IF THE PROCESS EVER EXCEEDS THIS TIME LIMIT, DETAILED CALIBRATIONS CANNOT CONTINUE AND MUST BE ABORTED.**

Section 13.0
Gantry Rotation Safety Check

This test proves that the scanner is safe to rotate at maximum rotation speed.

WARNING **CRUSH HAZARD.**

EQUIPMENT COULD EJECT FROM GANTRY.

ENSURE THAT NO PERSONNEL ARE IN THE SAME ROOM/AREA AS THE GANTRY, PRIOR TO AND DURING THIS SCAN.

Use DDC to Rotate the Gantry for 10 minutes, at the fastest allowed gantry speed.

1.) Launch Diagnostic Data Collection (DDC) Utility:
   a.) Open the Common Service Desktop
   b.) Click on the DIAGNOSITICS Icon
   c.) Click on the DATA ACQUISITION Folder
   d.) Click on the DIAGNOSTIC DATA COLLECTION Menu Item
2.) Prepare System for DDC Scan. Refer to Figure 12-51.
   a.) Select ROTATING X-RAY OFF
   b.) Type: **120** in Scan Time (sec) field
   c.) Type: **0** in the Gantry Velocity (sec/rev) field and press **ENTER**. The system will then default to the fastest allowable service mode revolution time.
   d.) No of Scans = **5**. This will result in 10 minutes of rotation.
   e.) Verify other settings, as shown.
   f.) Click on ACCEPT RX button, to send scan request to firmware

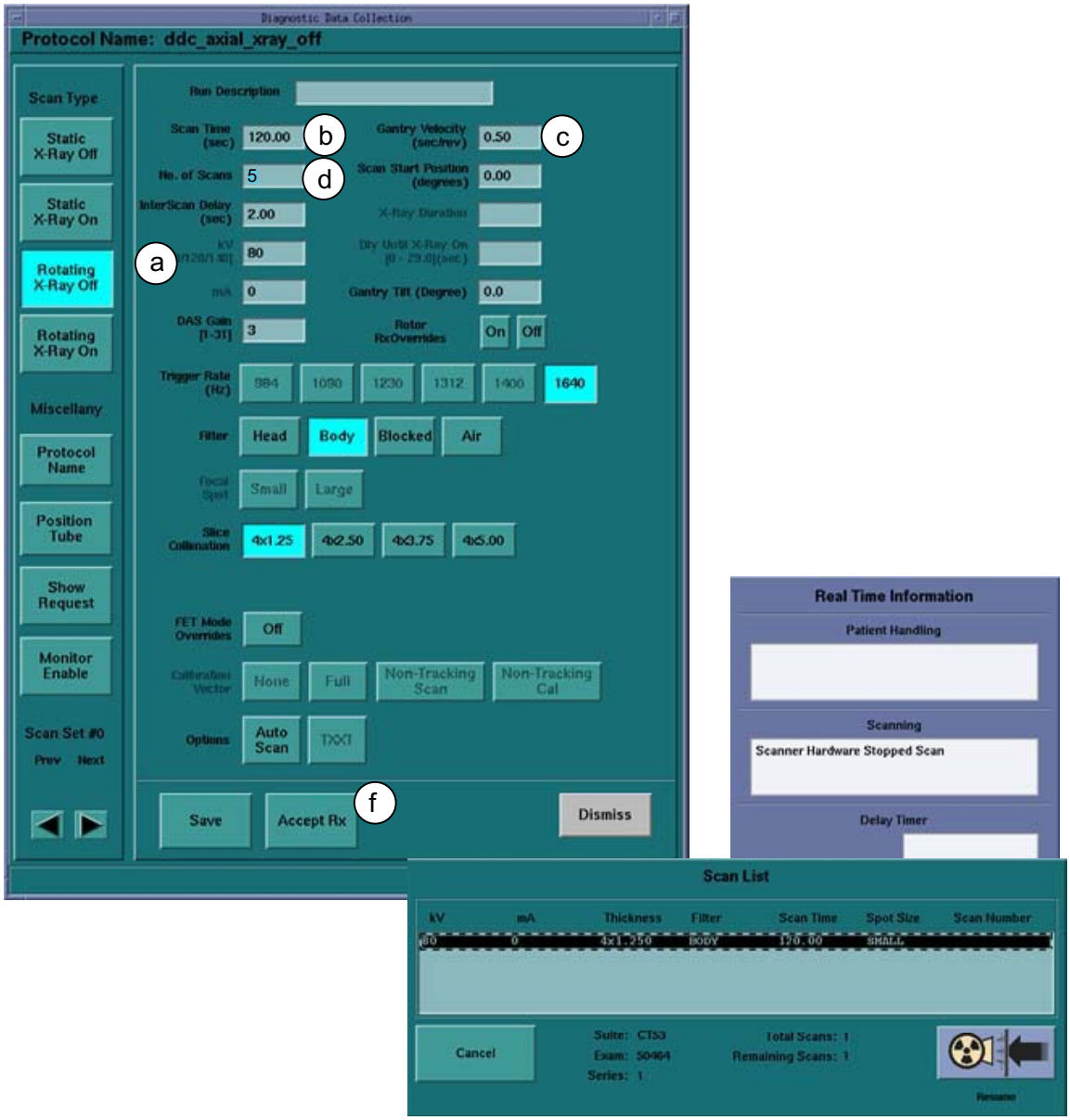

Figure 12-51 DDC Tool

The Utility:

- Displays the Scan List GUI and the Real Time Information window.
- After a few seconds, it starts flashing the **SCAN** button on the console.

3.) Press the Scan button on the Console, to start the DDC Scan. When complete, the DDC Utility dismisses the Scan List GUI and the Real Time Information window.

4.) If no issues arise, gantry rotation capability is safe for use.

Section 14.0
Exposure Time Accuracy

Begin at the top level Service Screens, and execute the following sequence of soft-keys:

1.) Select SERVICE DESKTOP.
2.) Select DIAGNOSTICS.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select MONITOR ENABLE, to display scan times in the message log.
5.) Change to the EXAMRX Desktop.
6.) Select NEW PATIENT and prescribe the following scans.

Section 15.0
Scout Scan Times

Use examrx to take scout scans with the following distances. (Total of six scans.)

1.) Distance in mm: **20, 25, 30, 40, 150, 300, 480**
2.) Use **120KV** and **40MA**
3.) Record the scan time, displayed in the message log, on the HHS data sheet.

Section 16.0
Axial and Helical Scan Times

16.1 Axial Scans

Use normal applications (new patient) to acquire Axial Scans with the following parameters:

1.) Use **120KV** and **40MA**

2.) Use the following scan time and FOV

SELECTED TIME	FOV
0.6 sec	small FOV
0.6 sec	large FOV
1.0 sec	large FOV
2.0 sec	large FOV
3.0 sec	large FOV
4.0 sec	large FOV

Table 12-4 Axial Scan Times and FOVs

16.2 Helical Scans

Use normal applications (NEW PATIENT) to acquire Helical Scans with the following parameters:

1.) Use **120KV** and **40MA**

2.) Use **10MM** Scan Thickness

3.) Use the following scan time and location

SELECTED TIME	SCAN LOCATION
15.0 sec	S70-170
28.0 sec	S135-I135
30.0 sec	S145-I145

Table 12-5 Helical Scan Times and FOVs

4.) When you complete the scan time tests, switch back to the SERVICE DESKTOP to display the Diagnostic Data Collection screen, and toggle the MONITOR ENABLE **OFF**. Otherwise, the message log fills with kV, mA and scan statistics.

Section 17.0
X-Ray Verification

Note: Refer to Chapter 2, Section 3.5 - X-Ray Verification for details on X-Ray Verification.

1.) Select SERVICE DESKTOP.
2.) Select DIAGNOSTICS.
3.) Select DAS TOOLS.
4.) Select X-RAY VERIFICATION.
5.) Run tests and record results in Form 4879 upon successful completion.

Appendix A
Mobile Service Concerns - Gantry

Section 1.0
Cover Management

Gantry top, right and left side cover removal is exactly the same as a fixed site. Refer to Chapter 8 for detailed instructions for removal of these covers.

Complete rear cover removal from the van is detailed in Section 1.3.

1.1 AK and K EuroVan

1.1.1 Gantry Front Cover Dolly Modification

In order to accommodate the restrictions on space in the mobile environment, the standard gantry front cover dollies must be modified prior to use. The set that is provided originally with the gantry will already be modified; however, should you need to replace them, you will order and receive the standard dollies.

The outside leg for both the right and left side dollies must be removed as shown in Figure A-1. To better orient yourself in determining which leg to remove, refer to Figure A-2.

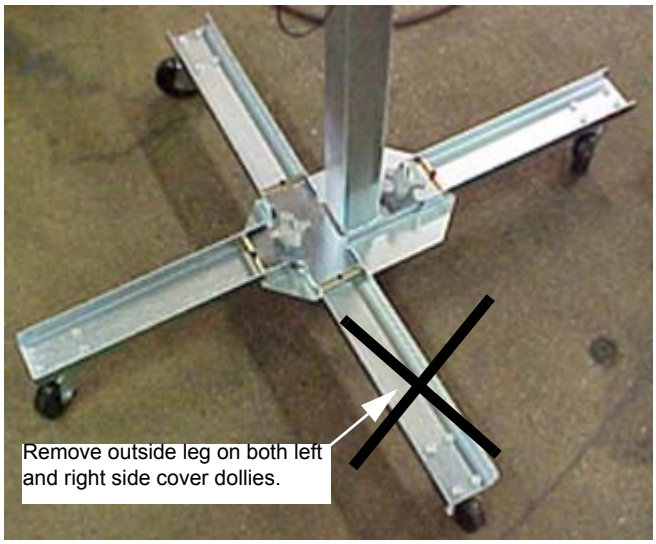

Figure A-1 Gantry Front Cover Dolly Modification

1.1.2 Front Cover Removal

1.) Per Chapter 8, Section 3.1 - Covers, beginning on page 607, attach the dollies and disengage the front cover from the gantry.

2.) Refer to Figure A-2. Move the cover forward between the table and gantry and pivot the cover forward until it is parallel with the table as shown.

3.) Move cover to end of table as shown and rotate one side around table.

4.) Flip cover upside down in storage position.

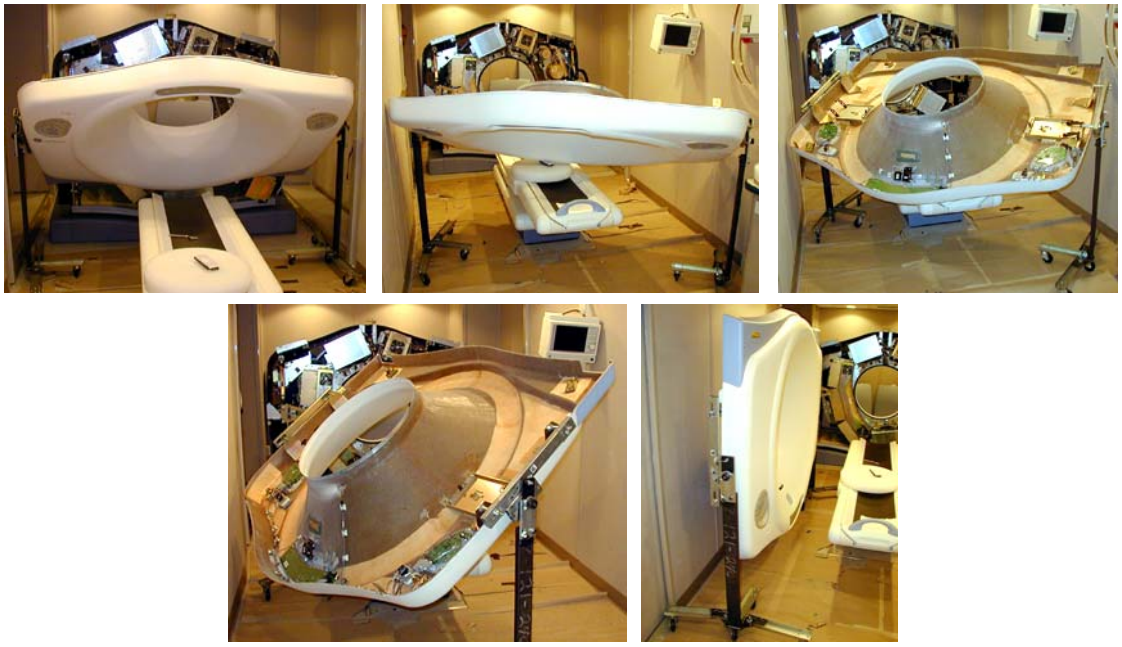

Figure A-2 Front Cover Manipulation on AK Van

1.2 EW Van

GANTRY FRONT COVER DOLLIES

Gantry front cover dollies are to be ordered from the van company, Ellis and Watts. The standard gantry front cover dollies can not be modified for use on this van.

