

***Signa® MR/i with Signa Select™ (ASP2)***  
***Learning and Reference Guide***  
***Volume 3:***  
***Optimizing Images with Imaging Options***

*2292263-100 Rev. 0 (03/01)*

*Copyright 2001 General Electric Company*



# Medical Device Directive

---

These products conform with the requirements of council directive 93/42/EEC concerning medical devices, when they bear the following CE Mark of Conformity:



This equipment generates, uses, and can radiate radio frequency energy. The equipment may cause radio frequency interference with other medical and non-medical devices and radio communications. To provide reasonable protection against such interference, the:

### GE Signa MR/i Systems

comply with emissions limits for (Group 2, Class A) Medical Devices as stated in EN 60601-1-2. However, there is no guarantee that interference will not occur in a particular installation.



If this equipment is found to cause interference (which may be determined by turning the equipment on and off), the user (or qualified service personnel) should attempt to correct the problem by one or more of the following measure(s):

- reorient or relocate the affected device(s);
- increase the separation between the equipment and the affected device;
- power the equipment from a source different from that of the affected device; and/or
- consult the point of purchase or service representative for further suggestions.

The manufacturer is not responsible for any interference caused by using interconnect cables that are not recommended or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

Do not use devices that transmit RF Signals (**cellular phones**, transceivers, or radio controlled products) in the vicinity of this equipment as they may cause performance outside the published specifications. Keep the power to these types of devices turned off when near this equipment.

The medical staff in charge of this equipment is required to instruct technicians, patients, and other people who may be around this equipment to fully comply with the above requirement.

Immunity/Emissions Exceptions: Note the exceptions from the EMC test results. Check with the business EMC engineer for this information.

In accordance with the international safety standard IEC 601-1, this system is a Class I device, acceptable for Continuous Operation, having ordinary protection against ingress of water with type B applied parts and is not for use in the presence of flammable anesthetics.

**CAUTION: User to call or contact the local authorities for disposal of the MR System at the end of its useful life.**

---

# Table of Contents

<b>Chapter About: About This Guide.....</b>	<b>Volume 1</b>
Introduction .....	About-1
Purpose of This Guide .....	About-1
Prerequisite Skills .....	About-1
How The Guide is Organized .....	About-2
Chapter Format .....	About-4
Introduction.....	About-4
About... ..	About-4
How To... ..	About-4
Graphic Conventions and Legend .....	About-5
Safety Notices .....	About-7
<b>Chapter 1: Working Safely .....</b>	<b>Volume 1</b>
Introduction .....	1-1
About... Working Safely .....	1- 4
Safety Information .....	1-5
Indications for Use.....	1-5
Restrictions on Use .....	1-5
Contraindications for Use .....	1-6
User Training .....	1-7
Magnet Hazards .....	1-8
Security Zone .....	1-8
Exclusion Zone .....	1-10
Quench with Vent Failure Hazards .....	1-11
Liquid Cryogen Concerns .....	1-11
Hazard Warnings .....	1-13
Laser Light Hazards.....	1-13
Peripheral Nerve Stimulation.....	1-13
Burn Hazards .....	1-16
Metal Heating Warnings.....	1-21
Thermal Stress .....	1-22
RF Power .....	1-22
Clinical Hazards.....	1-23
Acoustic Hazards .....	1-26
Equipment Hazards.....	1-26
Patient Alert System .....	1-30
Patient Emergencies .....	1-31
MR Compatibility .....	1-31
Safety Review .....	1-34
How to Work Safely .....	1- 35
Eliminate Magnet Hazards .....	1-36

Eliminate Ferromagnetic Items From The Security Zone .....	1-36
Limit Access to the Exclusion Zone—Screen Patients and Personnel ...	1-37
Patient Screening Form:.....	1-38
Respond to Emergencies .....	1-40
Patient Emergencies.....	1-40
Magnet Emergencies.....	1-41
Quench with Vent Failure .....	1-42
Protect the Patient from RF Burns .....	1-43
Protect the Patient’s Eyes and Ears.....	1-45
Check the Cryogen Levels .....	1-46
Systems with a Helium Level Meter.....	1-46
Systems with a Magnet Monitor Unit.....	1-47
Handle Contact with Liquid Cryogens .....	1-48
<b>Chapter 2: Getting Started and Basic Problem Resolutions.....</b>	<b>Volume 1</b>
Introduction .....	2-1
About... Getting Started .....	2- 3
Workstation Components .....	2-3
Magnetic Resonance Suite.....	2-3
PAC (Physiologic Acquisition Control) Unit .....	2-7
MR Table/Patient Transport .....	2-8
Console Room.....	2-9
Mouse Basics .....	2-13
System Cabinet Room (Computer Room) .....	2-14
Quality Assurance .....	2-15
Desktop Organization .....	2-16
Types of Menus.....	2-17
Basic Problem Resolutions .....	2-18
Mobile Site Configuration .....	2-18
Save Raw Data .....	2-21
How to Get Started Using Your System .....	2- 22
Configure a Mobile Site.....	2-23
Power on the MR System .....	2-26
Start Your Mobile System .....	2-26
Start a Stationary System.....	2-28
Navigate Through Screens and Menus .....	2-30
Perform a Daily QA Test .....	2-31
Shut Down your MR System .....	2-34
Reset the TPS .....	2-35
Save Raw Data.....	2-36
Power Down Under Emergencies.....	2-38

---

<b>Chapter 3: Scan Rx Desktop.....</b>	<b>Volume 1</b>
Introduction .....	3-1
About... the Scan Rx Desktop.....	3- 3
Patient Information .....	3-6
Abbreviated Patient Information .....	3-8
Patient Position .....	3-9
Patient Position .....	3-10
Patient Entry .....	3-11
Coil Type .....	3-11
Series Description .....	3-13
Imaging Parameters .....	3-13
Imaging Plane .....	3-13
Imaging Mode.....	3-16
Pulse Sequence .....	3-21
Imaging Options .....	3-22
Pulse Sequence Database Name .....	3-22
Protocol.....	3-23
AutoView Window .....	3-24
AutoView .....	3-24
Report Cursor.....	3-25
Update Images .....	3-26
Auto Window/Level .....	3-26
Save Window/Level.....	3-26
Maximize/Minimize.....	3-27
Scan Timing .....	3-27
Number of Echoes .....	3-28
Number of Shots .....	3-29
Echo Time .....	3-30
Repetition Time .....	3-33
Inversion Time .....	3-34
Flip Angle .....	3-35
Echo Train Length .....	3-36
Bandwidth.....	3-38
Additional Parameters .....	3-39
SAT Prescription Screen.....	3-40
Graphic Prescription Screen .....	3-42
Vascular Screen .....	3-45
User Control Variables (User CVs) Screen .....	3-46
Gating/Triggering Screen .....	3-47
Cine Screen .....	3-48
Multi Phase Screen .....	3-48
DWI Screen.....	3-50
Scanning Range .....	3-51

Field of View .....	3-51
Slice Thickness .....	3-52
Spacing.....	3-53
Start and End Location.....	3-55
FOV Center.....	3-55
Number of Slices/Slabs.....	3-56
Acquisition Timing .....	3-58
Acquisition Matrix .....	3-58
NEX .....	3-60
Phase FOV .....	3-61
Number of Acquisitions/Locations Before Pause.....	3-63
Frequency Direction.....	3-64
Auto Center Frequency .....	3-65
Flow Comp Direction .....	3-67
Autoshim.....	3-68
Phase Correct .....	3-69
Contrast .....	3-70
Rx Manager .....	3-71
Scan Modes.....	3-72
Gating Control .....	3-75
New Series .....	3-77
End Exam.....	3-78
Rx Manager List .....	3-79
View Edit .....	3-81
Prepare to Scan .....	3-82
Save Rx as Protocol .....	3-82
Auto Scan.....	3-83
AutoStep .....	3-84
Series Control and Advisory Panel .....	3-84
Save Series .....	3-85
Reset Values.....	3-85
Relative SNR% .....	3-85
SAR Level.....	3-86
Frames per Second Notification.....	3-86
Scan Operations .....	3-87
STL% or dB/dt Level.....	3-87
Prescan .....	3-88
Prep Scan .....	3-89
Scan.....	3-89
Reference Scan.....	3-90

---

<b>Chapter 4: Gradient, Shim, and Imaging Coils .....</b>	<b>Volume 1</b>
Introduction .....	4-1
About... Gradient, Shim, and Imaging Coils .....	4- 3
Gradient and Shim Coil Function .....	4-3
Gradient Coils .....	4-3
Shim Coils.....	4-5
Imaging Coil Function and Classification .....	4-5
Head Coil .....	4-6
Body Coil .....	4-7
Surface and Phased Array Coils .....	4-7
Coil Sensitivity Range .....	4-8
Adaptive Phased Array .....	4-8
Performing Coil QA .....	4-10
Performing Head Coil QA .....	4-10
Performing QA for Other Coils .....	4-11
How to Select Coils and Position the Patient .....	4- 12
Position the Patient .....	4-13
Head Coil .....	4-13
Body Coil .....	4-16
Surface and Phased Array Coils .....	4-18
<b>Chapter 5: Building and Saving Protocols .....</b>	<b>Volume 1</b>
Introduction .....	5-1
About... Building and Saving Protocols .....	5- 3
Building Protocols with the Protocol Manager .....	5-4
Selecting and Saving from Protocol Libraries .....	5-4
GE Library .....	5-5
Site Library .....	5-6
Picture This Library .....	5-6
Managing Site Protocols .....	5-7
How to Build and Save Protocols .....	5- 8
Build a Protocol .....	5-9
Copy a Protocol to the Site Library .....	5-14
Edit and Save a Protocol .....	5-16
Save Protocol While Scanning .....	5-19
Delete a Site Protocol .....	5-20
Copy a Series in a Protocol .....	5-22
Print Site Protocols .....	5-24
Save Site Protocols to MOD .....	5-27
Restore or Delete Site Protocols from MOD .....	5-31

**Chapter 6: Pre-Registering Patients and ConnectPro..... Volume 1**

Introduction ..... 6-1

About... Pre-Registering Patients and ConnectPro ..... 6- 3

    Pre-Registering Patients ..... 6-4

    Deleting a Registered Patient ..... 6-6

    Using ConnectPro Plus ..... 6-7

        Navigating the Schedule Window ..... 6-8

        Ending Exams with ConnectPro ..... 6-10

    Using Performed Procedure Step (ConnectPro Plus) ..... 6-12

    Guided Install for HIS/RIS DICOM ..... 6-13

    Guided Install for Mapping Protocols to Action Items ..... 6-13

How to Pre-Register Patients and Use ConnectPro ..... 6- 15

    Pre-Register a Patient..... 6-16

    Link a Protocol to a Patient at Pre-Registration..... 6-18

    Select a Registered Patient..... 6-20

    Sort the Patient Register..... 6-21

    Delete a Registered Patient ..... 6-22

    Enter Patient Information Using ConnectPro Plus (PPS) ..... 6-23

    Guided Install-HIS/RIS DICOM Mode ..... 6-27

    Guided Install-Mapping Protocols to Action Items ..... 6-30

    Assign Image Storage ..... 6-34

**Chapter 7: Scanning with a Protocol ..... Volume 1**

Introduction ..... 7-1

About... Scanning..... 7- 3

    Protocol Libraries ..... 7-4

        Picture This Protocol Library..... 7-5

        Site Protocol Library ..... 7-5

        GE Protocol Library..... 7-5

    Rx Manager ..... 7-6

        Rx Manager List ..... 7-7

        New Series ..... 7-9

        End Exam..... 7-10

        View Edit ..... 7-10

        Prepare to Scan ..... 7-11

        Save Rx as Protocol ..... 7-11

        Auto Scan..... 7-12

        AutoStep ..... 7-13

    Pulse Sequences ..... 7-13

    Imaging Options ..... 7-14

    Parameter Trade-offs ..... 7-15

        Factors that Affect Contrast ..... 7-15

        Factors that Affect Spatial Resolution ..... 7-16

        Factors that Affect Scan Time ..... 7-17

---

Factors that Affect SNR.....	7-18
Defining a Scanning Range .....	7-22
Explicit Prescription .....	7-22
Graphic Prescription .....	7-23
Defining Saturation Bands .....	7-32
Spatial Saturation .....	7-32
Chemical Saturation.....	7-37
Graphic SAT Prescription.....	7-41
How to Scan with a Protocol .....	7-45
Prepare the Patient for the Exam .....	7-46
Start a Scan Prescription .....	7-48
Transfer the Patient to the System Table .....	7-50
Position the Patient .....	7-51
Align and Landmark .....	7-54
Select a Protocol .....	7-58
Review the Protocol Parameters .....	7-60
Define a Scanning Range .....	7-62
Explicitly.....	7-62
Graphically.....	7-65
Radial Graphically .....	7-70
Define Saturation Bands .....	7-72
Scan.....	7-75
<b>Chapter 8: Optimizing Image Quality with Prescanning .....</b>	<b>Volume 1</b>
Introduction .....	8-1
About...Prescanning .....	8- 3
Purpose and Benefits .....	8-4
The Two Prescan Programs .....	8-4
Auto Prescan .....	8-4
Manual Prescan.....	8-4
Reasons for Auto Prescan Failures .....	8-5
Precessional and Transmit Frequency .....	8-6
Transmit Power and Flip Angle .....	8-6
Receiver Sensitivity .....	8-7
Prescan for Chemical Saturation .....	8-7
How to Prescan .....	8- 8
Automatically Prescan .....	8-9
Manually Prescan .....	8-10
Match Coarse Center Frequency to the Patient .....	8-10
Adjust the Transmit Gain to Achieve Optimum Flip Angle.....	8-12
Match Fine Center Frequency to the Patient .....	8-15
Adjust the Receiver Gain to Achieve Optimum Signal .....	8-17
Optimize Chemical Saturation.....	8-19

<b>Chapter 9: Displaying Images.....</b>	<b>Volume 1</b>
Introduction .....	9-1
About... Displaying Images.....	9- 4
Sorting Images .....	9-5
Viewport Control .....	9-5
Viewer Organization .....	9-6
Window/Level Control .....	9-6
Display Features .....	9-6
Cine Paging.....	9-7
Reference Image .....	9-8
Measuring .....	9-9
Image Annotation .....	9-10
System Supplied.....	9-12
User Preferences .....	9-16
Accelerator Commands .....	9-18
How to Display Images.....	9- 19
Sort Exams, Series, or Images .....	9-21
View Patient List.....	9-22
Refresh List.....	9-24
Display Images in Viewer.....	9-25
Set a Primary Viewport.....	9-29
Set a Secondary Viewport.....	9-30
Use Cine Page .....	9-31
Compare Images .....	9-34
Analyze Images.....	9-36
Manipulate Images .....	9-37
Magnify Images (Zoom) .....	9-37
Apply the Magnifying Glass .....	9-39
Scroll .....	9-40
Grid .....	9-41
Erase All.....	9-42
Hide and Show .....	9-43
Display Normal.....	9-44
Reference Image .....	9-45
Flip / Rotate.....	9-47
Annotate Images .....	9-48
Remove Annotation .....	9-50
Modifying a Displayed Matte .....	9-51
Apply Mattes to Images .....	9-51
Modifying a Displayed Matte .....	9-51
Measure.....	9-53
Enhance Images .....	9-54
Cross Reference a Series.....	9-56

---

Screen Save .....	9-58
Set Up User Preferences .....	9-59
Customize System Supplied Annotation .....	9-59
Tick Marks .....	9-62
Customize Grid Preferences .....	9-63
Control the Right Mouse Button.....	9-65
Control Series Binding.....	9-66
Apply Square Viewports.....	9-67
Customize the Window/Level Presets .....	9-68
Use Accelerator Commands .....	9-70
Save State.....	9-77
Reverse the Video (Inverse Video).....	9-78
<b>Chapter 10: Filming Images .....</b>	<b>Volume 1</b>
Introduction .....	10-1
About...Filming Images .....	10- 3
The Film Composer .....	10-4
Setting Up the Filming Parameters .....	10-5
Loading the Images.....	10-8
Printing.....	10-8
Using the F (Function) Keys .....	10-8
The Print Queue .....	10-11
The Remote Printer .....	10-11
How to Film Images .....	10- 12
Set Up the Film Composer.....	10-13
Load with Drag and Drop .....	10-15
Load with the Function (F) Keys .....	10-16
Load Text Pages.....	10-18
Erase an Image from the Film.....	10-19
Print Images .....	10-20
Select a Remote Printer.....	10-21
Check the Print Queue .....	10-23
Set Window and Level Presets .....	10-25
<b>Chapter 11: Managing Images .....</b>	<b>Volume 1</b>
Introduction .....	11-1
About... Managing Images.....	11- 3
Feature Status Area .....	11-4
Anonymous Patient .....	11-4
Archive Media .....	11-5
Selecting an Archive Device.....	11-5
Composition of Archiving Option .....	11-6
Labeling the Storage Media .....	11-6
Saving Images.....	11-7
Restoring Images from Local Archive Media .....	11-8

Archive Queue .....	11-9
Managing Disk Space .....	11-10
System Disk Space.....	11-10
Removing Images from the System Disk .....	11-11
Networks .....	11-12
Networking Terms .....	11-12
Network Queues.....	11-13
How to Manage Your Images .....	11- 15
Create an Anonymous Patient.....	11-16
Select an Archive Device.....	11-18
Label Storage Media .....	11-20
Save Images .....	11-23
Restore Images from Local Archive Media.....	11-26
Check the Archive Queues.....	11-30
Detach Storage Media.....	11-32
Manage Disk Space .....	11-33
Remove Image Data.....	11-33
Configure a Remote Host .....	11-35
Add a Host .....	11-35
Remove a Host.....	11-38
Update a Host.....	11-40
Network Images To & From Connected Stations .....	11-42
Network from the Scan Rx Desktop .....	11-42
Transmit Data to a Remote Host (Network Send).....	11-45
Retrieve Images from a Remote Host (Network Receive) .....	11-48
Check the Network Queue .....	11-51
<b>Chapter About: About This Guide .....</b>	<b>Volume 2</b>
Introduction .....	About-1
Purpose of This Guide .....	About-1
Prerequisite Skills .....	About-1
Chapter Format .....	About-2
Introduction.....	About-2
About.....	About-2
Glossary of Terms and Acronyms .....	About-2
Graphic Conventions and Legend .....	About-3
Safety Notices .....	About-5
<b>Chapter 1: Imaging with 3 Plane Localizer.....</b>	<b>Volume 2</b>
Introduction .....	1-1
About... 3 Plane Localizer.....	1- 3
3-Plane Localizer .....	1-3
Description.....	1-3
Background.....	1-3
Associated Imaging Options .....	1-5

---

Applications .....	1-5
Setting up a 3 Plane Localizer .....	1- 6
<b>Chapter 2: Imaging with Spin Echo Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	2-1
About... Spin Echo Pulse Sequences .....	2- 3
Spin Echo (SE) .....	2-3
Spin Echo Image Characteristics .....	2-5
Associated Imaging Options .....	2-8
Applications .....	2-9
Setting up a Spin Echo pulse sequence.....	2-10
Inversion Recovery (IR) .....	2-15
Inversion Recovery Image Characteristics .....	2-16
Associated Imaging Options .....	2-18
Applications .....	2-18
Setting up an Inversion Recovery pulse sequence.....	2-20
<b>Chapter 3: Imaging with Fast Spin Echo Pulse Sequences.....</b>	<b>Volume 2</b>
Introduction .....	3-1
About... Fast Spin Echo Pulse Sequences.....	3- 3
Fast Spin Echo (FSE) .....	3-3
Fast Spin Echo Image Characteristics .....	3-7
Associated Imaging Options .....	3-14
Applications .....	3-14
Setting up a Fast Spin Echo Pulse Sequence .....	3-16
Fast Recovery Fast Spin Echo (FRFSE) .....	3-21
Fast Recovery FSE Image Characteristics.....	3-22
Associated Imaging Options .....	3-24
Applications .....	3-25
Setting up a FRFSE pulse sequence .....	3-26
Fast Spin Echo-Inversion Recovery (FSE-IR) .....	3-30
FSE-IR Image Characteristics .....	3-31
Associated Imaging Options .....	3-33
Applications .....	3-33
Setting up a FSE-IR Pulse Sequence .....	3-34
FLAIR and T1 FLAIR .....	3-38
FLAIR and T1 FLAIR Image Characteristics .....	3-40
Associated Imaging Options .....	3-43
Applications .....	3-44
Setting up a FLAIR or T1 Flair pulse sequence .....	3-45
Single Shot Fast Spin Echo (SSFSE) and Inversion Recovery (SSFSE-IR) .....	3-50
Single Shot FSE and Single Shot FSE-IR Image Characteristics.....	3-52
Associated Imaging Options .....	3-54
Applications .....	3-54
Setting up a SSFSE or SSFSE-IR Pulse Sequence .....	3-56

<b>Chapter 4: Imaging with Gradient Echo Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	4-1
About... Gradient Echo Pulse Sequences .....	4- 3
Gradient Echo (GRE) .....	4-3
Gradient Echo Image Characteristics.....	4-5
Associated Imaging Options .....	4-7
Applications .....	4-8
Setting up a Gradient Echo pulse sequence .....	4- 9
Spoiled Gradient Echo (SPGR) .....	4-20
Spoiled Gradient Echo Image Characteristics .....	4-21
Associated Imaging Options .....	4-23
Applications .....	4-23
Setting up an Spoiled Gradient Echo pulse sequence .....	4-25
<b>Chapter 5: Imaging with Fast Gradient Echo Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	5-1
About... Fast Gradient Echo Pulse Sequences .....	5- 3
Fast Gradient Echo (FGRE) and Fast Spoiled Gradient Echo (FSPGR) .....	5-3
Fast Gradient Echo Image Characteristics .....	5-4
K-space .....	5-5
Associated Imaging Options .....	5-8
Applications .....	5-9
Setting up a Fast Gradient Echo pulse sequence.....	5- 10
<b>Chapter 6: Imaging with Time of Flight Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	6-1
About... Time of Flight Pulse Sequences.....	6- 3
2D Time of Flight GRE and SPGR .....	6-3
Time of Flight Image Characteristics .....	6-8
Associated Imaging Options .....	6-9
Applications .....	6-9
Setting up a 2D TOF pulse sequence .....	6- 10
3D TOF GRE/SPGR .....	6-15
Ramp Pulse .....	6-16
Applications .....	6-18
Setting up a 3D TOF pulse sequence .....	6- 22
<b>Chapter 7: Imaging with Fast Time of Flight Pulse Sequences.....</b>	<b>Volume 2</b>
Introduction .....	7-1
About... Fast Time of Flight Pulse Sequences .....	7- 3
Fast 2D Time of Flight GRE/SPGR .....	7-4
Gated 2D TOF.....	7-4
Time of Flight Image Characteristics .....	7-9
Associated Imaging Options .....	7-9
Applications .....	7-10
Setting up a Gated 2D TOF pulse sequence .....	7- 11

---

Fast 3D TOF GRE/SPGR .....	7-17
Associated Imaging Options .....	7-18
Applications .....	7-19
Setting up a Fast 3D TOF pulse sequence .....	7- 19
<b>Chapter 8: Imaging with Phase Contrast Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	8-1
About... Phase Contrast Sequences.....	8- 3
Phase Contrast (PC) .....	8-3
2D Phase Contrast (2D PC) .....	8-6
2D PC Oblique Imaging .....	8-7
Associated Imaging Options .....	8-8
Applications .....	8-8
Setting up a 2D Phase Contrast pulse sequence .....	8-10
Fast 2D Phase Contrast .....	8-15
Associated Imaging Options .....	8-16
Applications .....	8-16
Setting up a Fast 2D Phase Contrast pulse sequence .....	8-18
3D Phase Contrast (3D PC) .....	8-23
Associated Imaging Options .....	8-24
Applications .....	8-24
Setting up a 3D Phase Contrast pulse sequence .....	8-26
<b>Chapter 9: Imaging with Cine Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	9-1
About... Cine Pulse Sequences .....	9- 3
Cine GRE .....	9-3
Trigger Type .....	9-4
Update bpm.....	9-5
Locations per Acquisitions .....	9-5
Cardiac Phases to Reconstruct.....	9-6
Cine GRE Image Characteristics .....	9-9
Associated Imaging Options .....	9-11
Applications .....	9-12
Setting up a Cine pulse sequence.....	9- 12
Cine SPGR .....	9-17
Associated Imaging Options .....	9-18
Applications .....	9-19
Cine PC .....	9-19
Associated Imaging Options .....	9-22
Applications .....	9-22
Setting up a Cine PC pulse sequence .....	9- 23
Flow Analysis .....	9-28
Applications .....	9-36
Setting up a Flow Analysis pulse sequence .....	9- 37

<b>Chapter 10: Imaging with FastCard Pulse Sequence .....</b>	<b>Volume 2</b>
Introduction .....	10-1
About... FastCard Pulse Sequence .....	10- 3
FastCard .....	10-3
Arrhythmia Rejection.....	10-5
Image Characteristics.....	10-6
Associated Imaging Options .....	10-9
Applications .....	10-9
Setting up a FastCard pulse sequence .....	10- 10
<b>Chapter 11: Imaging with Echo Planar Pulse Sequences .....</b>	<b>Volume 2</b>
Introduction .....	11-1
About... Echo Planar Sequences .....	11- 3
Echo Planar Imaging (EPI) .....	11-4
Spin Echo EPI and Gradient Echo EPI .....	11-11
Associated Imaging Options .....	11-17
Applications .....	11-17
Setting up a Echo Planar Imaging pulse sequence.....	11- 19
Flair EPI.....	11-26
Associated Imaging Options .....	11-26
Applications .....	11-27
Setting up a Flair Echo Planar pulse sequence .....	11- 27
Diffusion EPI .....	11-32
Associated Imaging Options .....	11-39
Applications .....	11-41
Setting up a Diffusion Echo Planar pulse sequence.....	11- 42
<b>Chapter 12: Imaging with Spectroscopy Pulse Sequences.....</b>	<b>Volume 2</b>
Introduction .....	12-1
About... Spectroscopy Pulse Sequences.....	12- 3
Safety .....	12-3
Spectroscopy Overview .....	12-4
Chemical Shift .....	12-5
Brain Spectrum .....	12-6
Very Selective Spatial Saturation .....	12-7
Mode of Operation .....	12-8
Spectroscopy Single Voxel (PROBE SV) .....	12-10
Graphic ROI Prescription .....	12-11
Scan Mode Selection.....	12-11
Auto Prescan Description .....	12-12
Spectrum Display and Storage.....	12-13
Prescribing a PROBE/SV Acquisition.....	12-15
Setting up a PROBE/SV pulse sequence .....	12- 18
Spectroscopy Multi-Voxel (Probe-SI) .....	12-24
PROBE SI User CV .....	12-25