1.3 Complete Van Rear Cover Removal for All Van Manufacturers

This procedure is to be used to completely remove the rear gantry cover from the van. If this is not necessary, simply remove the cover with the standard rear cover dollies as shown in section 3.1 and store it behind the gantry.

Three people are required for this procedure.

1.) Remove and store the gantry front cover as per Section 1.1.2 of the Mobile Supplement Appendix.

2.) Remove the gantry rear cover as per the procedure in Chapter 8, Section 3.1 - Covers, beginning on page 607.

3.) Each of the two service people designated to manipulate the covers must now support the covers for removal of the dollies. Hang onto the dolly mounting posts which will act as handles during this procedure.

4.) The third service person should now remove the dollies and relocate them to the area where

re-attachment for transport off of the van is planned to occur.

5.) Flip the cover over such that the cone section is pointing to the rear of the van. Pay attention to clearances.

6.) The third service person should now raise the table to its maximum height and tilt the gantry to -30 degrees.

7.) Refer to Figure A-3, paying close attention to clearances, flip the gantry rear cover over the top of the gantry.

8.) Carefully place the cover on the table.

9.) Carry the cover over the table.

10.) Reattach the gantry rear cover to the rear cover dollies.

11.) Reverse the process to reattach the cover.

Figure A-3 Gantry Rear Cover Removal (Van)

Section 2.0
Tube Management

Mobile environments require careful handling of large and heavy components, due to space restrictions. Normal service procedures can be completed safely with planning and care.

1.) Remove Gantry front cover.
2.) Turn off the Axial Enable switch on the STC backplane.
3.) Position the X-ray tube to the 3 O' Clock position and engage the rotational lock.
4.) Turn off the HVDC and 120 VAC STC service switches.
5.) Remove the right gantry cover bracket.
6.) Raise the table to maximum elevation.
7.) Position the tube crate at the left rear side of the table for a clear work area.
8.) Disconnect any cabinets or sinks at the right rear side of the table. This will provide additional clearance for tube management.

Note: Some van models will have removable sinks or cabinets designed into the van. Do not forcibly remove any cabinet. Generally, cinch straps for these purposes are clearly visible.

9.) Remove tube crate top and place at the gantry base to receive the old X-ray tube.
- Use of towels, sheets or blankets will ease the movement of the crate top when the X-ray tube is loaded.
- Do not attempt to move x-ray tube without the crate top. This will damage the floor.
- Do not attempt to manually lift the 200 lb. X-ray tube. This will result in personal injury.

Figure A-4 Correct Crate Top/Bottom Placement

10.) Remove the X-ray tube from the gantry as per Chapter 12 - Tube Replacement.

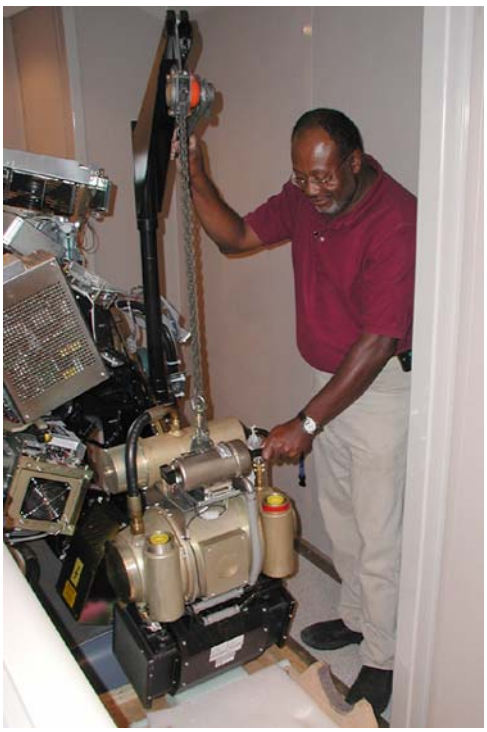

Figure A-5 Preliminary Tube Load/Unload Position

11.) Carefully guide the tube with one hand on the chain above the hook while lowering the tube. Continue to lower the tube with the chain hoist until the x-ray tube rests firmly in the crate top cradle. Disconnect the chain hoist.

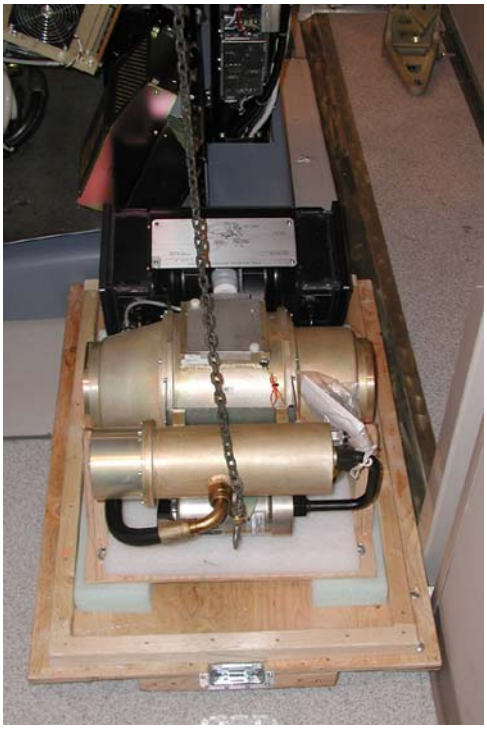

Figure A-6 Guide Tube onto Crate Top/Bottom

12.) Get down on both knees and carefully pull the crate top away from the gantry toward the console room about 1 meter.

Figure A-7 Sliding Tube Crate Top/Bottom

13.) Remove the X-ray tube crate sides from the new tube crate bottom and install on the old tube crate top with the handles toward the gantry.

Figure A-8 Installing Crate Sides

14.) Extend the handles and wheel the old X-ray tube into the console room. Be careful not to damage the walls with the crate handles.

Figure A-9 Main Tube Transport

15.) Remove the crate sides and install on the new x-ray tube crate bottom so that the handles are away from the x-ray tube radiator.

16.) Position the new x-ray tube at the right side of the table about 1 meter from the gantry.

17.) Remove that crate sides.

18.) Get down on both knees and push the crate bottom toward the gantry.

19.) Connect the chain hoist to the tube. Carefully guide the tube with one hand on the chain above the hook while raising the tube.

20.) Remove the crate bottom when the tube is suspended on the chain hoist. This will provide a clear working area to install the X-ray tube.

Section 3.0
Mobile Tilt Transport Switch

The sole purpose of the Mobile Tilt Transport Switch is to inform the driver that the gantry has been positioned correctly for transport. This means that the gantry top is tilted away from the table and is resting on the tilt stop blocks. All pressure has been relieved from the hydraulic cylinders. When this switch is activated a light will turn off on the outside of the van indicating it is safe for transport. This switch is not sensed by any component of the scanner and will not affect and scanner operations.

3.1 Simplified Circuit Diagram

Figure A-10 is a simplified circuit diagram. Refer to the Mobile Van Vendor manuals for detailed schematics. As shown the basic circuit is as follows:

- 12 volt source from van. Can be battery or generator power.
- 5 amp fuse located in fuse panel near generator control panel.
- Normally closed switch located on gantry right side. Reference Figure A-11.
- External Transport Lamp “OFF” when safe to transport. See Figure A-13.

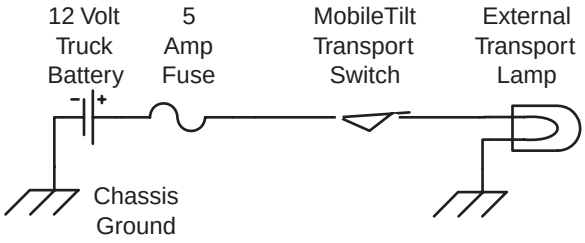

Figure A-10 Simplified Electrical Circuit

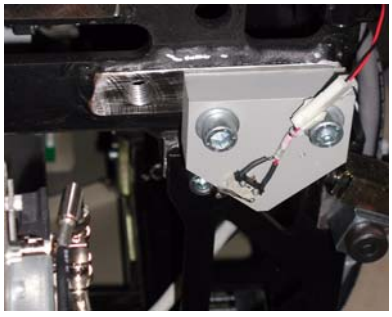

Figure A-11 Mobile Tilt Transport Switch

The Mobile Tilt Transport Switch harness is routed down to the base of the gantry and into the floor of the sub frame of the van.

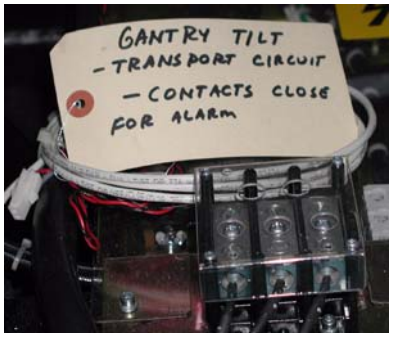

Figure A-12 Mobile Tilt Transport Switch Harness

Figure A-13 Example External Van Transport Lights - Multiple & Single

3.2 Mobile Tilt Transport Switch Adjustment

1.) Remove rear Gantry base covers and Gantry right side cover.
2.) Place Tilt relay board in Service mode using Normal/Service switch.
3.) Manually tilt Gantry Back until gantry is resting on tilt stop blocks.
4.) Adjust Mobile Tilt Transport Switch so it just “OPENS”.
   - DO NOT ADJUST TILT STOP BLOCK!
   - Use a Voltmeter set to read DC Volts.
   - Measure the switch terminals using Frame ground.
5.) Verify 12 VDC is present on one side of the switch and not present on the other.
6.) Tilt gantry forward and then back again. Verify switch adjustments.
7.) Verify External Transport Lamp operation, “OFF” when gantry is in transport mode, “ON” when gantry is in scanning mode.
8.) Place Tilt Relay Service switch to Normal position.
9.) Replace Gantry covers.

3.3 Mobile Tilt Transport Switch Replacement

1.) Disconnect switch using Mate-N-Lok plug.
2.) Remove two (2) screws securing switch to tilt stop block.
3.) Install new switch and connect harness.
4.) Perform adjustments per 3.2 - Mobile Tilt Transport Switch Adjustment.

Appendix B
Torque

Section 1.0
Recommended Torque Wrench Practices

1.) Never use a torque wrench to loosen a tightened fastener.
Permanent damage of the internal mechanism can occur due to excessive strain.

2.) Always approach the specified torque slowly. This is not a speed wrench.

   a.) Hand location is important. Position one hand at the axis of rotation and one hand on the tool handle. This give the user stability and accurate torque repeatability.

   b.) Always approach the desired torque evenly and slowly. If the desired torque is 66 N-m on 4 bolts, then tighten each bolt 50 to 70% of desired value. Then set the wrench to the required torque and tighten slowly until the wrench “Just Clicks”.

3.) Always release the tension on the torque wrench to prevent “spring set” on adjustable or “clicker” type torque wrenches. This will ensure correct torque settings throughout the range of the tool.

4.) Always allow the tool to reach room temperature.

   - Spring tension is the basis of “Clicker” type torque wrenches.
   - A spring’s tension changes with temperature.

5.) Calibrate the tool on a regular schedule.
Follow established local calibration processes.

6.) Do not drop or shock the tool.
Internal damage can occur. Calibration should be performed to ensure accuracy.

7.) Do not attempt to straighten a bent “Beam” or non adjustable wrench. Replace it.

8.) Never use a “Universal Joint” with a torque wrench.
The angle of the universal joint can change the torque value by more than 50%.