---

Setting up a PROBE/SI pulse sequence.....	12- 27
3D Focal CSI .....	12-32
Setting up a 3D Focal CSI pulse sequence .....	12- 35
<b>Chapter 13: Imaging with Cardiac Pulse Sequences.....</b>	<b>Volume 2</b>
Introduction .....	13-1
About... Cardiac Pulse Sequences .....	13- 3
Cardiac Introduction .....	13-3
FSE-XL with Blood Suppression .....	13-4
Associated Imaging Options.....	13-5
Applications .....	13-5
FSE-XL IR with Blood Suppression .....	13-6
Associated Imaging Options.....	13-8
Applications .....	13-9
Setting up a FSE-XL with Blood Suppression pulse sequence .....	13- 9
FastCine and FastCine PC .....	13-15
Trigger Type .....	13-17
Arrhythmia Rejection Window.....	13-18
# of Phases to Reconstruct.....	13-18
Views per Segment (VPS).....	13-18
Manual Arrhythmia Monitoring .....	13-18
Respiratory Gating with FastCine/FastCine PC .....	13-19
Associated Imaging Options.....	13-24
Setting up a FastCine pulse sequence .....	13- 25
Tagging .....	13-31
Applications .....	13-32
<b>Chapter 1: Improving Image Quality with Imaging Options.....</b>	<b>Volume 3</b>
Introduction .....	1-1
About... Imaging Options .....	1- 3
Options that Control Artifacts .....	1-4
Tailored RF .....	1-4
Variable Bandwidth .....	1-6
No Phase Wrap .....	1-9
Options that Enhance Spatial Resolution .....	1-12
Square Pixel .....	1-12
Matrix Zerofill Interpolation Processing .....	1-13
Slice Zerofill Interpolation Processing .....	1-15
Options that Enhance or Alter Contrast .....	1-17
Surface Coil Intensity Correction .....	1-17
Classic .....	1-20
Inversion Recovery Preparation.....	1-23
Driven Equilibrium Preparation.....	1-24
Options that Minimize the Effects of Motion .....	1-26
Flow Compensation .....	1-26

Respiratory Compensation.....	1-28
Respiratory Gating and Triggering .....	1-30
Cardiac Compensation .....	1-32
Cardiac Gating and Triggering .....	1-33
Options for Saturation Techniques .....	1-36
Spatial SAT .....	1-37
Chemical Saturation.....	1-39
Spectral Inversion at Lipids .....	1-40
Magnetization Transfer .....	1-42
Blood Suppression .....	1-44
Options to Balance SNR .....	1-45
Additional Imaging Options .....	1-45
Phase Offset Multi-Planar.....	1-45
Full Echo Train .....	1-47
Extended Dynamic Range.....	1-48
Sequential.....	1-49
Multi Phase .....	1-50
SmartPrep.....	1-52
Multi-Station .....	1-53
Real-Time .....	1-53
<b>Chapter 2: Gating and Triggering .....</b>	<b>Volume 3</b>
Introduction .....	2-1
About... Gating and Triggering.....	2- 3
Types of Gating and Triggering .....	2-5
Gating, Triggering, and CINE Data Acquisition .....	2-5
Gating.....	2-6
Triggering .....	2-7
CINE Acquisitions .....	2-9
ECG Waveform .....	2-9
P-Wave.....	2-10
P-R Interval.....	2-11
QRS Complex .....	2-11
ST Segment.....	2-11
T-Wave .....	2-11
R-R Interval .....	2-12
Diastole and Systole.....	2-12
ECG Leads .....	2-13
Peripheral (photo-pulse) Sensor .....	2-15
Respiratory Gating and Triggering .....	2-16
Respiratory Gating .....	2-16
Respiratory Triggering.....	2-17
Cable Connection Ports .....	2-17
ECG Lead Placement .....	2-18

---

Respiratory Bellows Placement .....	2-21
Gating Control .....	2-23
Waveform Display .....	2-24
Cardiac Sweep Rate .....	2-29
Lead Display .....	2-29
Cardiac Trigger Level .....	2-31
Cardiac Trigger Level Annotation .....	2-33
Audio Trigger Volume .....	2-34
Gating Reset and Update R-peak Amplitude .....	2-34
Combined Cardiac and Respiratory Gating/Triggering Screen .....	2-35
Cardiac Gating/Triggering Parameters .....	2-37
Respiratory Gating and Triggering Parameters .....	2-50
Combined Cardiac and Respiratory Gating/Triggering .....	2-56
Combined Cardiac and Respiratory Gating/Triggering Guide .....	2-58
Standard CINE Screen .....	2-66
Trigger Type .....	2-67
Locations per Acquisition .....	2-68
Number of Cardiac Phases to Reconstruct .....	2-68
Frequently Asked Cardiac Questions .....	2-69
How to Optimize Gating and Triggering .....	2- 73
Cardiac Gating/Triggering .....	2-74
Place Electrodes and Route the Cable .....	2-74
Set up the Gating Control Parameters .....	2-76
Regulate Contrast with Cardiac Gating .....	2-80
Respiratory Gating/Triggering .....	2-84
Place Bellows and Route the Tubing .....	2-84
Set up the Gating Control .....	2-86
Regulate Contrast with Respiratory Gating .....	2-88
<b>Chapter 3: Triggering CEMRA with SmartPrep .....</b>	<b>Volume 3</b>
Introduction .....	3-1
About... SmartPrep IA .....	3- 3
Description of SmartPrep IA .....	3-3
Tracker Volume .....	3-4
Imaging Volume .....	3-4
Threshold .....	3-4
Phases of SmartPrep .....	3-5
Centric K-space Filling .....	3-6
Elliptic-centric K-space Filling .....	3-8
Associated Imaging Options .....	3-9
Matrix ZIP .....	3-9
Slice ZIP .....	3-9
SmartPrep Timing Parameters .....	3-9
Maximum Monitor Period .....	3-9

Image Acquisition Delay .....	3-10
SPECIAL .....	3-10
Burst Scan Time/Turbo Mode .....	3-11
Contrast Mechanism .....	3-11
How to Use SmartPrep.....	3- 12
Scan with SmartPrep .....	3-13
Patient Preparation and Scan Start Up.....	3-13
Place the Tracker Volume.....	3-14
Place the Imaging Volume.....	3-15
Scan the Series .....	3-16
<b>Chapter 4: Bolus Chasing with SmartStep.....</b>	<b>Volume 3</b>
Introduction .....	4-1
About... SmartStep.....	4- 3
Description of SmartStep .....	4-3
Meta-series .....	4-3
K-space Filling .....	4-4
Turbo Mode .....	4-4
SPECIAL .....	4-4
Contrast Mechanism .....	4-4
How to Use SmartStep.....	4- 6
Scan with SmartStep .....	4-7
Patient Preparation and Localizer Set Up .....	4-7
Set Up of AutoStep Series .....	4-9
Prescan the Series .....	4-11
Scan the Prescribed Series .....	4-11
<b>Chapter 5: Imaging Real Time with iDrive.....</b>	<b>Volume 3</b>
Introduction .....	5-1
About... Imaging Real Time with iDrive.....	5- 3
iDrive .....	5-4
TR .....	5-7
NEX .....	5-7
Frequency Matrix.....	5-8
Phase Matrix / Phase FOV .....	5-8
Bandwidth .....	5-8
FOV and Slice Thickness.....	5-8
Home and Bookmark Images .....	5-9
Home Images .....	5-9
Bookmark Images .....	5-11
Cursor Control .....	5-11
Pan Cursor.....	5-11
Rotate Cursor .....	5-12
Translate Cursor.....	5-12
Tilt Cursor .....	5-12

---

Cut Plane Tools .....	5-13
Image Contrast Buttons .....	5-14
Orientation Buttons .....	5-16
Other Controls .....	5-16
Message Area.....	5-16
Single Image Save .....	5-17
Closing Real Time Interactive Imaging.....	5-17
Type-in Text Boxes .....	5-18
Rx Locations .....	5-18
IGRx Buttons .....	5-19
Image Buffer .....	5-20
Viewing Images That Are In The Image Buffer.....	5-22
Image Play Buttons.....	5-22
Applications .....	5-25
How to Image Real Time with iDrive .....	5- 26
Prescribe a Real Time Sequence.....	5-27
Drive Through the Image Volume.....	5-30
Adjust Image Contrast (iDrive Pro).....	5-31
Define Cut Planes .....	5-32
Prescribe Scan Locations for a Series.....	5-34
Time a Bolus (iDrive Pro) .....	5-36
Review and Manage the Image Buffer .....	5-37
Save Images (iDrive Pro).....	5-38
Use iDrive to Scan Complex Anatomy .....	5-39
IAC Application.....	5-39
Temporal Lobe Application.....	5-41
Orbit Application .....	5-42
TMJ Application.....	5-43
Spine Application .....	5-45
Knee Application .....	5-46
Shoulder Application .....	5-47
Brachial Plexus Application .....	5-49
Abdomen Application.....	5-50
Female Pelvis Application .....	5-52
Heart and 3D Aortogram Application.....	5-54
Use iDrive as 3 Plane Localizer.....	5-56
<b>Chapter 1: Sharpening and Smoothing Images with ClariView .....</b>	<b>Volume 4</b>
Introduction .....	1-1
About... Sharpening and Smoothing Images in ClariView.....	1- 3
The Purpose and Benefits of Image Enhancement .....	1-3
Series Assignment in the Browser .....	1-5
The ClariView Window .....	1-6
How to Sharpen and Smooth Images using ClariView .....	1- 8

Enhance Images with Smoothing, Sharpening, and MRA Algorithms .....	1-9
Enhance Images with Smoothing, Sharpening and MRA Algorithms .....	1-13
Reboot During the ClariView Procedure .....	1-13
<b>Chapter 2: Editing Patient Information .....</b>	<b>Volume 4</b>
Introduction .....	2-1
About... Edit Patient Information.....	2- 3
Data Available for Edits .....	2-3
Annotation of an Edited Exam.....	2-6
The Edit Patient Data Window .....	2-7
The Edit Log .....	2-8
How to Edit Patient Information.....	2- 9
Edit the Patient Data .....	2-10
View the Patient Log .....	2-14
<b>Chapter 3: Combining Images.....</b>	<b>Volume 4</b>
Introduction .....	3-1
About... Combining Images .....	3- 3
Image Combination .....	3-4
Image Addition .....	3-4
Image Subtraction .....	3-5
Maximum Pixel Extraction .....	3-6
Minimum Pixel Extraction.....	3-6
Binding Images .....	3-7
Image Combination Window .....	3-7
Saving a Series .....	3-8
Sliding the Ratio Bar.....	3-9
Accepting Negative Pixels.....	3-10
How to Combine Images.....	3- 11
Add One or Two Sets of Images.....	3-12
Subtract Two Images Within the Same Set or Two Sets of Images .....	3-14
Extract Minimum or Maximum Pixel Values .....	3-16
One Set of Images .....	3-16
Two Sets of Images.....	3-18
Bind Images .....	3-20
Post Process Three Station Runoffs .....	3-22
Subtractions.....	3-22
Acquire Collapsed Images with IVI.....	3-26
Bind Multiple Series into a Single Series .....	3-28
<b>Chapter 4: Defining a Region of Interest with MIROI .....</b>	<b>Volume 4</b>
Introduction .....	4-1
About... MIROI.....	4- 3
MIROI Basics .....	4-4
MIROI Layout .....	4-4
MIROI Tool Panel .....	4-6

---

Load Series .....	4-6
Draw ROI.....	4-7
Single and Multi-Voxel ROI Cursor.....	4-7
Cursor ROI.....	4-7
aA Icon.....	4-7
Window/Level Presets .....	4-7
Rotate Icons .....	4-8
Film Composer .....	4-8
Get Protocol/Delete Protocol .....	4-9
Browser .....	4-9
Help Menu .....	4-9
Quit .....	4-10
Manipulating the Image .....	4-10
Show/Hide .....	4-12
Smooth/No Smooth.....	4-12
Display Normal.....	4-12
Save View .....	4-12
Movie .....	4-12
Manipulating the Graph .....	4-12
Set X Unit .....	4-14
Set Y Unit .....	4-14
List Values/Time Graph.....	4-15
Histogram.....	4-16
Save View .....	4-16
Create/Hide Annotation .....	4-16
Show Deviation.....	4-16
How to Define a MIROI .....	4- 17
Load the Image Set Into MIROI.....	4-18
View A Single Pixel Curve.....	4-19
View a Curve of More than a Single Pixel .....	4-20
View a Curve Representing the Pixels within an ROI.....	4-21
Change the Scale of the Graph's Vertical Axis (Signal Intensity) .....	4-23
List Signal Intensity Values .....	4-24
Display a Histogram .....	4-25
Save the Graph Display .....	4-26
<b>Chapter 5: Creating Vascular Projections - IVI.....</b>	<b>Volume 4</b>
Introduction .....	5-1
About... IVI.....	5- 3
Valid Image Sets .....	5-3
MIP Projections .....	5-4
Layout .....	5-5
Threshold .....	5-8
Scalpel .....	5-9

How to Create Vascular Projections Using IVI.....	5- 11
Select the Image Set.....	5-12
Modify the Volume of Interest .....	5-14
Modify the Volume of Interest Using Scalpel .....	5-14
Modify the Volume of Interest Using Threshold.....	5-20
Rotate the MIP Images.....	5-25
Define a Batch Projection Series .....	5-28
Rotate Using First and Last Image.....	5-32
Delete an IVI Protocol .....	5-35
<b>Chapter 6: Reformat.....</b>	<b>Volume 4</b>
Introduction .....	6-1
About... Reformatting .....	6- 3
Valid Image Set .....	6-4
Series/Image Selection .....	6-5
Reformat Layout .....	6-5
Starting the Reformat Package.....	6-5
Plane Orientation Indicator .....	6-6
File Menu .....	6-7
Graphics Menu .....	6-7
Graphics Command Window.....	6-10
Tilt/Rotate Mode Select Button .....	6-17
Oblique Mode Select button .....	6-18
Windowing Parameter Preset buttons .....	6-19
View Type buttons .....	6-20
Movement/Rotation Increment buttons .....	6-25
Batch Command Window.....	6-26
Movie Loop Command Window .....	6-33
Previewing Command Window for Film Batch or Movie Loop .....	6-37
Identify mm. / Slices Command Window.....	6-39
Cursor / Annotations Command Window.....	6-42
Display / Graphics Options Command Window .....	6-44
Display / Color Window Command .....	6-46
Display / Film Command Window .....	6-48
On View Operations .....	6-50
MPVR (Multi-Planer Volume Reformat) .....	6-58
Applications For Reformat .....	6-59
How To Use Reformat .....	6- 60
Selecting the Image Set.....	6-61
Moving the Orthogonal View Locations .....	6-62
Adjusting the Oblique View Angle.....	6-63
Defining an Oblique Batch Series.....	6-64
Defining A Radial Batch Series .....	6-66
Defining a Curved Reformat View .....	6-68

---

Adjusting The Plane Thickness and Rendering Mode with MPVR .....	6-70
<b>Chapter 7: Creating 3D Models .....</b>	<b>Volume 4</b>
Introduction .....	7-1
<b>Chapter 8: Analyzing Images with FuncTool .....</b>	<b>Volume 4</b>
Introduction .....	8-1
About... FuncTool .....	8- 3
Description of FuncTool .....	8-3
Valid Image Sets .....	8-4
FuncTool Layout .....	8-5
Algorithms .....	8-10
Correlation Coefficient .....	8-10
Positive Enhancement Integral .....	8-11
Negative Enhancement Integral.....	8-12
Mean Time to Enhance .....	8-13
Maximum Slope of Increase .....	8-14
Signal Enhancement Ratio.....	8-14
Maximum Difference Function .....	8-15
Difference Function .....	8-16
Average .....	8-16
Diffusion Coefficient .....	8-16
Exponential Diffusion Coefficient.....	8-17
Ratio (A-B)/(C-D).....	8-17
MR Spectroscopy Protocols.....	8-17
Applications .....	8-17
3D CSI Viewport Layout .....	8-18
Concepts, Applications, and Terminology .....	8-19
The Chemical Shift or Upper Left (UL) Viewport .....	8-25
The Spectral Grid or Upper Right (UR) Viewport .....	8-27
The Metabolite Image or Lower Left (LL) Viewport.....	8-35
The Reference or Lower Right (LR) Viewport .....	8-38
3D Focal CSI Display Tool Command Window .....	8-40
Function .....	8-40
Get Protocol .....	8-42
Region of Interest.....	8-46
Hints.....	8-47
Saving and Filming Images .....	8-48
How to Post Process Images with FuncTool .....	8- 49
Display Valid Image Sets .....	8-50
Display the Graphs.....	8-51
Create Parametric Images .....	8-52
Function Algorithms .....	8-52
Protocol Algorithms.....	8-55
Adjust the Composite Overlay.....	8-59

Display 3D Focal CSI Images..... 8-60  
Create a Custom 3D Focal CSI Protocol ..... 8-63

## Chapter 1

# Improving Image Quality with Imaging Options

Where Am I?



## Introduction

This chapter focuses on scan parameters and how imaging options can control artifacts, enhance contrast and resolution, and minimize motion. This chapter provides a foundation that helps you to make decisions about when to use the different imaging options to achieve the desired image characteristics. The chapter highlights key concepts and provides brief guidelines for selecting imaging options. It contains information to help you learn how to:

- Control Artifacts
- Enhance Spatial Resolution
- Enhance and Alter Contrast
- Minimize Motion
- Suppress Signals with Saturation Techniques

In addition, this chapter answers the following questions:

1. What are the general types of imaging options?
2. How do options control artifacts?
3. How do options improve or modify resolution?
4. How do options improve or modify contrast?
5. How do options minimize motion?
6. How does bandwidth affect SNR?
7. What else does bandwidth affect?

# About... Imaging Options

This section presents the concepts necessary to understand the types of imaging options. Imaging options are used to control artifacts, enhance spatial resolution, alter contrast, improve signal-to-noise ratio, and minimize motion. Specifically, you need to understand:

- Options that Control Artifacts
  - Tailored RF
  - Variable Bandwidth
  - No Phase Wrap
- Options that Enhance Spatial Resolution
  - Square Pixel
  - Matrix ZIP
  - Slice ZIP
- Options that Enhance or Alter Contrast
  - Surface Coil Intensity Correction
  - Classic
  - IR Prepared
  - DE Prepared
- Options that Minimize the Effects of Motion
  - Flow Compensation
  - Respiratory Compensation
  - Respiratory Gating and Triggering
  - Cardiac Compensation
  - Cardiac Gating and Triggering
- Options for Saturation Techniques
  - Spatial Saturation
  - Chemical Saturation
  - SPECIAL
  - Magnetization Transfer
  - Blood Suppression
- Additional Imaging Options
  - Phase Offset MultiPlanar
  - Full Echo Train
  - Extended Dynamic Range
  - Sequential
  - Multiphase
  - SmartPrep
  - Multi-Station
  - Real-Time

## Options that Control Artifacts

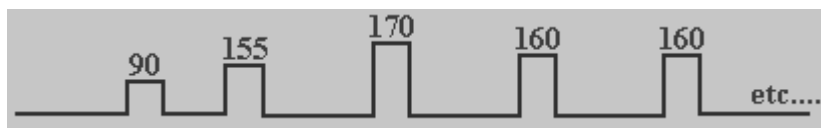
MR images are affected by a number of artifacts that require careful management to improve image quality. Some artifacts that are inherent to MR include aliasing and chemical shift artifacts. The following options are available to help control or eliminate artifacts while scanning:

- Tailored RF
- Variable Bandwidth
- No Phase Wrap

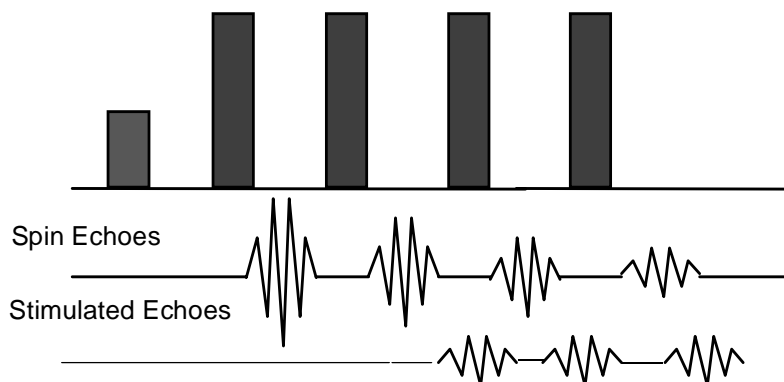
### Tailored RF

Tailored RF (TRF) modifies the echo train in Fast Spin Echo (FSE). It stabilizes the echo amplitudes to reduce the T2 contribution and geometric blurring in the short TE scans. By varying the flip angle of the first two refocusing pulses and keeping the remaining focusing pulses the same, the echo amplitudes can be made fairly constant. The result is a reduction of blurring.

The following figure is an example of the varying refocusing flip angles that occur with the TRF option.



The multiple rephasing pulses used in FSE create both spin echoes and stimulated echoes. This causes blurring and increased contribution from tissues with long T2 times. TRF modifies the flip angle of the rephasing pulses to compensate for the stimulated echoes.



Both SAR and RF amplitude requirements are lessened with the reduced flip angles on the refocusing pulses. This improves the safety threshold and increases the number of slices per TR period when the sequence would otherwise be SAR limited. This is because the 180° refocusing pulses are decreased to approximately 160°.

The lower amplitude refocusing pulses also create a reduction of Echo Space (ESP) because of their lower pulse widths. Lower ESP and reduced SAR increases efficiency in the pulse sequence. Because of the lower ESP, higher echo train lengths (ETLs) obtain equivalent contrast as lower ETL FSE scans. This coupled with the increased slices afforded by the reduction of SAR results in the same coverage.

NOTE: TRF is available with FSE sequences only.

NOTE: TRF images are annotated TRF.

NOTE: The type-in command for TRF is **TRF** and is not case dependent.

### Applications

Use TRF to reduce the brightness of CSF and geometric blurring on PDW (Proton Density weighted) FSE sequences.

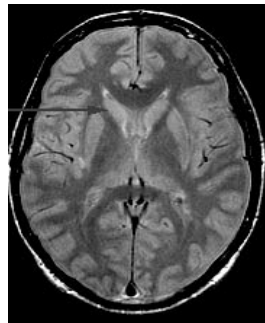
TRF produces images with:

- less blurring
- slightly less SNR
- flatter contrast for T2s
- slightly more slices per TR



PD FSE with TRF

Each image represents the same FSE protocol with an exception of TRF on the left.



PD FSE without TRF

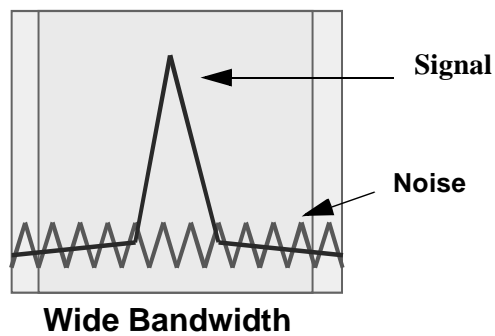
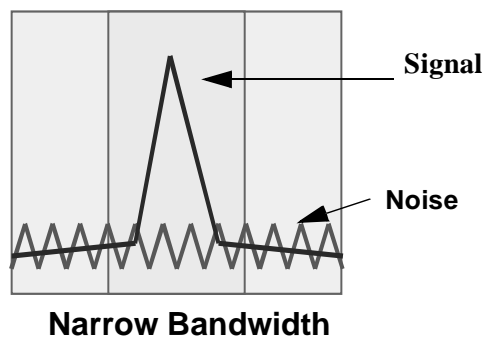
**Something to Think About...**

- Because the flip angles are less than 180°, the contrast for a FSE acquisition sequenced with TRF pulses may be slightly different than a FSE acquisition without TRF.

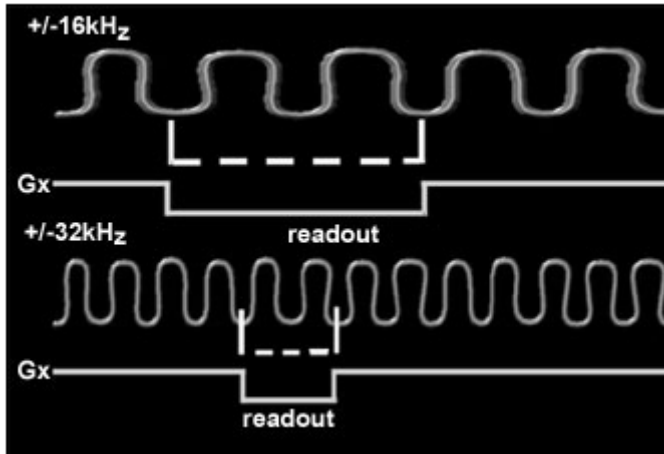
**Variable Bandwidth**

Variable bandwidth (VBw) affects chemical shift and SNR by adjusting the range of frequencies read by the system. An image's receive bandwidth (RBw) defines how many frequencies the image encompasses. It is the number of frequencies the system hears on either side of the center frequency, which is set during prescan.

Note in the figures below that a narrow RBw reads the same amount as a wide RBw, with less noise incorporated.

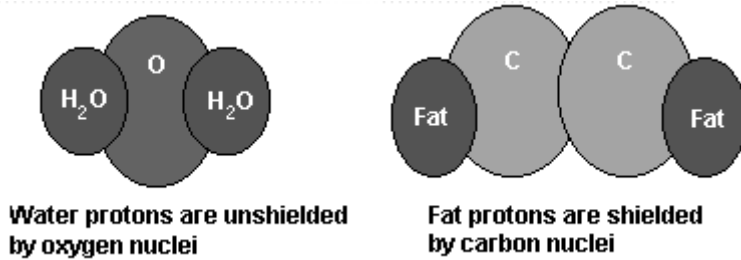


As RBw decreases, the rate at which the echo is sampled is slowed down by the readout gradient.



A  $\pm 32$  kHz RBw samples much faster than a  $\pm 16$  kHz RBw.

The RBw affects the appearance of chemical shift artifact. Chemical shift results from different chemical environments of fat and water.

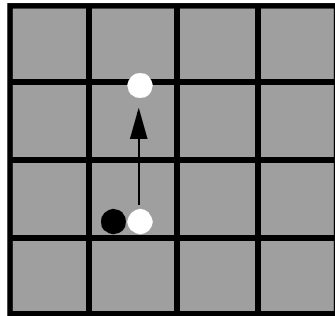


Fat and water protons precess at slightly different frequencies. The shifting is from the difference in the frequencies. The chemical shift increases as the field strength increases.

<b><u>Field Strength</u></b>	<b><u>Chemical Shift</u></b>
1.0T	148 Hz
1.5T	220 Hz

As RBw increases, the pixel shift between fat and water nuclei also increases. Black banding at fat/water interfaces in the

frequency direction is caused by chemical shift and is increased or decreased by the RBw.



Pixel shift depends on bandwidth and Frequency matrix (Fmatrix). At 1.5T Pixel Shift= $220/(BW/Fmatrix)$

Notice black banding at fat water interfaces in the frequency direction.