9.) Always use the torque wrench with a 90 degree angle whenever possible.

   a.) Figure B-3 illustrates the effects not being perpendicular.

   b.) The 25 degree tilt is the physical limit of a Bondhus Ball End Hex key.

   c.) Use the specified torque value for the HV tank mounting fasteners. Do not attempt to calculate the sin angle correction.

   There is less than 2% error for up to 10 degrees of tilt from the desired angle.

   d.) Minimize the angle as much as possible.

10.) Always clean fastener threads to reduce friction.
Fasteners should thread easily using finger pressure.

   a.) Replace fasteners or clean threads using a tap or die, compressed air, brass brush.

   b.) Never use a tap to clean thread inserts. It will damage them requiring replacement.

11.) Never lubricate a fastener unless specifically instructed.
Loctite is considered in the design. It must be used when specified.

12.) Replace Nylon nuts if they are finger loose.

13.) **ALL FASTENERS HAVE A TORQUE REQUIREMENT.** DEFAULT TABLES SHOULD BE USED **ONLY** IF THE SERVICE DOCUMENTATION DOES NOT SPECIFY A TORQUE VALUE.

Section 2.0
General Torque Cross Reference

Table B-1 and Table B-2 are provided as default references only. Use the appropriate replacement procedure to verify the correct torque requirement for each specific fastener.

Note: The *Illustrated Parts List* contains Engineering drawings that should also be used as a reference. These drawings call out specific instructions as notations, where needed.

NOTICE **Use Table B-1 and Table B-2 only as a last resort. If the Service documentation does not contain specific torque values, the default values can then be assumed to apply.**

All Fasteners use either "flat and lock washers" or loctite. These items must be used as specified.

FASTENER SIZE	TOOL SIZE HEX KEY	TOOL SIZE SOCKET	TORQUE IN N-M	TORQUE IN LBF-FT	TORQUE IN LBF-IN
M3	2.5 mm	5.5 mm	1	-	8.9
M4	3 mm	7 mm	2.3	1.7	20.4
M6	5 mm	10 mm	7.9	5.8	70
M8	6 mm	13 mm	19	14	168
M10	8 mm	16 mm	38.4	28.3	-
M12	10 mm	18 mm	66.4	48.9	-
M16	14 mm	24 mm	160	117.8	-

Table B-1 Default Torque Values as Specified by GEHC CT for LS Plus and Forward

FASTENER SIZE	TORQUE IN STEEL	TORQUE IN ALUMINUM	TOOL SIZE HEX KEY	TOOL SIZE SOCKET
3/8 - 16	25 +/- 2 Lbf-Ft 33.9 +/- 2.7 N-m	20 +/- 2 Lbf-Ft 27.1 +/- 2.7 N-m	5/16	9/16
1/4 - 20	8 +/- 1 Lbf- Ft 10.85 +/- 1.36 N-m	5 +/- 0.5 Lbf-Ft 6.8 +/- 0.7 N-m	3/16	7/16
8 - 32	20 +/- 2 Lbf-In 2.26 +/- 0.23 N-m	15 +/- 2 Lbf-In 1.7 +/- 0.23 N-m	9/64	5/16

Table B-2 Default Torque Values as Specified by GEHC CT for LS QXI and Previous

Many service operations on this CT scanner require a torque wrench. The use of a torque wrench may appear complicated because there are several standards and metrics. Using conversion factors and the conversion chart below can simplify that task.

First, only use a calibrated torque wrench. Use a torque wrench that is on a Calibration schedule and is approved by GE Healthcare-AM Service. The kit that can be used that is on a regular Calibration schedule is kit number 46-268445G1. This torque wrench kit has wrenches that measure inch pounds and foot pounds.

Second, make any necessary conversions for the torque wrench you are using.The units of measure are typically marked on most torque wrenches. To make conversions to Kgcm and Newton meters, use the following conversion table, or calculate using conversion factors.

Kilogram Centimeter (Kgcm)	Inch lbs (in-lbs)	Foot lbs (Ft-lbs)	Newton Meters (Nm)
1	0.868	-	-
2	1.74	-	-
3	2.6	-	-
4	3.5	-	-
5	4.3	-	-
6	5.2	-	-
7	6.1	-	-
8	6.9	-	-
9	7.8	-	-
10	8.7	-	0.98
20	17.4	1.4	1.96
30	26.0	2.2	2.94
40	34.7	2.9	3.92
50	43.4	3.6	4.90
60	52.0	4.3	5.88
70	60.8	5	6.86
80	69.4	5.8	7.85
90	78.1	6.5	8.83
100	86.8	7.2	9.81
200	173.6	14.5	19.61
300	260.4	21.7	29.42
400	347.2	28.9	39.23

Table B-3 Torque Conversion Cross Reference

TORQUE CONVERSION FACTORS

- To convert Kgcm to foot-lbs, multiply Kgcm by 0.07233
- To convert Kgcm to inch-lbs, multiply Kgcm by 0.8679
- To convert Kgcm to N-m, multiply Kgcm by 0.0981
- To convert N-m to inch-lbs, multiply N-m by 8.8508
- To convert N-m to foot-lbs, multiply N-m by 0.73756
- To convert foot-lbs to N-m, multiply lbf-ft by 1.3558
- To convert inch-lbs to N-m, multiply lbf-in by 0.11298

Section 3.0
Torque Formula

T = R x F x sin (angle)

Where: T = Torque in N-m

R = Distance from axis of rotation

F = Force Applied

Sin(90) = 1

From this formula we can see that it is necessary to apply the force at a 90 degree angle to the axis of rotation to achieve accurate fastener torque. This same principle can be applied when using accessories with the torque wrench. See Figure B-1 and Figure B-2.

Note: The length of a standard square drive extension has no effect on torque since it is along the axis of rotation. See Figure B-3.

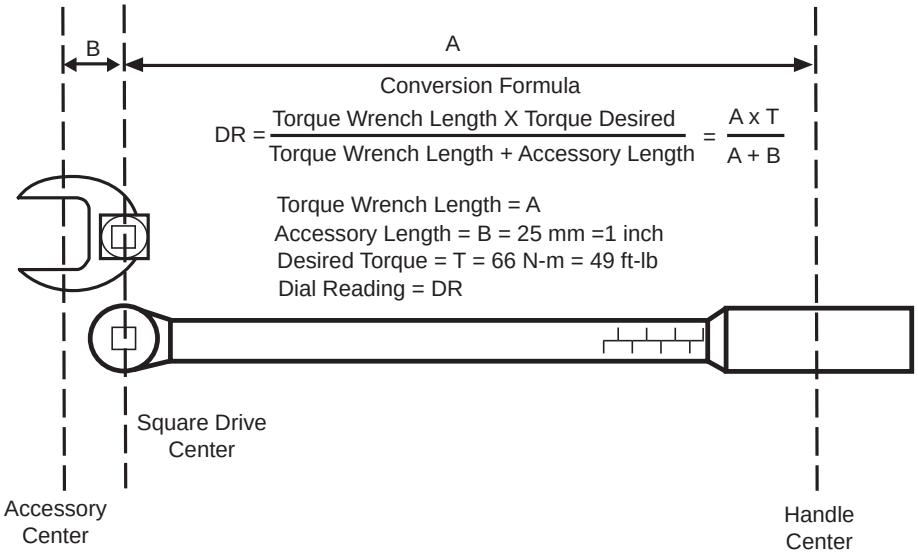

Figure B-1 Formula to adjust for Straight Line Accessory

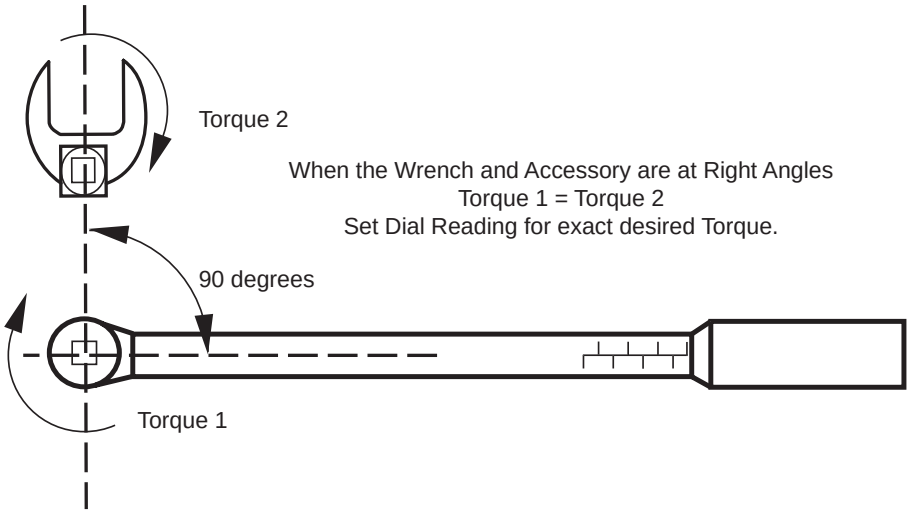

Figure B-2 Formula for 90 Degree Accessory Usage

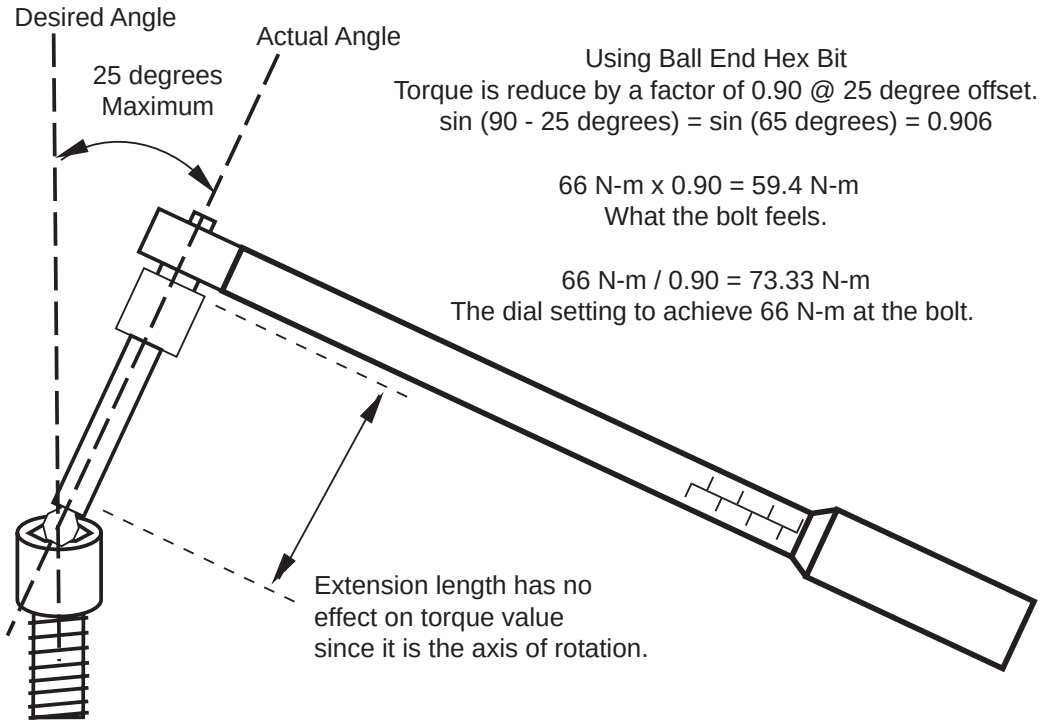

Figure B-3 Formula when not at 90 Degree to Axis of Rotation

Section 4.0
Torque Wrench Accuracy

It needs to be clearly understood that “torque” is an indirect measure of tension or “preload force”. The components of a bolted joint can be defined as,

- Preload force (Fp), bolt stretch.
- Tension force (Ft), resistance of bolted materials.
- Clamping force (Fc), difference of preload and tension forces.
- Shear force (Fs), sideways or sliding force of bolted materials.

Therefore, Fc = Fp - Ft

With shear force, a properly designed and tightened joint, the friction between the bolted materials absorbs the stress and the bolt itself feels little to no load.

There are other factors that need to be considered as well. Fastener material has a large effect on torque versus preload force. Lubricants can also significantly change the effects of torque versus preload force. Anti-seize compounds can reduce the needed torque up to 20%.

In short, torque measurement is an economical method of achieving a properly tensioned joint. Other methods are available, but training needs and tool expense increase.

CT Engineering has taken into account the variability of using torque wrenches. The design standard applied is a safety factor of 8 on all fasteners, after the “G Force” load is calculated for each component. This is to ensure clamping force is maintained without exceeding the strength of the fastener.

Various studies have been performed on the effectiveness of torque wrench accuracy. The following conclusions have been made.

PRELOAD MEASURING METHOD	ACTUAL PRELOAD FORCE ERROR
“Feeling”	> 35%
Torque Wrench	+/- 25%
Angle Torquing	+/- 15%
Indicating Washer	+/- 10%
Fastener Elongation	+/- 5%
Strain Gauge	+/- 1%

Table B-4 Torque Method Accuracy

As demonstrated in Table B-4, not using a torque wrench is the worst case event.

The “Feeling” method also changes with the tool. A ¼” drive “feels” different than a ½” drive.

Appendix C
Hardware Cross-Reference

SOCKET HEAD CAP AND THREAD PITCH	HEX KEY SIZE NOMINAL	HEX HEAD CAP AND THREAD PITCH	SOCKET WRENCH SIZE NOMINAL
M1.6 x 0.35	1.5mm	N/A	N/A
M2 x 0.4	1.5mm	N/A	N/A
M2.5 x 0.45	2.0mm	N/A	N/A
M3 x 0.5	2.5mm	N/A	N/A
M4 x 0.7	3.0mm	N/A	N/A
M5 x 0.8	4.0mm	M5 x 0.8	8.0mm
M6 x 1.0	5.0mm	M6 x 1.0	10.0mm
M8 x 1.25	6.0mm	M8 x 1.25	13.0mm
M10 x 1.5	8.0mm	M10 x 1.5	16.0mm
M12 x 1.75	10.0mm	M12 x 1.75	18.0mm
M14 x 2.0	12.0mm	M14 x 2.0	21.0mm
M16 x 2.0	14.0mm	M16 x 2.0	24.0mm
M20 x 2.5	17.0mm	M20 x 2.5	30.0mm
M24 x 3.0	19.0mm	M24 x 3.0	36.0mm
M30 x 3.5	22.0mm	M30 x 3.5	46.0mm
M36 x 4.0	27.0mm	M36 x 4.0	55.0mm
M42 x 4.5	32.0mm	M42 x 4.5	65.0mm
M48 x 5.0	36.0mm	M48 x 5.0	75.0mm

Table C-1 American Standard Metric Hex/Socket Head Cap Screws to Tool Cross Reference

Appendix D
Installation of FlexTrial Options

Section 1.0
Description

FlexTrial is a trial program offering GE Healthcare customers a chance to “try before they buy” purchase option software. It helps customers evaluate application software—with no financial obligation or risk.

Option keys are automatically activated for 30 days through an automated web-based download procedure. For sites that can not be accessed remotely, a key can be sent to a local GE employee, via e-mail or file download, and configured on the system manually.

Section 2.0
Information Required to Order FlexTrial Options

Before any FlexTrial option can be ordered, two pieces of information must be obtained from the system. If this information is not obtained, the request will be invalid.

1.) System ID. This is the system ID used when problem calls are placed for the system (i.e., Cares or Must). This identifies the means by which the service organizations uniquely identify the system.

2.) The system’s unique Host ID. To find this ID number: at the Computer Console, go to the SERVICE DESKTOP and select SHELL. At the system prompt, type the following:

`check_config` ENTER

The system will respond with a number up to 10 digits (e.g., `1234567890`). This is the system’s unique Host ID number. No two SGI computers have the same number.

Section 3.0
Requesting an Option FlexTrial

To request a software option FlexTrial:

On the internet, call up the GE Healthcare URL (http://www.gehealthcare.com) and select the community tab, or contact your local Software Sales Representative.

- In the Americas, contact GE Healthcare Direct at 1-800-886-0815.
- In Europe, contact GEMSE Direct at 00 800 CALL GE Healthcare (00 800 2255 4367);
  Northern Europe local +44 1753 874 881;
  Iberian Peninsula +34 91 375 4584;
  France +33 1 49 93 22 46;
  Central Europe +49 69 95 30 72 23;
  Italy +39 02 754 19 681
- In Asia, contact James Tan at +65-97 36 82 43
- or your local Service Sales Specialist.

The Software Sales Representative will verify system compatibility and forward the customer a FlexTrial agreement confirming their interest in the software for a limited trial of 30 days.

Time will expire for the software option at the completion of the 30 day period.

Section 4.0
Configuration for Systems with Remote Connection

Once connectivity of the system is established and successful download of the required key(s) has been achieved, the process requires no intervention by local GE personnel. The option key will be shown in the options list, but an application shutdown and startup, as prompted by the system, is required for the option to be enabled.

Section 5.0
Configuration for Systems without Remote Connection

A number string that represents the software license key will be generated. This key is valid for only 30 days. Once the key has been generated, it can be e-mailed, FTP'd to GLOBE, or sent to an address designated by the Software Sales Representative at the time the request was placed.

Note: Once a FlexTrial Key is generated, it will work for 30 days only. Any delay in manually configuring the key to the customer site will shorten the time the customer has to try the feature.

If you are to receive a license Key for a site, your e-mail will receive a new message with the subject line, "`License Key File for SysID:XXXX`". `XXXX` will be the system ID used when ordering the FlexTrial. Open the message and scroll to the bottom of the message to find the activation key(s). See Figure D-1.

```
#-------------------------------------------------------------------------
#License strings will be added below in the created package
#-------------------------------------------------------------------------
sprep99 flextrial 30 277a05aca21101312f672196
smartprep flextrial 30 18048594ac1101312f670668
```

Flex Trial keys

Figure D-1 FlexTrial keystring is the last 24 character string at the bottom

Figure D-1 shows two keys that have been sent. The number of keys depends on how many were ordered.

Once the keys are received, to activate, do the following at the system computer:

1.) Go into the **Service Desktop/ Utilities/ Install Options/ Start**.

2.) The ***LightSpeed Software Options*** window will be displayed. Select INSTALL. The window titled ***Select Mechanism*** will appear.

3.) From the ***Select Mechanism*** window, select FLEX TRIAL. The ***Enter String*** window will appear.

4.) In the ***Enter String*** window, enter the 24-digit character license string, and select ACCEPT. The ***LightSpeed Software Options*** window will then be displayed.

5.) From the ***LightSpeed Software Options*** window, select QUIT. The ***Options*** window will then be displayed.

6.) In the ***Options*** window, select OK.

7.) Restart the applications software, or shutdown and reboot the system by selecting the SHUTDOWN icon.

Section 6.0
Permanent Download Key Installation (Future Capability)

To permanently install a purchased permanent option with a downloaded option key, follow the procedure below.

1.) Go into the **Service Desktop/ Utilities/ Install Options/ Start**.

2.) The ***LightSpeed Software Options*** window will come up. Select INSTALL. The window titled ***Select Mechanism*** will be displayed.

3.) From the ***Select Mechanism*** window, select PERMANENT. The ***Select Device*** window will then be displayed.

4.) From the ***Select Device*** window, select MANUAL. The ***Enter String*** window will then appear.

5.) In the ***Enter String*** window, enter the 24-digit character license string, and select ACCEPT. The ***LightSpeed Software Options*** window will then be displayed.

6.) From the ***LightSpeed Software Options*** window, select QUIT. The ***Options*** window will then be displayed.

7.) In the ***Options*** window, select OK.

8.) Restart the applications software or shutdown and reboot the system by selecting the SHUTDOWN icon.

Section 7.0
De-Install a FlexTrial Option

Should there be a need to de-install a FlexTrial option before its 30 day expiration period, follow the procedure below:

1.) Go into the **Service Desktop/ Utilities/ Install Options/ Start**.

2.) The ***LightSpeed Software Options*** window will come up. Select the option(s) to be de-installed and select REMOVE. The ***SW Options Error*** window will then be displayed.

3.) From the ***SW Options Error*** window, select OK to permanently remove the option. The ***LightSpeed Software Options*** window will then be displayed.

4.) From the ***LightSpeed Software Options*** window, select QUIT. The ***Options*** window will be displayed.

5.) In the ***Options*** window, select OK.

6.) Restart the applications software or shutdown and reboot the system by selecting the SHUTDOWN icon.

Appendix E
LightSpeed Family Hardware Compatibility

Section 1.0
Recon CPU

Table E-1, below, can be used to help identify which model recon CPU — a.k.a. Power PC (PPC), RIP board or Motorola board — is used on which LightSpeed family console.

GE Part #	Motorola Part #	Used On Console Part #	(J15) Jumper Settings	(J16) Jumper Setting	Memory Size	Description
2207232* 2197234* 2197234-3	MVME2306	2180551	2-3	2-3	32MB	LS (QX/i) Octane I w/ O2 and H1.1 SW
2197234-4	MVME2306	2180551	2-3	2-3	32MB	LS (QX/i) Octane I w/ O2 and H1.2 SW
2197234-2	MVME2308	2180551-2	2-3	2-3	128MB	LS (QX/i) Octane I w/o O2
2197234-2	MVME2300	2266832 2266832-2	2-3	2-3	128MB	LS Plus with Octane I
2197234-2	MVME2300	2304732 2304732-2	2-3	2-3	128MB	LS Plus with Octane II
2197234-2	MVME2300	2266832-3 2266832-4	2-3	2-3	128MB	LS Ultra with Octane I
2197234-2	MVME2300	2304732-3 2304732-4	2-3	2-3	128MB	LS Ultra with Octane II

* Obsolete product

Table E-1 Recon CPU & Console Compatibility Matrix

Section 2.0
DIP Board

Table E-2, below, can be used to help identify which model DIP board is used on which LightSpeed family console.

GE Part #	Used On Console Part #	Description
2160800	2180551	QX/i with Octane I w/ O2 and H1.1 (DIP Board found in O2 computer)
2160800	2180551	QX/i with Octane I w/ O2 and H1.2 (DIP Board found in O2 computer)
2216666	2180551-2	QX/i with Octane I w/o O2
2245261	2266832 2266832-2	Plus with Octane I
2245261	2304732 2304732-2	Plus with Octane II
2259530	2266832-3 2266832-4	Ultra with Octane I
2259530	2304732-3 2304732-4	Ultra with Octane II

Table E-2 DIP Board and Console Compatibility Matrix

Appendix F
ESD Management and Device Handling

Section 1.0
Electrostatic Discharge and Proper Device Handling

The circuit boards and disk drives for this system contain densely populated electronic components that are expensive and electrically sensitive. An electrostatic discharge (**ESD**) between 100 and 1000 V may damage a component. This is substantially less than the 3000 V discharge needed to feel any static. An **ESD** may cause an immediate failure, or it may weaken components to produce future, intermittent problems.

Always use the **ESD** strap pro-actively. Put circuit boards inside an anti-static bag or approved container before it is handled by a non-grounded person, moved from the grounded (**ESD** safe) area, or stored. Always place the board top side up on a flat surface when it is unmounted. Never handle the part outside its anti-static container unless the surrounding surfaces and you are grounded. Discharge the outside of the container before transferring the part.

PRO-ACTIVE ACTION	PROCEDURE
Turn power OFF	Turn power OFF before you touch, insert or remove parts containing electronic components.
Use wrist strap	Unless you are working near a live 30 V or more circuit, ground your wrist to the specially designed ground plug on the unit before you touch any parts. This includes connecting cables to a drive, board, device, or bulkhead. While wearing your strap, test it with a specially designed meter. If it fails, it may be due to dry skin; apply lotion to your wrist and test again. Throw away any strap that is more than three months old.
Don't let anything other than your grounded hand touch the electronic **FRU**	Do not let your sleeve, tie, pen, Styrofoam cup, plastic manual binder or clothing touch the circuit board or disk drive. Wearing cotton clothes and shoes with rubber-like soles may lessen how much **ESD** you generate walking across the room. Working in a room where relative humidity is under 20% can generate electrostatic voltages of 7000 to 35,000 Volts. However it only takes 100 V to destroy an **EEPROM**.
Use proper handling	Handle circuit boards, disk drives, or any electronic part as little as possible. Place them on an anti-static workbench pad or in a grounded static dissipative bag. Do not stack components. Store circuit boards in an anti-static container. Pink, blue, or clear poly bags do NOT give protection from external sources of **ESD**. Instead, a grounded anti-static box may be used as a static free work surface.
Treat failed parts the same as good ones	Don't add to the expense, complication and future un-reliability of a part by allowing it to be repeatedly zapped. Treat failed parts with proper **ESD** handling.