Summary Table

<u>Assume 256 Matrix RBw</u>	<u>Image Width in Hz</u>	<u>Hz/ Pixel</u>	<u>Chemical Shift in Pixels</u>	<u>Readout Time</u>	<u>% Increase in SNR</u>
±16kHz	32 kHz	125	1.5T = 1.8 1.0T = 1.2	8 ms	-
±13kHz	24 kHz	94	1.5T = 2.2 1.0T = 1.6	10 ms	12%
±8kHz	16 kHz	62.5	1.5T = 3.5 1.0T = 2.4	16 ms	40%
±4kHz	8 kHz	31	1.5T = 7.0 1.0T = 4.8	32 ms	100%
±2kHz	4 kHz	16	1.5T = 14 1.0T = 9.3	64 ms	180%

For example, if an image is acquired at ±16kHz (32,000 Hz) across a 256x256 matrix, there are  $32,000 \div 256$ , or 125 Hz per pixel. Fat and water at 1.5T resonate 220 Hz apart, and therefore their signals are not contained in one pixel. Their signals are displayed as chemical shift within the image.

NOTE: VBw is available under most circumstances. Certain protocols require a specific bandwidth and VBw is locked out.

NOTE: Images are annotated VB.

NOTE: The type-in command is **VBW** and is not case sensitive.

### Applications

- Use VBw to increase SNR.
- Use VBw to decrease blurring in FSE and EPI protocols.
- Widen the RBw to decrease readout time (min TE and ES).

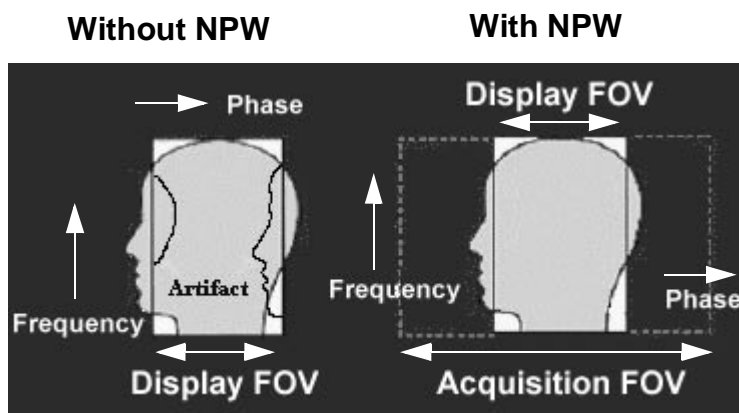
	<u>SNR</u>	<u>Sampling Time</u>	<u>MinTE</u>	<u># of Slices</u>	<u>Motion</u>	<u>Chem Shift</u>
As RBw ↓	↑	↑	↑	↓	↑	↑

### Something to Think About...

- Narrowing the RBw decreases the amount of noise but increases the readout time and chemical shift.
- As signal-collection time (readout time) increases, motion artifacts may appear. Like the exposure time of a camera, if the exposure time is increased and the subject moves, the image blurs.

### No Phase Wrap

No Phase Wrap (NPW) prevents phase wraparound artifacts. The phase wraparound artifact, or aliasing, occurs when anatomy extends beyond the imaging FOV in the phase direction. Signal from the anatomy outside of the FOV is artificially reconstructed in the opposite side of the image. This happens because the RF pulses delivered also excite the nuclei outside the area of interest, causing them to emit signals. The system collects this data and mismaps the signal, folding it back into the reconstructed image.



NPW doubles the Acquisition FOV in the phase direction and halves the NEX value.

NPW is designed to eliminate wrap-around artifact. With this technique, the FOV is doubled in the phase encoding direction. The new enlarged FOV should now encompass all anatomy. When NPW is selected, the system automatically saves the central half of this larger image and discards data collected from the outside of the specified FOV. When using NPW, both the FOV and number of phase encoding steps are doubled, so the pixel size remains constant. Doubling the number of phase encoding steps would double the acquisition time, so the NEX value is halved. Therefore, no change in resolution, signal to noise, or acquisition time occurs.

Use NPW whenever anatomy extends beyond the FOV in the phase direction.



NOTE: NPW is compatible with most pulse sequences.

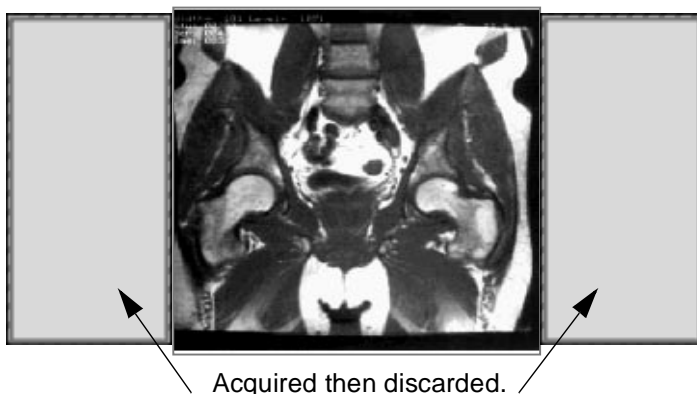
NOTE: Images are annotated NP.

NOTE: The type-in command is **NPW** and is not case sensitive.

The following figure shows the hips outside the FOV wrapping into the image. Note the aliasing is worse in the phase direction.



With NPW, the system automatically saves the central half of the image and discards data collected from the outside of the specified FOV.



### Applications

- Use NPW when the FOV selected in the phase direction is smaller than the anatomy being scanned. Some common examples are pituitary, coronal hips or shoulders, and axial spines.
- Swapping phase and frequency on a sagittal or coronal image places phase in the long axis of the body, resulting in aliasing. NPW can help to correct the problem.

### Something to Think About...

- Motion artifacts are somewhat more noticeable when using NPW. Increased NEX values average the data and help to reduce motion artifacts. When NPW is turned on, the programmed NEX value is cut in half (e.g., 2 is cut to 1, 4 is cut to 2), losing the benefit of data averaging that comes with higher NEX values (2,4,6). An alternative is to keep the NEX value greater than 1.

Instead of using NPW, use SAT pulses positioned next to the FOV to reduce aliasing.

- NPW with one NEX extends scan time slightly due to overscans necessary with 0.5 NEX.
- Not compatible with POMP, Square Pixel, EPI, Phase FOV less than one, or Resp Comp high-sort method.

## Options that Enhance Spatial Resolution

This section focuses on imaging options which may be used to help produce consistent high quality images by enhancing the resolution of the image. The following imaging options are available to enhance resolution:

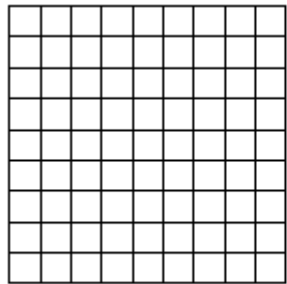
- Square Pixel
- ZIP 512
- ZIP 1024
- ZIP x2
- ZIP x4

### Square Pixel

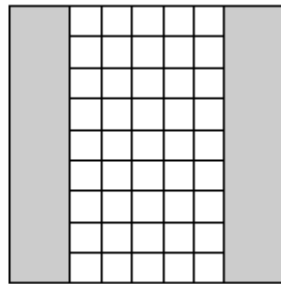
Square pixel maintains a square pixel regardless of the matrix. The pixel size is determined by the FOV divided by the frequency axis of the matrix. Square pixel scales the FOV by the ratio of the phase to frequency value. If the matrix is not balanced, an asymmetrical FOV results. Selecting square pixel results in resolution based on the selected frequency axis combined with a reduced phase matrix for a shorter scan time.

To calculate the size of the phase FOV, divide the phase matrix value by the frequency matrix value (e.g.,  $192 \div 256 = 0.75$ , the new phase FOV is 75% of a full FOV).

The following figure demonstrates that with Square Pixels, the FOV decreases with varied matrix choices but the resolution is unchanged.



1. 24cm x 24cm FOV



2. 24cm x 18cm FOV

1. 256x256, Square Pixels, 24 cm x 24 cm FOV
2. 256x192, Square Pixels, 24 cm x 18 cm FOV.

NOTE: Square Pixel is compatible with most pulse sequences.

NOTE: The images are annotated SqP.

NOTE: The type-in command is `SQP` and is not case sensitive.

### Applications

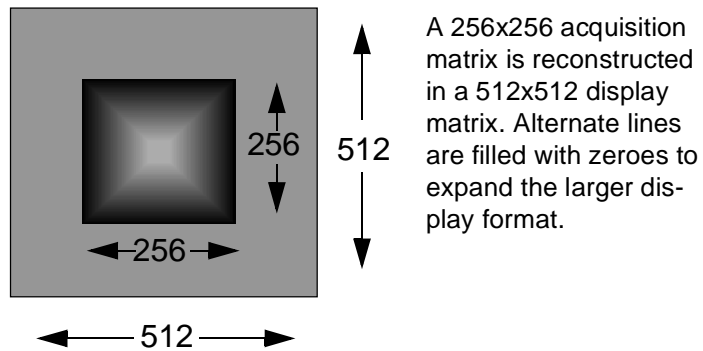
- Use Square Pixel to increase spatial resolution when an asymmetrical FOV is acceptable.
- Use only when the anatomy in the phase direction is smaller than the new reduced FOV. Common examinations include:
  - Sagittal and coronal cervical spines and knees.
  - Axial and coronal heads.
  - Sagittal thoracic and lumbar spines.

### Something to Think About...

- POMP and NPW are not compatible with Square Pixel.
- Aliasing occurs if anatomy is outside the FOV.
- As the phase FOV gets smaller, the SNR is decreased.

### Matrix Zerofill Interpolation Processing

In-plane spatial resolution Matrix Zerofill Interpolation Processing (ZIP) uses zero filling to reconstruct images in a 512x512 or 1024x1024 format even if acquired in a different format. It enhances existing resolution but does not create additional resolution.



NOTE: ZIP 512 is available with the following pulse sequences:

- FSE and FSE-IR
- FLAIR
- 3D Fast GRE/SPGR
- 3D TOF
- 3D Fast TOF
- SmartPrep IA

NOTE: ZIP 1024 is only available with 2DFSE and 3DTOF.

Matrix ZIP increases the visibility of resolution inherent in the image—note the increased sharpness of the vessel edges.



256 phase acquisition and 512 reconstruction



256 phase acquisition and 256 reconstruction

## Applications

- Use Matrix ZIP to better visualize the available in-plane resolution.
- Use Matrix ZIP to minimize the impact of decreasing acquisition matrix.

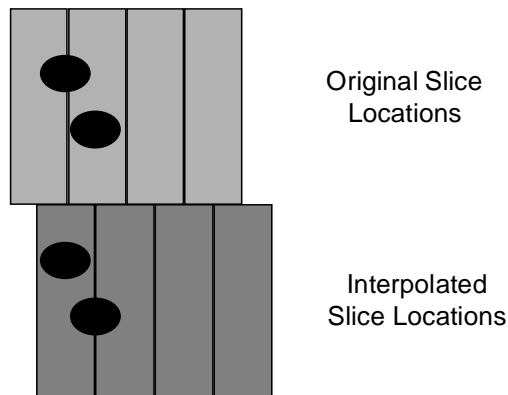
## Something to Think About...

- ZIP 512 produces a small decrease in SNR as compared to a 256x256 matrix. However, the SNR of a scan with ZIP 512 is much higher than the same scan with a 512x512 acquisition matrix.
- ZIP 1024 produces a small decrease in SNR as compared to a 512x512 matrix.
- ZIP 512 images take longer to reconstruct and require more disk storage space than 256 images. This additional reconstruction time and required storage space is identical to an acquired 512 image.
- ZIP 1024 images take longer to reconstruct and requires more disk storage space than a 512x512 image.
- ZIP 512 and 1024 enhances apparent image resolution. It can make truncation (Gibbs) artifacts more noticeable. Increasing the phase matrix value up to 256, or increasing the NEX can reduce this artifact.
- If a frequency matrix > 256 is selected (e.g., 512, 384, etc.), then selecting ZIP 512 has no effect since 512 recon is already used.
- NPW is not compatible with ZIP 1024.
- ZIP 1024 images cannot be transferred to and displayed on a non-LX system.
- ClariView cannot be used on ZIP 1024 images.
- Increased processing times with IVI and Reformat with ZIP 1024 images.

## Slice Zerofill Interpolation Processing

Through-plane spatial resolution Slice Zerofill Interpolation Processing (ZIP) interpolates new slice locations in a 3D volume. It changes the slice center, but not the slice thickness. This technique improves through-plane resolution by

interpolating the acquired scan data to create new images. There are no penalties in scan time and SNR.



NOTE: Slice ZIP imaging options, ZIP x2 and ZIP x4, are available with the following pulse sequences:

- 3D FGRE/SPGR
- 3D TOF
- 3D Fast TOF
- SmartPrep IA

NOTE: Slice thickness must be divisible by:

- 0.2 when using ZIP x2
- 0.4 when using ZIP x4

**Applications**

Use slice ZIP to:

- Increase through-plane resolution.
- Smooth reformations or IVI projections.
- Reduce partial volume artifact due to the position of the anatomy within the slice.
- Reduce the number of acquired slices in a 3D volume and resulting scan time.
- Enhance Fast GRE 3D imaging for musculoskeletal, breath-hold abdomens, breast, and MRA imaging.

**Something to Think About...**

- Slice ZIP has no effect on SNR.
- Slice ZIP comes at the expense of an additional factor in reconstruction time.

- The number of overlapped slices and discarded end slices automatically are doubled or quadrupled if you select slice ZIP. Keep this in mind if slice thickness is decreased; **desired anatomy may be discarded.**
- On the Scanning Range screen, the Slice Location value multiplied by the Slice ZIP factor equals the actual number of reconstructed slices minus the discarded slices.
- Although Slice ZIP is useful for improving 3D image resolution, it is possible to select slices that are too thick. Gibbs ringing artifacts can result when the slice thickness gets too large, typically greater than or equal to 2 mm in the head, or greater than or equal to 4 mm in the body. This ringing artifact can occur in both the phase and the slice direction. It is most often apparent on reformatted images when the artifact occurs in the slice direction.
- ZIP x4 only gives a marginal improvement in effective resolution over ZIP x2. ZIP x4 images are overlapped by 75% of the slice thickness instead of 50%. The marginal improvement in effective resolution comes at the expense of an additional factor of 2 in reconstruction time.

### Options that Enhance or Alter Contrast

Although pulse sequences are the major determinants of image contrast, certain imaging options can also affect image contrast. This section introduces various imaging parameters that enhance contrast and quality in your images. The following options alter or enhance image contrast:

- Surface Coil Intensity Correction
- Classic
- IR Prepared
- DE Prepared

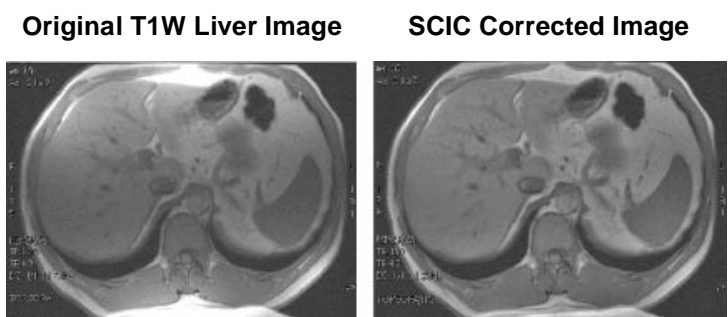
#### Surface Coil Intensity Correction

An image created using a surface coil has an intensity fall-off determined by the coil properties. This intensity fall-off causes distracting artifacts and makes it difficult to film images at a single window/level setting. The Surface Coil Intensity Correction (SCIC) feature is an automatic post-processing

technique that corrects the low spatial frequency intensity modulations, reduces noise, and enhances contrast in the image. It produces a series of filtered images with decreased intensity near the coil, reducing the areas of bright spots.

SCIC is an imaging option available for pre-configured coils. With SCIC, each scanned series produces two reconstructed series: one original and the other corrected using SCIC.

The following figure shows two images of the liver. The image on the left was acquired before SCIC with the Torso coil and the image on the right was acquired after SCIC with the Torso coil. Note the increase in uniform signal intensity on the image acquired with SCIC.



### Coil Specific Selections

The SCIC imaging option is supported by all imaging planes and pulse sequences, but is only available with the coils listed in the table below. Select Surface Coil Intensity Correction on the Imaging Options screen. If you request processing for an invalid coil, the SCIC option is not available for selection.

SCIC is available with the following coils:

	1.0 and 1.5T Coils	1.0T Coils Only	1.5T Coils Only
<b>USA Instruments CTL Spine Coil</b>	USCTLTOP, USCS123, USCS12		
	USCTLMID, USCT234, USTL345, USTS23, USTS34		
	USCTLBOT, USTL45, USLS456, USLS56		

	1.0 and 1.5T Coils	1.0T Coils Only	1.5T Coils Only
<b>GE by Teledyne CTL Spine Coil</b>	CTLTOP, CS123, CS12,		CT234
	CTLMID, TL345, TS34, TL45	TL456	TS23
	CTLBOT	LS567, LS56, LS67	LS456, LS56
<b>Other Coils</b>	ENDOREC		
	TORSOPA		
	PVUPPER		
	TPUPPER, TPLOWER		

NOTE: It is recommended to use the SCIC processed images along with the corresponding images that have not been processed with SCIC.

NOTE: A SCIC processed image has SC added to the beginning of its series description.

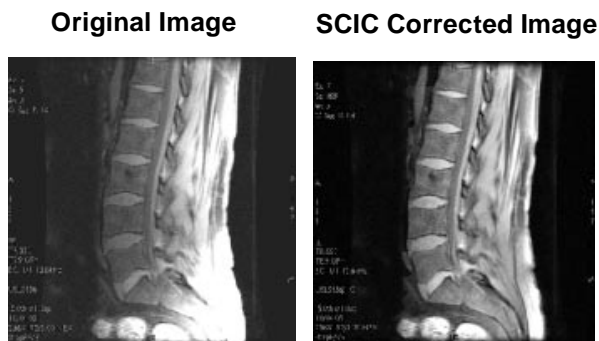
NOTE: The SCIC processed images are annotated with SCIC following the coil name. For example, an imaged processed with the CTL coil would be annotated CTL/SCIC.

NOTE: A new series number is assigned to the post-processed images. The SCIC processed series is numbered 100 more than the non-processed series. For example, if series 4 has SCIC applied, the SCIC processed series is labeled 104.

### Applications

Use SCIC to reduce the bright flare from fatty tissues adjacent to coils.

- Spine Coils (cervical spine, thoracic spine, and lumbar spine).
- Torso and Peripheral Vascular Coils (abdomen, chest, lower extremity).
- Endorectal Coils (prostate, pelvis).



**Something to Think About...**

- The AutoViewer only displays the non-processed images. You must go into the Browser to view the SCIC processed images.
- Once you select the SCIC imaging option, if you change to an unsupported coil, the SCIC option is turned off and a pop-up message appears on the prescriptions screen.
- The SCIC option is not compatible with the Real-time option. When SCIC and Real-time are selected together, a error message is reported when you exit the Imaging Options screen.
- Before beginning a SCIC sequence, check the available image disk space. The system does not check for available disk space before starting SCIC sequences. If, during a SCIC sequence, the disk capacity becomes full, the sequence halts and posts a message stating that there is not enough available disk space. Data acquisition or SCIC reconstruction cannot resume until disk space is available. Remove exams from the disk and reboot the system to complete the reconstruction of the SCIC images.
- All exams that use Performed Procedure Step and SCIC must complete the exam from the Display Browser. To successfully complete the exam for PPS, use the procedure defined in Volume 1, Chapter 6.

**Classic**

Classic is an option that can be used with a SE or any FSE-based pulse sequence and is very sensitive to center frequency adjustment. Classic minimizes the signal from the off-center frequency nuclei to increase the signal variations between muscle and fat. It also reduces the annefact for FSE

sagittal spine imaging. Classic is available with FSE-based pulse sequences only.

NOTE: Classic images are annotated CL.

NOTE: The type-in command is **CLA** and is not case sensitive.

### Applications

Classic is effective on SE pulse sequences with long TEs.

- Use classic to produce images with a lower signal from fat in anatomy such as orbits or extremities.
- Use classic when looking for a larger variance between muscle and fat signal. Its effects can be emphasized via center frequency adjustment.

Note the variance between muscle and fat signal in the following SE sequence with classic.



**SE without Classic**

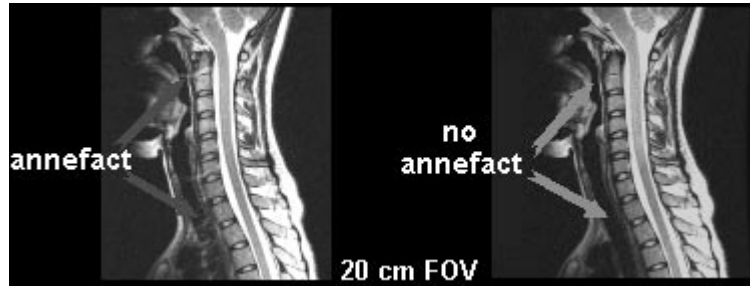


**SE with Classic**

Classic is effective on FSE pulse sequences in homogeneous fields to reduce unwanted signal.

- Use classic for sagittal spine images with FOVs up to 28 cm to reduce anefact.

Note the reduction in the artefact in the following FSE image with classic.



FSE without Classic

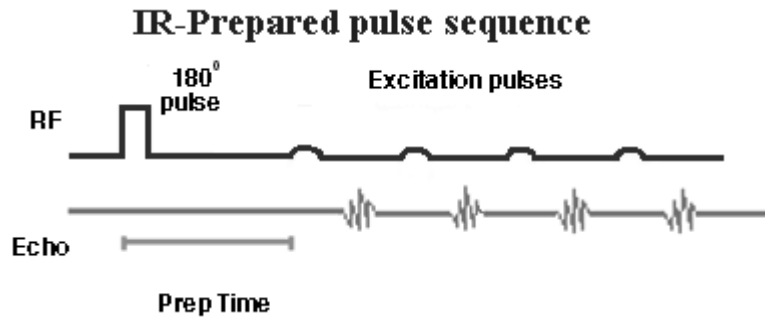
FSE with Classic

**Something to Think About...**

- Classic slightly decreases SNR.
- Classic produces lower signal intensities from a wide range of frequencies. If you want to see many shades of gray, do not use classic.
- Classic is sensitive to center frequency choice.
  - Centering on fat decreases water signal.
  - Centering on water decreases fat signal.
  - Centering on midpoint decreases both fat and water signal.
- Classic is not a substitute for chemical saturation.
- Classic with FSE-based sequences may experience signal drop-off at the edge of the FOV.
- Only effective if imaging FOV is homogeneous.

## Inversion Recovery Preparation

Inversion Recovery Preparation (IR Prepared or IR Prep) uses a  $180^\circ$  RF preparation pulse delivered prior to the imaging sequence to enhance T1 weighting.



The initial  $180^\circ$  RF pulse is followed by a waiting period (prep time), where the desired contrast is allowed to evolve before the RF excitation pulse is applied. The prep time allows for longitudinal magnetization (T1) differences to occur similar to the  $180^\circ$  inversion pulse in an IR sequence.

Centric phase encoding is used to take advantage of the contrast that evolves during the prep time before a steady-state condition develops.

NOTE: IR Prep is available with 2D and 3D, Sequential, FGRE pulse sequences.

NOTE: The IR Prep time is noted in the TI field on the image.

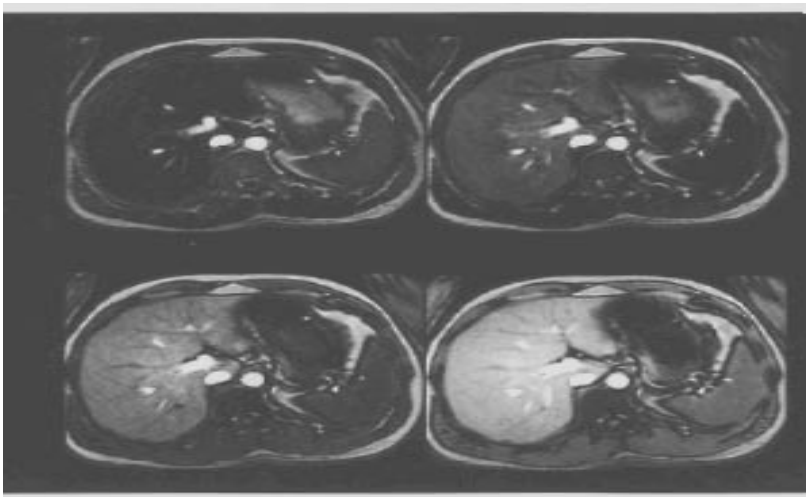
NOTE: The type-in command is **IRP** and is not case sensitive.

**Applications**

- Use IR Prep to enhance T1 contrast.
- Use IR Prep to suppress signals from selective tissues.

<i><u>IR Prep Time</u></i>	<i><u>Tissue Suppressed</u></i>
200-400	Liver
80-130	Fat
400-600	Spleen
700-800	CSF

- Use longer prep times as field strength increases.



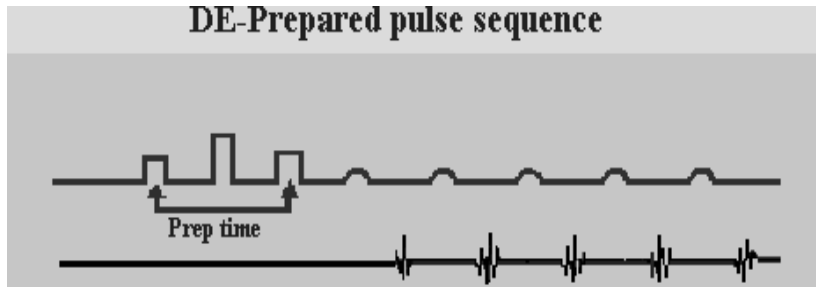
**Something to Think About...**

- Some degree of blurring may occur due to varying amounts of T1 relaxation as the protons recover from the initial 180° prep pulse. Centric phase encoding helps reduce blurring.

**Driven Equilibrium Preparation**

Driven Equilibrium Preparation (DE Prepared or DE Prep) uses a series of 90°/180°/90° RF preparation pulses delivered prior

to the imaging sequence. This is designed to produce more T2-weighted contrast with FGRE pulse sequences.



The initial 90° pulse creates transverse magnetization, which immediately begins to dephase. The amount of dephasing is controlled by the prep time. The longer the prep time, the more dephasing and the more T2-weighting. The remaining transverse magnetization is rephased by the 180° RF pulse. After another delay (prep time) where more T2 decay can occur, a 90° pulse is applied, driving the remaining transverse magnetization back to longitudinal.

NOTE: DE Prep is available with FGRE sequential pulse sequences.