Table F-1 Actions that Reduce the Chances of ESD damage

PRO-ACTIVE ACTION	PROCEDURE
Use a special vacuum	Only use a vacuum of the type that prevents electrostatic buildup.
Use Ionizing Fan	The ionizing fan reduces the amount of charge built up in an area. The fan can be turned on and pointed in a general direction to keep an area from becoming statically charged. The fan can also be pointed at a single location to eliminate charge on that piece of equipment. Allow air to flow for at least six (6) seconds, for charge to dissipate.

Table F-1 Actions that Reduce the Chances of ESD damage (Continued)

Section 2.0
ESD Management Process

ESD MANAGEMENT TOOLS

GE Healthcare CT has evaluated current ESD process and recommends the following items be utilized to aid in the prevention of materials damage due to ESD events.

1.) Anti-Static kit
- Work Station Monitor
- Wrist Strap
- 20 foot grounding cord
- Anti-static mat (Field Supplied)

2.) Aero Duster Air Spray System
3.) Aero Duster Spray (Field Supplied)
4.) High Output Ionizing Fan
5.) ESD Smock
6.) Safe Skin Nitrile Gloves
7.) Amax Contact and Circuit Board Cleaner (Field Supplied)
8.) ESD Flex Boots (4 and 8 Slice Detectors)
9.) Elastomer Tweezers (4 and 8 Slice Detectors)
10.) Elastomer Removal Pick (4 and 8 Slice Detectors)
11.) Spare Elastomers w/container (4 and 8 Slice Detectors)
12.) Alcohol Pads 91% (4 and 8 Slice Detectors)
13.) 16 Slice ESD Boots (16 Slice Detectors)

PROCESS DIFFERENCES

1.) Nitrile Gloves replace Finger Cots.
   a.) Finger cots can leave black particles on surfaces.
   b.) Incorrect dressing of finger cots results in skin oils contamination.
2.) Aero Duster Spray System replaces Metal Tube used for Canned Air.
   Can spray angle is critical. No Liquid Spray allowed. New Aero Duster Spray System provides user the flexibility of access to components while the Aero Duster can remains upright.
3.) High Output Ionizing Fan
   Applies physics laws to dissipate charge on insulating materials.

Figure F-1 ESD Workstation Monitor and Wrist Strap

- Monitor requires a 9 volt battery.
- Monitor will “Beep” when you are not properly grounded.
- Wrist strap must contact your skin. Do not place on top of clothing or Nitrile gloves.

Figure F-2 DAS/Detector Interface Tools

- ESD Flex Boot Covers to protect detector from ESD damage
- Alcohol wipes to clean flex leads prior to installation on the DAS/Detector Interface (DDIF).
- Plastic tweezers and pick to remove and install elastomers.
- Aero Duster attachment to remove debris from the DDIF assembly.

Figure F-3 ESD Nitrile Glove

Use Nitrile gloves to prevent skin oil contamination. DO NOT use any other type of glove.

Figure F-4 Full Length Smock

Use an ESD smock to prevent static discharge from your clothing. The wrist strap will not remove static charge from your clothing. The ESD smock will not remove charge from you clothing, it is a barrier to prevent ESD damage.

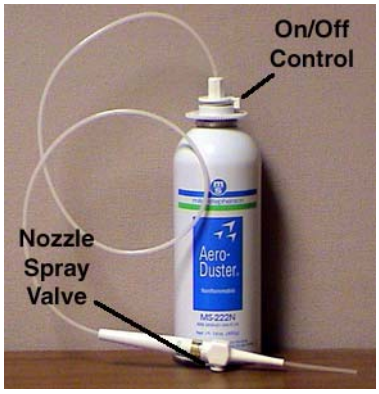

Figure F-5 Aero Duster and Spray System Attachment

- Remove the standard Aero Duster trigger.
- Rotate Aero Duster Attachment to the OFF position.
- Snap onto top of Aero Duster can. (Set attachment to OFF position before removal)

Figure F-6 Ionizing Fan

Section 3.0
Service ESD Tool Usage

NOTICE **When using aero duster to remove debris, do not allow liquid to contact any components. The evaporation of this liquid will generate static charge resulting in microphonic noise or ESD damage.**

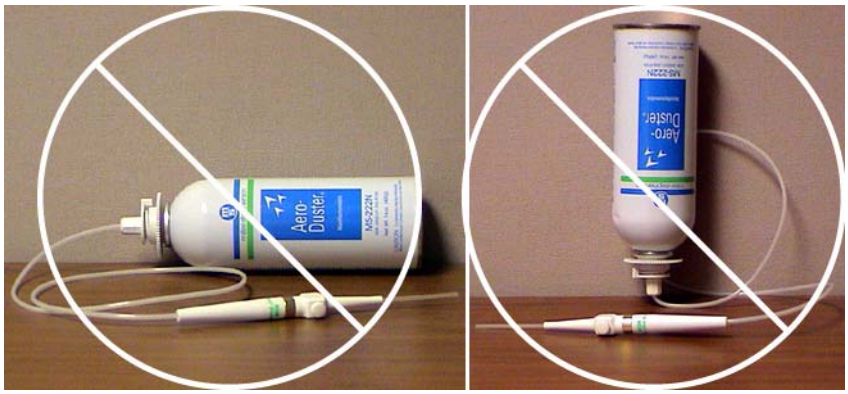

Figure F-7 Wrong Angles will generate Liquid Spray

- Do not use Aero Duster Spray as shown in Figure F-7. This will create a liquid stream which will charge the surface as it evaporates.
- Always hold can upright as in Figure F-5 and clear the hose attachment by spraying away from any surface. Do this to ensure no liquid is discharged.
- Liquid discharge can be seen as a mist at the output of the nozzle and a frosting on surfaces.
- You want to HEAR the spray, NOT see it.

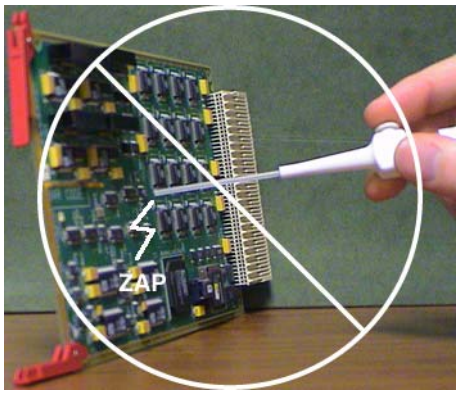

Figure F-8 Incorrect Aero Duster Nozzle Use

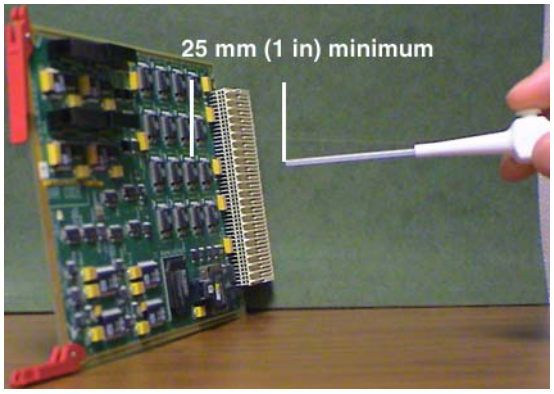

Figure F-9 Proper Aero Duster Nozzle Use

- Never touch the tip of the nozzle to any surface. The tip can be charged in excess of 10,000 volts. This can result in severe ESD damage and/or microphonics noise.
- Charge on the nozzle tip will not be transferred by the flow of gaseous spray. Maintain at least 25 mm or 1 inch from any surface.
- Always clear the nozzle, away from surfaces, of any potential liquid spray.

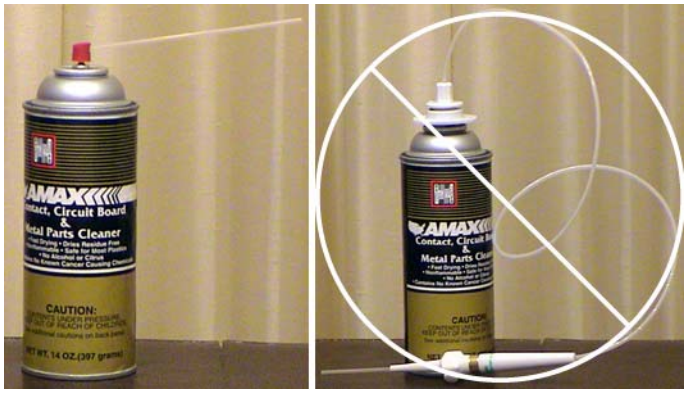

Figure F-10 Amax Cleaner Correct and Incorrect Usage

- Amax Contact and Circuit board cleaner can be used to dissipate static charge.
- Amax Contact Cleaner should not be used on the elastomers. The elastomers will absorb the liquid preventing proper evaporation. The result will be microphonics noise and artifacts.
- Do not attach the Aero Duster attachment to any other chemicals.

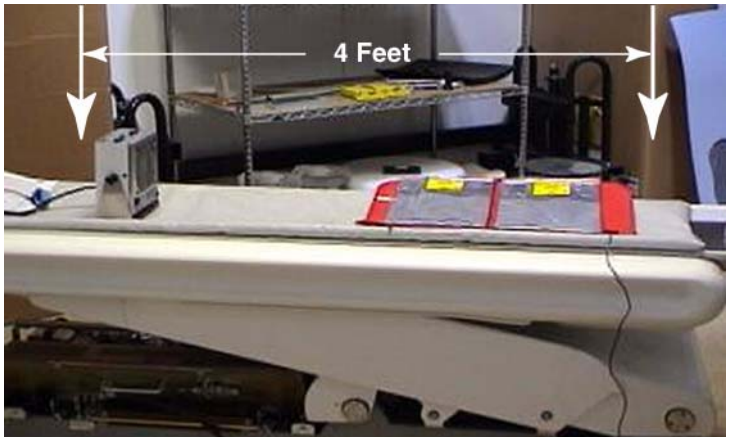

Figure F-11 Preparing your work area

- Place the static mat near the end of the cradle. Connect the ground lead to the Threaded Rod for the Gantry Balance Trim Weights on either side of the DAS.
- Place the Ionizing Fan on the cradle blowing across the static mat. Set the fan speed to high. The effective coverage of the fan is less than 6 feet.
- Use the table service outlet to power the Ionizing Fan.

Figure F-12 Using the Ionizing Fan to dissipate charge at the DDIF

- The Ionizing Fan is to be used to dissipate built up charges.
- It takes about six seconds for the fan to dissipate any charge.
- Slowly direct the air flow from the fan across the affected area. Make several passes over the area.
- There are no visual or physical indications to show effectiveness in this process.
- The fan will be most useful when dealing with the detector and DAS, but can be used on other components as well.

Glossary

TERM	MEANING
10-BASE2 or 5 or T 100-BASE T	A 10BASE connection can transfer data between networked computers at up to 10 Mbps. 10Base2 is thin coaxial and segments must be no longer than 185 m (607 ft). 10Base5 is thick coaxial and segments must be no longer than 500 m (1640 ft). 10BaseT is twisted pair wiring; use Category 5 or better. The Octane can support 100BASE T which transfers at 100 Mbps.
140 SPECint92	The computer industry has developed a standard measure of integer, floating point, and other system performance to better compare actual system performance under real conditions, unlike the older MIPS or MEGAFLOPS ratings. The SPECint92 is a standard measurement of integer performance across various computing systems.
A/D, ADC	**A**nalog to **D**igital **C**onverters are used to convert analog electrical signals to digital quantities.
AE Title	**A**pplication **E**ntity is the DICOM name for a machine with a DICOM purpose on a network. The site's network administrator assigns a specific title to each application entity. You must carefully enter this information with the same capitalization as it is given to you.
AiM	**A**pplication **I**ntegration **M**echanism is a simple mechanism to enable new modules to share data and messages with older modules. The idea is to limit the interactions between the to-be-integrated application and the "integrated" ones. It is proposed as an efficient way to add new applications to the SdC platform, such as an existing *Advantage Windows* system. The design paradigm of AiM is referred to as weakly coupled design.
Air Cals	Air Calibration This calibration is a series of scans that are taken of only air. The images are reconstructed and the CT numbers adjusted to give a number of -1000 for each pixel.
API	**A**pplication **P**rogramming **I**nterface is the network software libraries or subroutines from which an application writer can call upon for various services.
ARP	**A**ddress **R**esolution **P**rotocol is a network protocol that maps ethernet addresses to IP ones.
ASIC	**A**pplication **S**pecific **I**ntegrated **C**ircuit.
AUI	**A**ttachment **U**nit **I**nterface. An IEEE 802.3 connecting the Media Access Unit (MAU) to the networked device. It also refers to the connector that attaches the host port to an AUI cable.
AW	**A**dvantage **W**indows workstation is a stand alone image work station. The system is Sun Computer based and the software was developed in France.
back projection	Mathematically summing and averaging all the data for a given pixel from every CT view during acquisition. The recon processor creates three dimensional voxels in two dimensions which eventually become the display image pixels. Given a filtered projection, this term refers to the process of smearing the projection back across an image matrix.
Balum	RF impedance matching device.
bandwidth	The frequency range that contains the significant ultrasound content. It also describes the amount of data that a circuit or network can handle.
BOW	**B**eam **O**n **W**indow is the alignment of the X-Ray beam to the window on the detector.
bps	**b**its **p**er **s**econd
bulkhead	Bulkheads are panels where peripherals, laptops, modems or networks can be connected.
bus	A parallel communications pathway composed of a group of wires, or of traces on a board or within a chip. The same bus can be used for different signals when tristate ICs are used because those not needed can be turned off; their output is changed to high impedance.
byte	A byte is eight bits numbered 0 through 7 (Bit 0 is the least significant bit). A byte is the smallest unit stored by a computer. Its location has one unique address. The VME standard divides all locations into four groups that share the same last two digits, 00, 01, 10, 11, in their address.

TERM	MEANING
Cam A, Cam B	Cams A & B are used to pre-patient collimate the x-ray beam.
CAN	**C**ontroller **A**rea **N**etwork.
cat	UNIX command used to create or print files on the screen or to a file or device
CBF	**C**enter **B**ody **F**ilter. CBF is the alignment of the X-Ray tube focal spot to the center of the body filter in the collimator. This is the left/right alignment when looking at the gantry from the table.
CCB	**C**ollimator **C**ontrol **B**oard - Provides the electrical control to position the bowtie filter and the collimator cams.
CCITT	**C**onsultative **C**ommittee for **I**nternational **T**elephone and **T**elegraph is an organization that sets worldwide voice and data communications standards.
CDROM	**C**ompact **D**isk **R**ead **O**nly **M**emory.
CGI	**C**ommon **G**ateway **I**nterface is an API developed for the Internet.
client	The computer or application that uses computer services provided by another computer or application. Each can then be optimized for their task.
CMOS	**C**omplementary **M**etal **O**xide **S**emiconductors are densely populated Integrated Circuits (ICs). They tend to need less power than TTL ICs. Nominal operating levels are 0 - 0.8 V for Low and 3.4 - 5 V for High. TTL compatible CMOS recognizes 2.4 V as High. CMOS chips are readily damaged by ESD.
Collimator mounting plate	Mounting plate to fasten collimator to the rotating base.
control bus	A control bus carries signals used to initiate memory and data I/O operations.
CPDU	**C**ompact **P**ower **D**istribution **U**nit. Originally this was called the CRPDU. It is a cabinet used to supply power to the entire system.
CPU	**C**entral **P**rocessing **U**nit. The CPU or host is contained on the SBC board.
cron	A cron is a UNIX process that runs at regular intervals when the system is not busy with higher priority tasks. Looking for scheduled patient data on the network is a cron task.
CTS	**C**lear **T**o **S**end. Serial control signal from the DCE.
CUP	**C**ommon **U**nix **P**latform is a foundational software library that CT and MR share. CUP monitor is used to control the most fundamental processes, like the startup and shutdown of the scanner.
DA, DAC	**D**igital to **A**nalog **C**onverter
daemon	A daemon is a UNIX background software process. The routing daemon maintains a routing table or database used to select the appropriate network interface when transmitting packets. This routing table contains a single entry for each route to a specific network or host.
DAS	**D**ata **A**cquisition **S**ystem is used to collect the data from the detector, convert it to digital, and send it to the Front End Processor.
DAS Channel	There are 768 DAS channels per slice. Only 765 are connected to the detector channels. Outer channels from the detector are ganged or paralleled on the DAS backplane, therefore fewer DAS channels per slice than detectors.
DAS Count	Approximately 0.5 PPM (parts per million) of full scale. Equals one LSB (least significant bit) of DAS data word with largest FPA gain, i.e. exponent bits equal to 00 binary.
DAS Gain	DAS gain Is actually preamp gain. It is a gain code defining the size of the integration capacitance. DAS gain is proportional to the inverse of the capacitance or gain code. DAS gain is set prior to scan. Lower gain code means less full scale signal, but better DAS electronic noise performance.
DASM	**D**ata **A**cquisition **S**ystem **M**anager. The DASM is the interface to a camera for filming the images. The DASM takes a single image and transmits it digitally or in analog form, depending on the type of DASM.

TERM	MEANING
datagram	The smallest unit of network data
DCB	**D**AS **C**ontrol **B**oard. Controls DAS functions including sending digital DAS data to RF slip ring, and receipt and status back to the rest of the system.
DCD	**D**ata **C**arrier **D**etect. Serial control signal from the DCE.
DCE	**D**ata **C**ommunication **E**quipment is an EIA term that refers to a digital device designed to emulate or provide a transmission connection, such as a modem. RS-232 signals move in one prescribed direction relative to the DCE or DTE.
DCM	**D**ICOM **C**ommand **M**anager. The DCM is software that provides the Application Programming Interfaces (APIs) that implement DICOM tasks. A DICOM task initializes the DCM kernel on the AK server which will communicate with the remote DICOM station using DCM APIs.
Detector Cell	The detector cell is the smallest element of the detector. There are 912 detector cells per row. A detector cell is approximately 1 mm in “X” by 2 mm in “Z” right on the scintillator.
Detector Channel	A detector channel consists of 16 diodes (cells) arranged in the “Z” direction. A detector channel is sometimes referred to as a Detector Column.
Detector FETs	**F**ield **E**ffect **T**ransistors used to select the Photodiode combination of detector rows for post collimation slice thickness. The FETs are locat DCB.
Detector Module	A group of 16 detector channels, each channel divided into 16 cells (also called Helios Pack).
DICOM	**D**igital **I**maging and **CO**mmunication in **M**edicine. DICOM is a computer file and protocol standard used by the medical imaging industry. It enables the transfer of data between various medical scanners and devices, regardless of manufacturer. The ACR (American College of Radiology) and NEMA (National Electrical Manufacturers Association, diagnostic imaging vendors) are working together to help make this evolving standard a reality. It is designed with PACs, Ethernet, networking type applications in mind so that information can be shared across electronic networks linking many kinds of computers. The practical emphasis has been on medical device manufacturers to conform so that their patient data from one particular modality are readable by computers, workstations, printers, medical scanning devices from many vendors. A DICOM task will initialize the DCM kernel on the AK server which will communicate with the remote DICOM client station using DCM APIs.
DIP	**D**AS **I**nterface **P**rocessor. The DIP takes raw scan data from RF slip ring and writes it to disk
DMA	**D**irect **M**emory **A**ccess provides fast transfers between circuit board memory and its destination. The DMA controller relieves the CPU of managing I/O operations between RAM and disk or A/D devices. It is used to transfer completed axial images from the SRC to the OC.
DNS	**D**omain **N**ame **S**ervice is a software protocol that translates Internet location names which are easier to remember to their IP addresses.
domain	The domain name identifies the machine/computer on a network.
DOS MODE	MODs labeled (formatted) for storing images have a DOS like structure. MODs formatted for software have a UNIX structure. There are some DOS MODE commands in /usr/g/bin to help you view and copy files between the Image Archive media and the system.
DRAM	**D**ynamic **R**andom **A**ccess **M**emory
DSP	**D**igital **S**ignal **P**rocessor is an integrated circuit (IC) that performs special function digital calculations.
DSR	**D**ata **S**et **R**eady. Serial control signal from the DCE.
DTE	**D**ata **T**erminal **E**quipment is an EIA term that refers to a digital device designed or configured to provide data, such as a computer or peripheral. RS-232 signals move in one prescribed direction relative to the DCE or DTE.
DTR	**D**ata **T**erminal **R**eady. Serial control signal from the DTE.

TERM	MEANING
ECL	**E**mitter **C**oupled **L**ogic. A family of ICs used for high-speed signal transfer applications. It is faster than TTL. It requires voltages of -5 and -2 V which are labeled 5VN and 2VN. ECL differential signals are parallel terminated.
EFS	**E**xtent **F**ile **S**ystem. EFS was used on R3.5 and earlier for SGI IRIX OC disks. Starting with R3.6, the OC disk uses the XFS system. The SBC disks still use EFS.
EIA	**E**lectronic **I**ndustries **A**ssociation is a US government department that provides the latest electronic related standards for engineers and manufacturers.
Elastomer	Rubber-like conductor of electricity.
EMC	**E**lectro-**M**agnetic **C**ompatibility describes an electronic device that resists other and curbs its own electromagnetic influence.
EPROM	**E**rasable **P**rogrammable **R**ead **O**nly **M**emory uses ultraviolet light through a window on the chip to erase it.
ESD	**E**lectro**S**tatic **D**ischarge. Always use a known working (tested) wrist strap grounded to the unit before you touch any part with electronic components. There are several special grounding plugs on the frame for this. It is highlighted with a yellow icon label. Place the removed part in an anti-static bag or on a grounded pad. Protect it from further damage.
ETC	**E**nhanced **T**able **C**ontroller manages table/cradle movement and gantry tilt.
ethernet	Ethernet describes a hardware protocol for transferring data on a local area network (LAN). Ethernet cable can be coaxial, twisted pair or fiber optic.
Ethernet Address	Every system on an Ethernet network must have a unique Ethernet address. The physical Ethernet address of your system is the unique number assigned to the Ethernet board in the host. This unique number is assigned to the manufacturer of your Ethernet hardware by the IEEE (formerly by Xerox, one of the original developers of Ethernet). This is not to be confused with the IP address, which can be set arbitrarily.
Ethernet Switch	Connects the SBC, OC, ICE box, and gantry controllers together on the internal network.
FES	**F**ast **E**thernet **S**witch
FIFO	**F**irst **I**n, **F**irst **O**ut. FIFO is a memory device in which the first piece of data stored in the buffer is the first removed; can be used as a buffer to align outputs.
firewall	A firewall is a computer that prevents unauthorized access to the network upon which it resides. A correctly configured internal computer can reach outside the firewall. See 'proxy.'
FPA	**F**loating **P**oint **A**mplifier. Auto-ranging gain stage between preamp and Analog to Digital converter on converter board. Gain from FPA is used to generate exponent portion of DAS data word.
FPGA	**F**ield **P**rogrammable **G**ate **A**rray is a standardized ASIC. It's a digital component that is designed and programmed to perform a specialized board function.
FRU	**F**ield **R**eplaceable **U**nit. A GE Acronym for items that can be replaced by field personnel.
ftp	**F**ile **T**ransfer **P**rotocol is a TCP/IP standard that is used to move files between computers on a network. It is particularly needed between dissimilar computers. It also describes Internet sites that use this protocol. Popular Web browsers and PC applications eliminate the need for you to know the FTP commands by simplifying the interface.
gateway	A gateway is a program or computer that handles moving data from one network to another. It often refers to communications between different kinds of networks. It handles client input and output for the server. The Gateway Host Name is also the AE Title.
Gentry I/O	Generator / Gantry I/O is located in the On Board Computer Chassis. It performs miscellaneous gantry and generator functions.
GND	Ground is used both as a signal reference and a power return path.