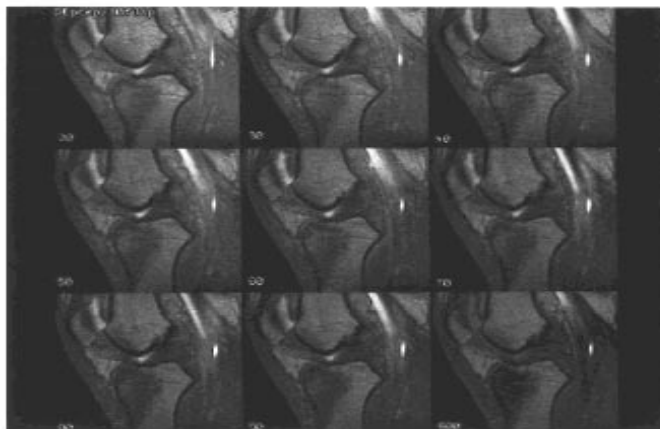
NOTE: The images are annotated with the prep time.

NOTE: The type-in command is **DEP** and is not case sensitive.

NOTE: The system automatically selects the minimum TR.  
Select prep times based on the contrast to be created.

### Applications

- Use DE Prep to enhance T2/T2\* contrast.



**Something to Think About...**

- Some blurring may occur with prep pulses. Centric phase encoding is used to minimize the blurring.

**Options that Minimize the Effects of Motion**

Almost all motion of significant amplitude gives rise to artifacts in MR imaging. The following imaging options help to decrease or avoid the artifacts caused by motion:

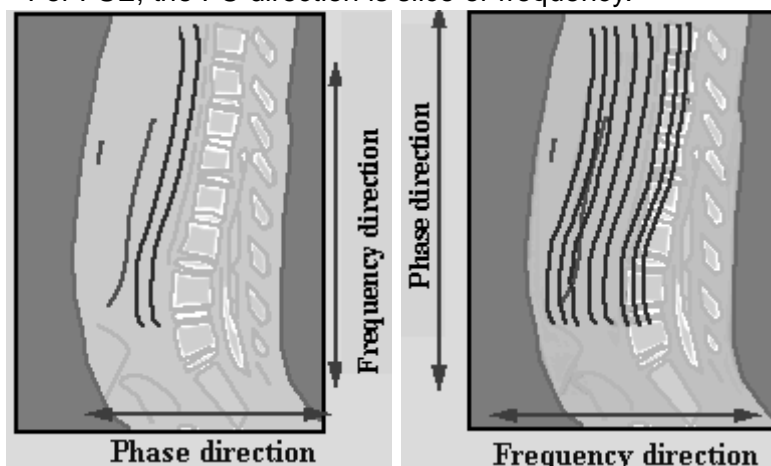
- Flow Compensation
- Respiratory Compensation
- Respiratory Gating and Triggering
- Cardiac Compensation
- Cardiac Gating and Triggering

**Flow Compensation**

Gradient moment nulling or flow compensation (FC) uses gradient pulses to correct the phase value of flowing nuclei and minimize artifacts caused by slow flow. Flowing nuclei experience phase shifts and mis-map in the phase direction. FC resets the phase value to the original value.

The flow direction must match the direction the FC gradient is applied:

- For SE or GRE, the FC direction is slice and frequency.
- For FSE, the FC direction is slice or frequency.



NOTE: FC is compatible with most pulse sequences.

NOTE: Images are annotated FC.

NOTE: The type-in command is **FC** and is not case sensitive.

### Applications

- Use FC to reduce the flow artifact from slow to moderate flow:
  - In plane flow has high signal.
  - Through plane flow has moderate signal.
- Use FC to improve the myelographic effect on T2W spines.



FC makes CSF signal appear brighter, while reducing vascular and CSF pulsatile flows.

Use FC only if the frequency direction is S/I.

- Use FC combined with SAT pulses that are perpendicular to the flow to produce:
  - A grey appearance in CSF at the superior edge of a sagittal FOV, or blood vessels.
  - Optimal suppression of motion artifacts.
- Use FC combined with POMP to decrease motion artifacts.

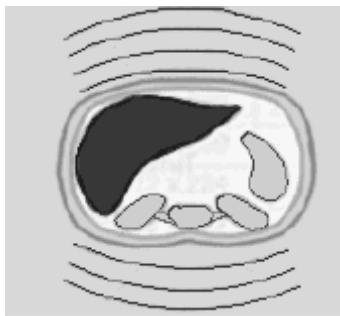
### Something to Think About...

- When acquiring sagittal or coronal images and selecting FC, do not swap phase and frequency. Reducing motion from slow moving protons only occurs when protons are moving in the direction to which the FC gradient is applied.
- A maximum of two echoes can be used with FC.
- FC increases the minimum TE, which in turn decreases T1W when acquiring short TR/TE scans.
- Due to the increase in TE and gradient use with FC, the maximum number of slices allowed can decrease.
- When a scan value within a protocol results in an incompatibility, the system sets the Protocol TR to the PSDs default TR. For example, if a T2, sagittal of the

spine is prescribed using a FOV of 36 cm or larger with Phase and Frequency swapped and FC turned on, when the protocol is downloaded, the TR is changed from the T2 value to the PSDs default TR. The solution to this problem is to rebuild the protocol and do not have FC and Phase/Frequency swapped with a FOV larger than 36 cm.

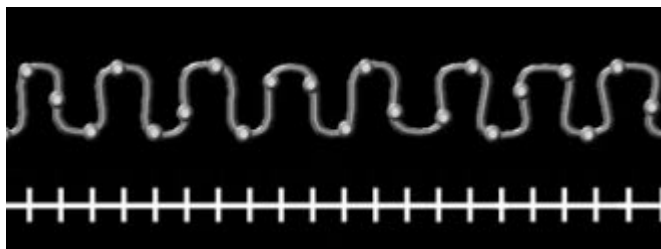
### Respiratory Compensation

Respiratory Compensation (RC) uses the respiratory waveform to sort the phase encoding data to minimize respiratory ghosting.



Without Resp Comp, the body wall creates ghosts in the phase direction.

RC uses bellows to track the motion of the body wall during image acquisition and the waveform is displayed on the PC monitor.



RC then sorts the data during reconstruction using two methods, low order and high order sorts.

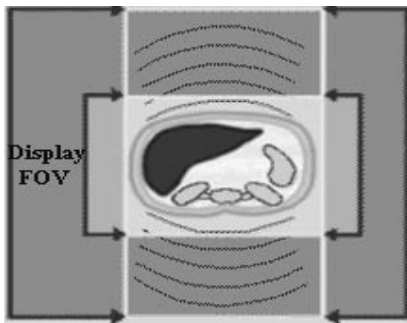
- RC low sort mode occurs when 1 NEX is selected and when 1 or 2 NEX is selected with POMP. It reorders how K-space is filled. Instead of acquiring the lines of K-space

sequentially, it stores them so that the same lines correspond with the same part of the respiration cycle.



With 1 NEX, the system uses low sort and places the ghosts close to the body wall.

- RC high sort mode occurs with multi-NEX acquisitions. High sort doubles the FOV in the phase direction. In order to maintain image resolution, it doubles the number of phase-encoding steps it acquires. Since this alone would double the scan time, the NEX is halved to keep the scan time the same. The top and bottom data are then discarded from the resultant image, and the motion artifact from the patient's respiration is reduced.



With 2 NEX and 4 NEX, the system uses a high sort mode. High sort places ghosts outside the reconstructed FOV.

<u><i>What You Select</i></u>	<u><i>What the System Acquires</i></u>
Desired FOV	Doubles the FOV in the phase direction
Desired Phase Matrix Value	Doubles the phase matrix to maintain resolution.
Desired NEX	Cuts the NEX in half to maintain scan time.

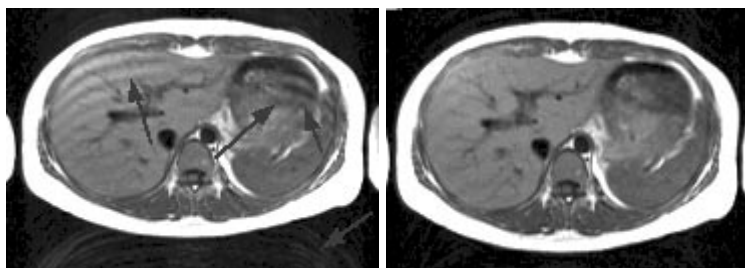
NOTE: RC is compatible with most pulse sequences, with the exception of FSE.

NOTE: The images are annotated RC.

NOTE: The type-in command is **RC** and is not case sensitive.

### Applications

- Use RC to reduce the effects of breathing motion when respiratory triggering or breath-holding is not possible.
- Use the respiratory waveform without RC to observe the patient’s compliance with breathing instructions.



No RC

RC

### Something to Think About...

- Do not use the respiratory waveform display for patient monitoring.
- RC slightly lengthens scan time.
- RC is more effective with shorter TR scan prescriptions.
- Increased vessel motion may occur with 2 or 4 NEX because the system halves the NEX value, which decreases the benefits of motion averaging.
- You cannot prescribe a NEX value greater than 4.
- RC requires that the patient have a consistent breathing pattern during the acquisition. Look for the message-Resp OK. If the system scans without the message Resp OK, there is no RC benefits.
- You cannot use RC with rectangular FOV.

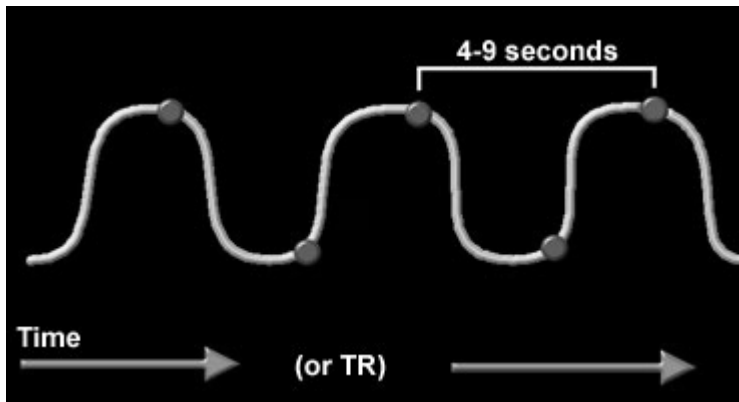
### Respiratory Gating and Triggering

Respiratory Gating and Triggering uses a bellows sensor that detects the motion of the abdominal wall. The respiratory waveform represents the excursion of the abdominal wall throughout the course of inspiration and expiration. The waveform is a pattern of the patient’s breathing. The pulse sequence determines whether the system uses gating or triggering, however, Respiratory Triggering is not available for most sequences.

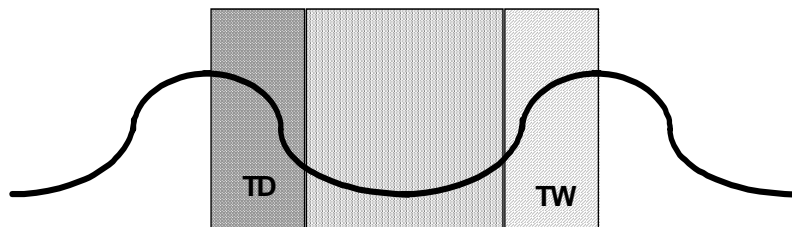
Respiratory Gating uses the respiratory waveform to determine the point at which data acquisition is to take place and TR is

applied continuously throughout the respiratory cycle. Data acquisition is generally performed during the quiescent (most quiet) period of the respiratory cycle. This is at end-expiration/beginning-inspiration, the "valley" of the cycle. Respiratory Gating is performed in FastCard, FastCINE, Fast2D PC, 3D Fast GRE/SPGR, 3D Fast TOF, and SmartPrep IA.

Respiratory Triggering (RT) uses the respiratory cycle to initiate RF application and data acquisition. RT reduces respiratory artifacts by synchronizing image data collection with the respiratory cycle. It uses the patient's inspiration to trigger data acquisition. The minimum TR is restricted by the patient's inspiration to expiration cycle. For most people, this takes anywhere from 4 to 9 seconds. This makes this type of scan only suitable for T2 scans. If you want to obtain T1 or proton density weighting but still compensate for respiratory motion, use respiratory compensation.



RT uses the respiratory waveform to monitor the patient's breathing pattern. Data acquisition only occurs during the data acquisition window and when the trigger point and window are defined.



TD and TW place data collection in the "quiet" phase of the cycle.

RT delivers the RF pulse after the trigger delay when the R-wave is detected. The scan sequence is stopped and data acquisition does not take place during the trigger window.

NOTE: RT is only compatible with 2D FSE pulse sequences, 3D Fast GRE/SPGR, and 3D Fast TOF.

NOTE: RT is not compatible with 3D FSE, Gating (ECG or Peripheral) and respiratory compensation.

NOTE: Scans acquired with respiratory triggering are annotated RTr.

NOTE: The type-in command is **RTr** and is not case dependent.

NOTE: The respiratory bellows are required.

### Applications

- Use RT instead of RC or breath-hold on very sick patients who cannot hold their breath or have a consistent breathing pattern.
- Use RT in scans with a TR comparable to or longer than the respiratory interval.



Respiratory Triggering collects data during the "quiet" phase of the respiratory cycle to minimize phase ghosting.

### Something to Think About...

- RT does not employ respiratory arrhythmia rejection.
- RT is not used during Prescan. During the Scan TR pass, the PSD sets TR to the estimated effective TR.

NOTE: For more information on respiratory gating and triggering, refer to Volume 3, Chapter 2, Gating and Triggering.