TERM	MEANING
GSB	**G**antry **S**ervice **B**ox Located on the right side of the gantry. It can be used to turn off Gantry 24 hour power, the Axial Drive and the HVDC voltage. LEDs indicate status of each function.
GUI	**G**raphical **U**ser **I**nterface.
HAS*	**H**igh **A**ddress **S**trobe indicates that the eight most significant bits (23:16) of an address will be transferred. Address Strobe, AS*, transfers the first 16 bits (15:0). Used to transfer VME data.
Helical Acquisition Modes	• hi Speed mode, AKA 6 to 1 pitch (table travels 6 macro rows per rotation) • hiQ mode, AKA 3 to 1 pitch (table travels 3 macro rows per rotation).
HEMIT	**H**igh **E**fficiency **M**otor **I**solation **T**ransformer.
HEMRC	**H**igh **E**fficiency **M**otor **R**otor **C**ontroller. The HEMRC is a device used to accelerate and rotate the x-ray tube anode.
HIS	**H**ospital **I**nformation **S**ystem describes a computer system that retrieves and stores patient personal data and their diagnostic images on a network. Some of these HIS systems are compatible with CT scanners.
HSC	**H**elios **S**mart **C**ollimator
HSD	**H**igh **S**peed **D**isk holds scan data
HSSD	**H**i**S**peed **S**can **D**ata disk is used for saving raw data as it comes from the DAS. Located in the console.
HTML	**H**yper**T**ext **M**arkup **L**anguage is an Internet standard that decrees how a web page should be tagged in order to display information as intended, or to go to another place on the Internet or to start a particular function.
HTTP	**H**yper**T**ext **T**ransfer **P**rotocol is an information serving protocol that helps make the Internet possible because it is generic, stateless and object oriented means to transfer files.
hypertext	Hypertext describes the kind of information that the Internet supplies; beside text, there are sounds, voice recordings, maps, pictures, animations, videos, 3D simulations, live interactive games and conversations, links to other information sources.
ICD	**I**nspection **C**ertification **D**ocument arrives with new equipment. It is used to prove the unit was tested. A SHIPMENT and INSTALLATION card accompany it. They are submitted to headquarters upon those events to track the location of the unit.
ICE, ICE Box	**I**mage **C**hain **E**ngine. Preprocesses scan data and backprojects data into image. Includes PowerPC (RIP) and PEG-IG board.
ICMP	ICMP is the error and control message protocol used by the Internet protocol family. It is used by the kernel to handle and report errors in protocol processing. It may also be accessed through a `raw socket' for network monitoring and diagnostic functions. ICMP is used internally by the protocol code for various purposes including routing, fault isolation, and congestion control. Receipt of an ICMP redirect message will add a new entry in the routing table or modify an existing one. ICMP messages are routinely sent by the protocol code.
IF or I/F	**I**nter**F**ace.
Insite Modem	Data communication device.
InterNIC	The Internic provides the primary directory and IP address registration services for the American part of the Internet.
IP	**I**nternet **P**rotocol describes globally used computer communications applications like ping, telnet, and ftp. These are not specific to GE Healthcare. IP is the internetwork datagram delivery protocol that is central to the Internet protocol family. Programs may use IP through higher-level protocols such as the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP), or may interface directly using a ``raw socket.'' `pings' have an IP and ICMP header.

TERM	MEANING
IP Address	Every computer on the Internet has a unique IP Address consisting of four 8 bit integers (bytes) separated by dots. Each part can be number from 0 to 255. One portion identifies the host and another the network. That portion can be from one to three contiguous parts. IP Address allocation is managed by a central authority.
IPC	**I**nter **P**rocess **C**ommunication. IPC is the exchange of data between two software processes, either within the same computer or over a network. It implies a protocol that guarantees a response to a request. Examples are Unix sockets, RISC OS' messages and Microsoft Windows' DDE
IRIX	IRIX is a UNIX-based operating system from Silicon Graphics (SGI) that is used in its computer systems from desktop to supercomputer. It is an enhanced version of UNIX System V Release 4. IRIX integrates the X Window system with OpenGL, creating the first real-time 3-D X environment.
ISDN	**I**ntegrated **S**ervices **D**igital **N**etwork is a telecommunication media used by phone companies. It transfers data through existing phone lines five time faster than V.32bis modems.
ISO	ISO Alignment is the alignment of the focal spot of the tube to the center channel of the detector. This alignment is left/right when viewing the gantry from the table.
ISR	**I**nterrupt **S**ervice **R**outines are needed in a real-time (VME) system to notify, respond, or process new conditions then get out of the way of the next interrupt. It resets a device, starts a task, reads or writes data, tells the CPU of a user request, a software error, a hardware fault.
kernel	Describes the portion of a computerized machine that controls it. Sometimes it means the hardware, the Central Processing Unit (CPU), that controls all the Input/Output (I/O) and coordinates the operation of all hardware; sometimes it means the software that does this. Since it involves both, one cannot do its job without the other, kernel really means the controlling hardware and software.
Keyboard	Input device.
LAN	**L**ocal **A**rea **N**etwork. A network for transferring data or images that is confined to a small area. Usually within the same building.
LSB	**L**east **S**ignificant **B**it. Bus names include the number of signals that comprise that bus. The number that appears after the colon is the LSB of that bus. The following example has eight signal lines. EXAMPLE: BUSNAME(7:0)
LUT	**L**ook-**U**p **T**able is memory under VME control that quickly adjusts parameters for a specific system control or performs a mathematical function via mapping.
malloc errors	This is a fatal situation for software; if it could not correctly allocate memory space for an operation, the system cannot continue.
MBD	**M**odem **B**ack **D**oor offers another way for InSite to access the scanner when the PPP connection does not work.
mean	The arithmetic average of all values in a set.
memory map	Each component on a board has its own unique address in the VME memory map. Each BE board has a range of VME addresses assigned to it. The boards reside in the VME memory map in two different areas: the short I/O space and the extended memory space.
MFM	**M**essage **F**ormat **M**anager. MFM is the AKSERVER (software) component that translates data to DICOM format so that it can be sent to another DICOM device on the network.
MNP	**M**icrocom **N**etworking **P**rotocol compresses uncompressed files as they are transferred through a modem.
MOD	**M**agneto **O**ptical **D**isk is a storage device that can be recycled. It is used to store system software, files, and images.
modem	Device used to transmit digital information across phone lines. It is an abbreviation for Modulator-Demodulator.

TERM	MEANING
Mouse	Input device.
MSB	**M**ost **S**ignificant **B**it. Bus names include the number of signals that comprise that bus. The number that appears before the colon is the MSB of that bus. The following example has eight signal lines. EXAMPLE:
MTM	**M**essage **T**ransfer **M**anager. A DICOM term
MTU	**M**aximum **T**ransmission **U**nit. Internet datagrams can be fragmented and reassembled during their transmission. If the datagram is larger than the MTU of the network, it is fragmented on output.
MUX	Multiplexer selects one of multiple inputs to be routed to one output.
mv	UNIX command to move a file to another location or to rename it.
NDIS	**N**etwork **D**evice **I**nterface **S**pecification describes 3Com and Microsoft drivers needed to make TCP/IP networking happen.
Net Mask	A Net Mask is an IP Address filter that eliminates communication/noise from network devices of no interest to your machine
Network Interface	Connection from local unit to network.
Network Protocol	Makes use of a Point to Point Protocol (PPP) to communicate with the OnLine Centers. The PPP allows standard TCP/IP connectivity tools to be used as if the modem connection where part of a TCP/IP based network. Multiple levels of access security are used to insure that unauthorized users cannot access the system. For PPP to work correctly, a unique IP address must be assigned to either the modem or to the SGI computer gateway.
Network Type Support	100BASE T describes the speed and hardware that can be used to connect computers. The Indigo2 supports either AUI or 10BASE T. It does not support 100BASE T. The Octane however supports 10BASE T and 100BASE T depending on what it senses when it boots. SGI configuration settings for networking are in file /etc/inetd.conf. To reset the network when applications are down: enter**: KILLALL -V -HUP INETD**
NFS	**N**etwork **F**ile **S**ystem describes a computer system that can use or supply other computer systems even if they are dissimilar. NFS consists of client (user) and server (supplier) systems. An NFS server can export local directories for remote clients to use. A NFS client can then use those remote files.
NIS	**N**etwork **I**nformation **S**ervices is an NFS service that supports distributed databases for maintaining administrative files for the network, like passwords, host addresses. Network Information Services (NIS) provides a centralized database of information about systems on the network. This service can be used to look up the hostname or IP address of a particular system on the network.
NVRAM	**N**on-**V**olatile **R**andom **A**ccess **M**emory is used to hold important system info.
OBC	**O**n **B**oard **C**omputer, the CPU that is on the rotating frame. It is used to monitor and control the components on the rotating frame.
OBCR	**O**n **B**oard **C**omputer (**R**emote) Same as the OBC. Used when pinging the OBC.
OC	**O**perator's **C**onsole. Consists of Octane CPU, hard drives, 2 21" CRT's (Cathode Ray Tube).
OC	**O**perator's Console **C**omputer is the Silicon Graphics Computer.
Octane	Host computer (SGI)
OE	**O**utput **E**nable signal
packet	A packet is a group of binary digits representing data and control which is sent in a well defined format over a network.
Partition	A *disk partition* can be used as a file system, a logical volume, or raw disk space.

TERM	MEANING
P-Cal	Phantom Cal: The phantoms are made of water (CT# 0) or teflon (CT# ~100). Large medium and small phantoms are scanned and the images generated. Then an adjustment is made to give each pixel the correct CT#. This is applied to all images scanned.
PCI-FE	Serial expansion device
PDU	**P**ower **D**istribution **U**nit. Also referred to as the Compact Power Distribution Unit.
PEG-IG, PIG	**PEG**asus **I**mage **G**enerator board. Image backprojection board. (VME based).
ping	A command you use to check whether another device on the network is on or reachable. Example: `ping hostname (or IP adr). You identify the network host or gateway by name or IP address. You get this information from the site's system administrator.
PLD	**P**rogrammable **L**ogic **D**evice is also an ASIC.
POR	**P**lane **O**f **R**otation. This is the physical alignment of the focal spot of the tube with the aperture of the collimator. The alignment is towards or away from the table.
Port	For network configuration, enter the number that the administrator has assigned for the DICOM application.
POSIX	**P**ortable **O**perating **S**ystem **I**nterface for UNI**X**. POSIX is an IEEE standard that defines the language interface between application programs and the UNIX operating system. Adherence to the standard ensures compatibility when programs are moved from one UNIX computer to another. POSIX is primarily composed of features from UNIX System V and BSD UNIX.
PPP	**P**oint to **P**oint **P**rotocol enables a computer to access a network with a telephone, a fast modem and a service provider.
Preamp (preamplifier)	8-channel custom ASIC on the converter board that integrates the current signal from the detector. Also serves as anti-aliasing filter before analog to digital conversion of the signal from the detectors.
PROM	**P**rogrammable **R**ead **O**nly **M**emory is programmed by burning fusible links inside the chip. Once burned, they cannot be changed.
protocol	A recipe of software, parameters and settings that will enable two computers to communicate.
proxy	A network proxy enables a computer user to communicate across a firewall of an intranet whose access from the outside world is guarded by that firewall. Business employees need to configure their web browser software proxies for various protocols used to access Internet information is various ways, http being the most common. Home users who have an independent service provider do not need or use proxies.
Radial Alignment	Radial Alignment This is the alignment of the detector so that both ends are equidistant from the focal spot of the tube.
RAM	**R**andom **A**ccess **M**emory
RCIB	The CAN bus and control lines from the HCB (HEMRC Control Board) to the CCB and DCB on the rotating side of the gantry.
reconfig	A shell started program with a GUI that changes system parameters.
Ref-Channels (Reference channels)	DAS channels 1 through 3 on each slice. Used to normalize DAS data to x-ray source intensity; consequently should be outside patient anatomy.
register	A digital, electronic device for temporary storage of a value.
repeater	A network repeater is a device to connect two or more devices to a subnet; the last port on a repeater can be used to connect multiple hubs. A repeater conditions the signal and with the hub port can extend the physical distance between devices. This is important because there are limits to how far a cable length can be effective.
REQ	Request signal

TERM	MEANING
RF Ring	Communication channel to passes raw image data from the rotating side of the gantry(SDAS) to the stationary side.
RF Shoe	Picks up the RF signal from the RF ring.
RI	**R**ing **I**ndicator is a serial control signal from the DCE.
RIP	**R**econ **I**nterface **P**rocessor. The Power PC single board computer (VME based).
RIS	**R**adiology **I**nformation **S**ystem describes a computer system that retrieves and stores patient personal data and their diagnostic images on a network.
ROI	**R**egion **O**f **I**nterest
router	A router is a device that determines what path network traffic will take to reach its destination. It extends a local area network (LAN) to create a larger inter-network. It uses the routing information inside the data and the criteria programmed into it to make decisions on how to most efficiently route the data.
routine	A specialized software program or module. This system uses Activity Manager and Delivery routines.
Routing Table	A file that identifies network interfaces; it details the names and IP addresses of all the routers and gateways in the network.
RS-232	Electronic Industries Association (EIA) standard for serial data transmission that prescribes signals by voltage level and pin location.
RS-422	EIA standard for the serial exchange of digital data between two pieces of electronic equipment that uses a balanced, or differential, interface. It uses relative differences between a positive and negative signal without reference to a common ground. This enables greater speed and immunity to noise or EMI.
RTS	**R**eal **T**ime **S**tatistics
RTS	**R**equest **T**o **S**end. Serial control signal from the DTE.
RxD	**R**eceived **D**ata. Serial data from the DCE to the DTE. It is input to the host from a peripheral or modem.
SARQ	**S**tationary **A**utomatic **R**etry **Q**uery. Small board used in transmitting data across the slip rings to the rotating part of the gantry. It generates an ECC error code used to verify data integrity. It is located in the STC chassis.
sash	**S**tand-**a**lone **sh**ell can be started from the SGI command monitor prompt, reached by interrupting the CTi boot and selecting 5. You can use sash to find and load files and devices, files outside the reach of the command monitor, the SGI PROM, meaning files in IRIX or SBC Unix.
SCP	**S**ervice **C**lass **P**rovider describes a DICOM task/device that allows other devices on the network to query the SCP for images or data. A SCP task listens on the specified port for the Application Entities (AE) that it has been configured to hear. SCP is like a server.
SCSI	**S**mall **C**omputer **S**ystem **I**nterface is a peripheral interface standard commonly used for hard disk drives and some printers to speed up data transfer.
SCU	**S**can **C**ontrol **U**nit is a term for the chassis that contains the RIP and PEG-IG boards; the boards reconstruct scan data into image files.
SCU	**S**ervice **C**lass **U**ser describes a DICOM task/device that uses another unit on the network to store or print images or get patient information so that the technologist does not have to key it in. SCU is like a client
SDAS	**S**caleable **D**ata **A**cquisition **S**ystem - Converts analog detector data to digital data.
SDAS Converter Board	Converts analog detector signal to digital data. 64channels, 8 pre-amps, 2 A/D's per board. 48 boards per SDAS.

TERM	MEANING
SdC	**S**tation **d**e **C**onsultation French for Advantage Windows workstation.
SDD	**S**can **D**ata **D**isk. Replaces the HSD (high speed disk).
SDM	**S**ervice **D**esktop **M**anager. Graphical User interface used to access service related tools and functions.
semaphore	A software object that handles device reservations for tasks.
server	A server is a computer system or application that provides the programs and disk space that a client computer or application possibly somewhere else on the network uses. The communication link between a server and client is called a socket.
SGI	**S**ilicon **G**raphics **I**ncorporated Company makes the Silicon Graphics Computer, which is why it is referred to as the SGI computer.
socket	The software structure that enables a communication link between any two network computer processes, like a server and client, is called a socket. You need an IP address and a port to establish a socket. The verb 'bind' is often used in connection to socket.
Software Level - Application	Applications Level is the software level where the scanner specific software has been initialized and the system could be used to: scan, archive, display, film, etc.
Software Level - Boot	Boot level is where no software is running other than what can be run out of CPU firmware. This was often referred to as `Prom Monitor' or `Boot Prompt' or Single User Mode.
Software Level - Operating (Irix)	Operating is the software level in between `Boot Level' and `Applications Level'. This is often referred to as the Operating System level. The system will normally start and login as user `ctuser' leaving the User Interface ready for selection of Irix and Unix Commands or start-up of the Scanner Applications Software.
SOP	**S**ervice **O**bject **P**air, a DICOM software term. Server Object Pair is Service Class User plus Service Class Provider. Client/Server
STC	**ST**ationary **C**omputer used to monitor ETC and OBC status. Controls communications between the SBC and the ETC & OBC. Also monitors the axial rotation of the gantry.
subnet	A subnet is a group of connected computers or hosts. The network portion of their IP addresses would match, but the host portion would be unique.
System State	Program available on Service PM menu that enables you to save and restore protocols, calibration, configuration, Auto Voice, Display Preferences, and characterization of the Table, Gantry, and InSite features. This should be done with a Max Optics MOD. Mark this MOD so that no one will use it for Image Archive. The LABEL instruction under that feature will reformat your System State MOD into a DOS MODE format, destroying it.
task	The smallest complete unit of software. A task can use and wait for system resources without explicit concern for other tasks.
TCP	**T**ransmission **C**ontrol **P**rotocol (software) assumes the datagram service it is layered above is unreliable. A checksum over all data helps TCP implement reliability. Using a window-based flow control mechanism that makes use of positive acknowledgments, sequence numbers, and a retransmission strategy, TCP can usually recover when datagrams are damaged, delayed, duplicated or delivered out of order by the underlying communication medium. If the local TCP receives no acknowledgments from its peer for a period of time, as would be the case if the remote machine crashed, the connection is closed and an error is returned to the user. If the remote machine reboots or otherwise loses state information about a TCP connection, the connection is aborted and an error is returned to the user.
TCP/IP	**T**ransmission **C**ontrol **P**rotocol/**I**nternet **P**rotocol is a common standard for transferring data across the Internet.
telnet	Telnet is another TCP/IP standard; telnet is a protocol that enables your computer to logon to a remote computer and query that computer for its information or use its programs.
Termination	Termination is required at both ends of a SCSI bus.

TERM	MEANING
TRAM	**T**exture **R**andom **A**ccess **M**emory on the MG1,0 and MG1,1 boards used to perform pixel interpolations and hold same image data.
tristate	Describes electronic device whose output may be HIGH, LOW, or high impedance meaning not driven This makes it possible to use the same bus for different purposes. It also is used as a verb to mean to disconnect the unused circuitry by making it's connection high impedance.
TTL	**T**ransistor to **T**ransistor **L**ogic is low with voltage levels from 0 to 0.8 V, and high at levels of 2.4 to 5 V. This is also called Vcc, digital logic, and 5V.
Tube Mounting Plate	Mounting plate between tube and collimator.
TxD	**T**ransmitted **D**ata. Serial data from the DTE to DCE. It is serial data from the host to a peripheral or modem.
udp	**u**ser **d**atagram **p**rotocol. A network term.
UID	**U**nique **ID**entifier
URL	**U**niform **R**esource **L**ocator is a way to define a resource location on a network. It describes the type of service (http, ftp, or telnet, and its exact location by network, if different, its directory and its file name. Format: protocol://computer[:port]/path/filename Example: http://www.microsoft.com
V.34	A CCITT standard for modem communications that extends the V.32 connection rate to 28.8 k bps. With data compression, this rate can theoretically go to 115.2 kbps but the condition of most phone company links prevents that from happening. This standard was previously known as V.Fast and V32terbo.
V.42	A CCITT standard for modem communication that improves throughput by correcting errors and compressing data
V.Everything	A CCITT standard for modem communications that improves throughput by adapting to the modem to which it connects and using optimal protocols.
VLSI	**V**ery **L**arge **S**cale **I**ntegration of electronic circuits on one chip.
VME	**V**ersa **M**odulo **E**urocard
VME ASIC	The SBC CPU has a master ASIC that implements the VMEbus interface standard. It contains a DMA controller, local and global interrupt handlers, and the VMEbus R/W logic. The other boards have a slave VME Interface ASIC to communicate with that master ASIC.
VME_ADR	Thirty-one lines of three state driven one directional signals that identify the devices that will receive or place data on the bus. All devices are memory mapped.
VME_AM	Address Modifier; a VMEbus signal that broadcasts information about the address during the address load cycle such as whether it is short (16 bits), standard (24), or extended (32 bits long). It can be used to identify a sequential transfer which is not to be interrupted until the entire data block is transferred. Six lines are reserved for this purpose.
VME_AS*	Address Strobe is a three state driven signal whose falling edge indicates the master has placed a stable, valid address and modifier onto the bus. Besides ADR, an address consists of AM, LWORD*, and IACK*.
VME_BERR*	VMEbus Error is generated by any slave board if the data size is wrong or an error occurred in a transfer; it is generated by the CPU bus timer if a data transfer fails to occur.
VME_DAT	Thirty-two lines of three state driven bidirectional data used to transfer information between the CPU and the other boards on the VMEbus.
VME_DS0* or 1	Data Strobe is a high current, three state VMEbus signal driven by the VME host and interrupt handlers. The falling edge of a Data Strobe informs when data should be read or written. When combined with LWORD and ADR01, they also indicate the size and type of data transfer.

TERM	MEANING
VME_DTACK*	Data Transfer Acknowledge signal is driven low by a slave or interrupter. During a write cycle, DTACK* is asserted after the slave has received data on the bus. During a read or interrupt acknowledge cycle, it is asserted to tell the master it has placed the requested data on the bus.
VME_IACK*	Interrupt acknowledgment is accomplished by a VME daisy chain. IACK jumpers should be open or removed if there is a board in its associated Back End slot. One must be installed to continue the interrupt path if there is no board in a slot.
VME_IRQ0n*	Interrupt Requests; see ISR also. These seven lines are monitored by the MVME166 for signals from the other boards that indicate that an I/O process is waiting, that no device responded to a command, that a voltage or output is wrong. The highest numbered request line has the highest priority. Software assigns the priorities and what appropriate routine should be implemented.
VME_LWORD*	Long WORD select is a three state VMEbus address signal driven low by the VME host and used with ADR01, DS0*, DS1* to indicate a 32-bit data transfer.
VME_SYSRESET*	A control signal that resets every board. This happens when the unit is powered ON, or the RESET switch on the CPU is pressed.
VMEbus	**V**ersa**M**odule **E**urocard bus; an IEEE backplane standard that prescribes how data transfers will be managed. The VMEbus can handle 8, 16, and 32 bit transfers. It has multiprocessing and interrupt capability. The maximum data transfer rate is 40 MB/sec.
X Window	X Window is a windowing system developed at MIT, which runs under all major operating systems. X lets users run applications on other computers in the network and view the output on their own screen.
XCR	Ethernet Converter - 10BaseT to 10Base2
xfs	Starting with R3.6, the host uses the XFS filesystem rather than EFS. XFS uses database journaling technology to provide high reliability and rapid recovery. Recovery after a system crash is completed within a few seconds, without the use of a filesystem checker such as the fsck command. Recovery time is independent of filesystem size. XFS is designed to be a very high performance filesystem. Under certain conditions, throughput exceeds 100 MB per second.
Y/C	An abbreviation for a composite video signal that carries color, sync and brightness information. The Y portion – called luminance – carries the sync and brightness and can be used for black and white as well as color video. The C signal – called chrominance or chroma – carries color information, and synchronizes with the horizontal frequency.
Z-Alignment	After changing a tube, both the BOW (beam on window) and POR (plane of rotation) need to be done. Since the collimator & detector have not changed position, the X-Ray tube only needs to be adjusted toward or away from the table. (Assumes the collimator & detector are in the correct position.) The Z-Align can do this with one adjustment instead of two.
Z-CHANNELS	DAS channels 763 through 765 in each slice. Used to control “Z” direction centering of beam on detector via the collimator. Have special detector FET control lines, to select outer detector cells.

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