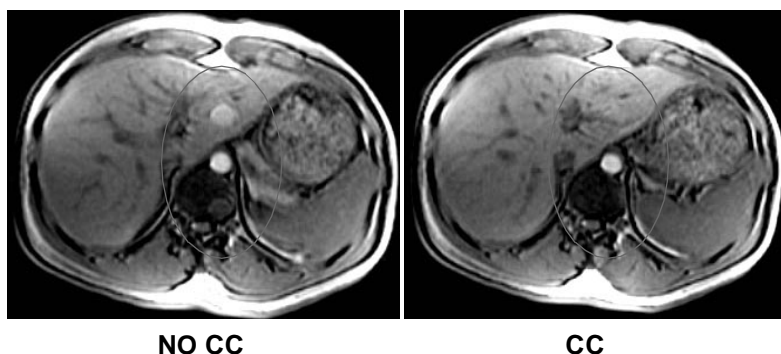
### Cardiac Compensation

Cardiac Compensation (CC) uses the cardiac cycle to sort the phase encoding data to minimize pulsatile ghosting. CC uses the cardiac waveform to fill the most critical lines of K-space with data acquired during diastole, when flow is slower. The phase steps acquired during the systolic phase fill the outer edges of K-space.

NOTE: CC is available with GRE and FGRE only.

NOTE: Images are annotated CC.

The following figure shows images of the liver acquired without CC and with the CC imaging option.



### Applications

Use CC to decrease flow artifact.

### Something to Think About...

- Vessels have a bright appearance with reduced motion artifact.
- CC may result in more slices per acquisition than the same parameters with no CC and SAT pulses turned on.
- CC is not a substitute for cardiac gating.

## Cardiac Gating and Triggering

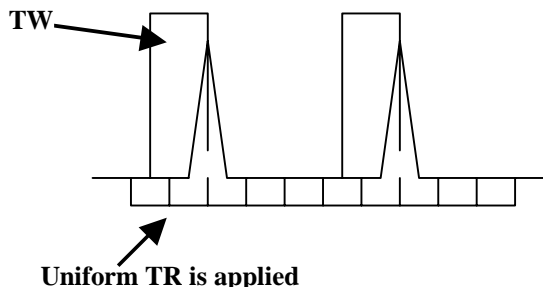
Cardiac and Peripheral Gating/Triggering allows the same data to be collected at the same points of the cardiac cycle for each repetition of the pulse sequence. The benefit is that the motion is always the same and is essentially "frozen" —allowing motion artifacts to be reduced, or sometimes eliminated.

The pulse sequence determines whether the system uses gating or triggering, however, it is not necessary to remember which process is used with which sequence. Choose the desired pulse sequence and select Cardiac Gating/Triggering at the Imaging Options window and the system automatically performs the appropriate process.

Cardiac Gating monitors the cardiac cycle, but does not use a trigger to initiate RF application. RF is applied throughout the cycle at the defined TR time, and data is acquired when the physiological event occurs. FastCard, FastCINE, 3D Fast

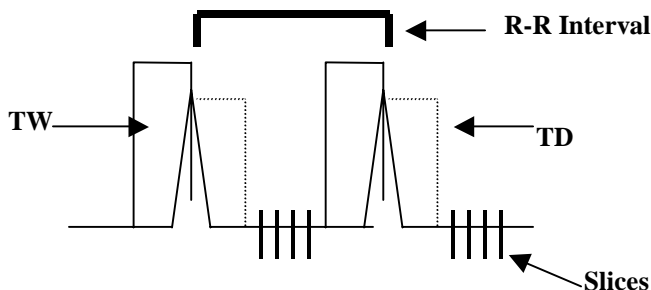
GRE/SPGR, 3D Fast TOF, and Fast 2D PC can use cardiac gating.

The following figure demonstrates a cardiac gated acquisition, displaying the Trigger Window and the application of a uniform TR.



Cardiac Triggering is a technique that turns RF application and image acquisition on and off based on a trigger detected within the cardiac cycle. The trigger window is set as a percentage of the cardiac cycle. Triggering synchronizes data acquisition with the waveform cycle, and all image data is acquired at the same phase in the cycle for each slice prescribed. Spin Echo, Fast Spin Echo, and Multi-Planar 2D GRE/SPGR sequences can use cardiac triggering.

The following figure demonstrates a cardiac triggered acquisition, noting the Trigger Window, R-R Interval, Trigger Delay and when the slices are acquired.

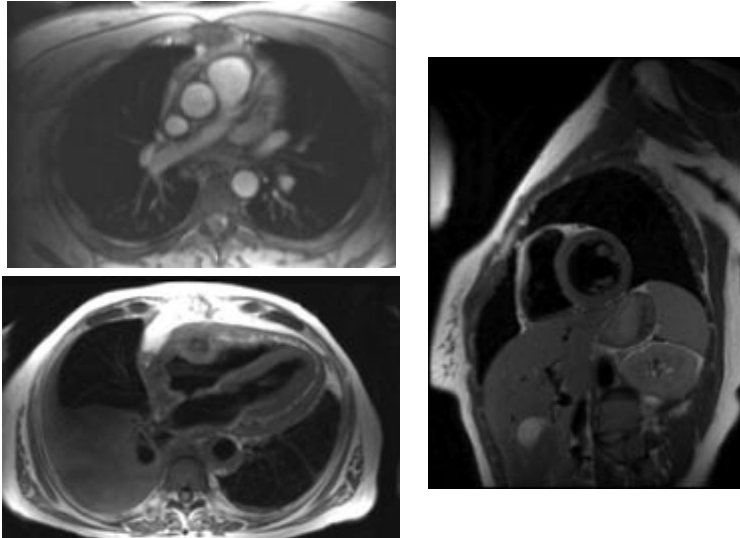


NOTE: Cardiac gating is annotated as EG for ECG gating.

**Applications for Cardiac Gating/Triggering**

- Use cardiac gating during Cine-PC to examine flow.
- Use cardiac gating/triggering when imaging the heart for structure or function.

- Use cardiac gating/triggering when imaging in the thorax.



Cardiac gating/triggering can eliminate motion by using the heart's electrical activity as reported by the ECG to trigger the RF data acquisition.

Peripheral Gating uses a photopulse sensor that detects the blood flow in the vascular bed. The photopulse waveform represents blood flow, not the electrical activity of the heart. Peak blood flow occurs at the peak of the waveform, the R-wave. Peripheral Gating begins the acquisition by recognizing the arrival of the R-wave. The TR available is governed by the patient's heart rate.

The following figure shows the R-R Interval is from one peak waveform to the next.



NOTE: Peripheral gating is annotated PG.

### Applications for Peripheral Gating

Use peripheral gating during head or C/T spine imaging to minimize pulsatile motion of CSF on T2 or T2\* scans.



Gating can "freeze" the effects of pulsatile motion on the brain and spine or heart.

### Something to Think About...

- Gating/Triggering can increase the scan time.
- If the signal is lost during the acquisition, it aborts the scan.
- Proper electrode placement is critical to a successful gated scan. Adjust the electrodes until a strong signal is received.

NOTE: For more information on cardiac gating/triggering, refer to the chapter Gating and Triggering.

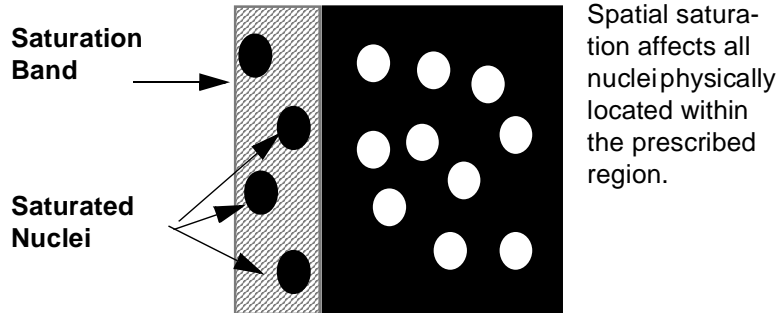
### Options for Saturation Techniques

There are several saturation techniques available to saturate and therefore suppress specific signals in your images. Saturation pulse choices are found on the Additional Parameters and User Control Variable page. Specifically, they are:

- Spatial Saturation
- Chemical Saturation
- SPECIAL
- Magnetization Transfer

## Spatial SAT

Spatial saturation delivers RF pulses to a selected location inside or outside the FOV to saturate and eliminate unwanted signal from the nuclei.

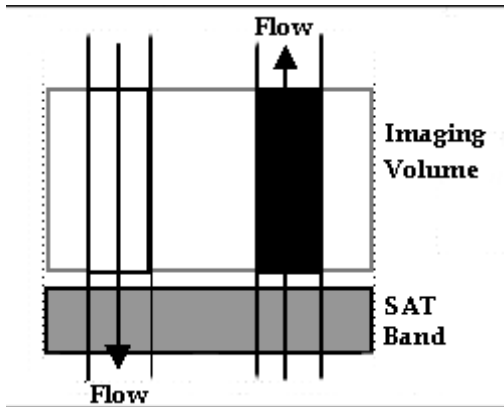


NOTE: Saturation bands can be prescribed explicitly or graphically and are compatible with most pulse sequences.

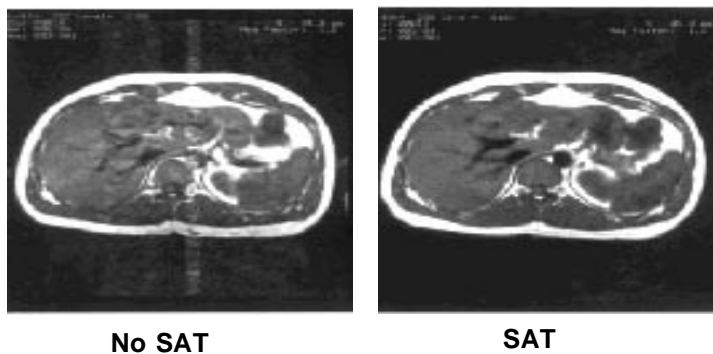
NOTE: Images are annotated St: (direction). A capital letter means the SAT pulse is outside the FOV; a lower case letter means the SAT pulse is inside the FOV.

## Applications

- Use SAT bands outside the FOV to eliminate the signal from unwanted flow. Position the SAT band between the source of flow and the imaging volume.



SAT band between the source of flow and before it enters the imaging volume.



- Use SAT bands inside the FOV to eliminate the signal from moving structures.

Spatial SAT band



**Something to Think About...**

- SAT pulses take time to apply and increase the SAR. Therefore, SAT pulses can reduce the number of slices available.
- In general, if the TR divided by the number of slices is greater than 150 ms, SAT is not effective.
- Concatenated SAT is not compatible with explicit or graphic SAT.
- A combination of cardiac gating and SAT can create a band of small hash marks in the image. To avoid this, use Recommended Trigger Delay located on the cardiac gating/triggering parameters window.
- Overlapping SAT bands can result in artifacts.

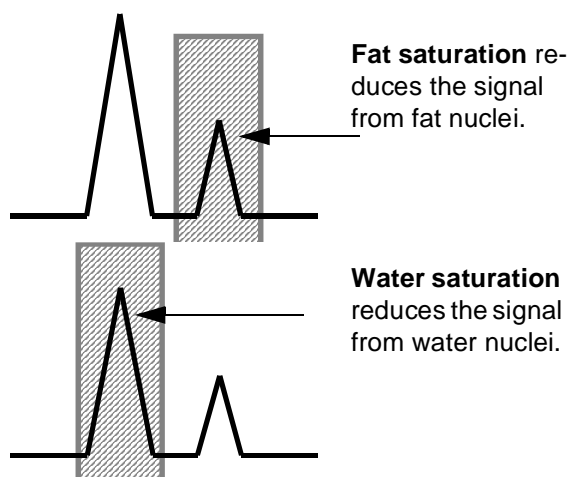
NOTE: For additional information on the SAT Additional Parameter, refer to the chapter Scan Rx Desktop, Volume 1.

NOTE: For additional information on Spatial SATs, refer to the chapter Scanning with a Protocol, Volume 1.

## Chemical Saturation

Chemical saturation delivers RF pulses within the FOV at a specific frequency to saturate and eliminate unwanted signal from selected nuclei. Chemical saturation takes advantage of the fact that fat and water precess at different frequencies.

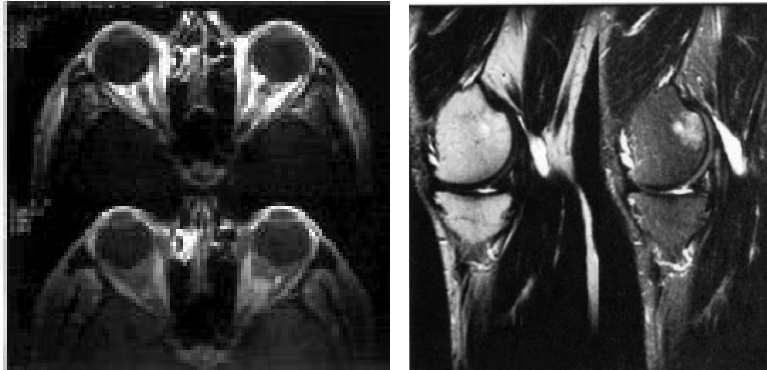
Chemical saturation affects only the nuclei precessing at the same frequency as the RF pulse.



NOTE: Chemical saturation is compatible with most pulse sequences.

## Applications

- Use chemical saturation to reduce the signal from competing tissue and to increase the conspicuity of pathology.
  - To suppress fat in abdominal studies and thereby reduce anterior breathing artifacts.
  - To suppress the fat in musculoskeletal tumors in contrast studies.
  - To identify fatty infiltrate in livers.
- Use chemical saturation to reduce chemical shift artifacts.
- Use chemical saturation to identify fat or fatty structures by its low signal intensity.



**Something to Think About...**

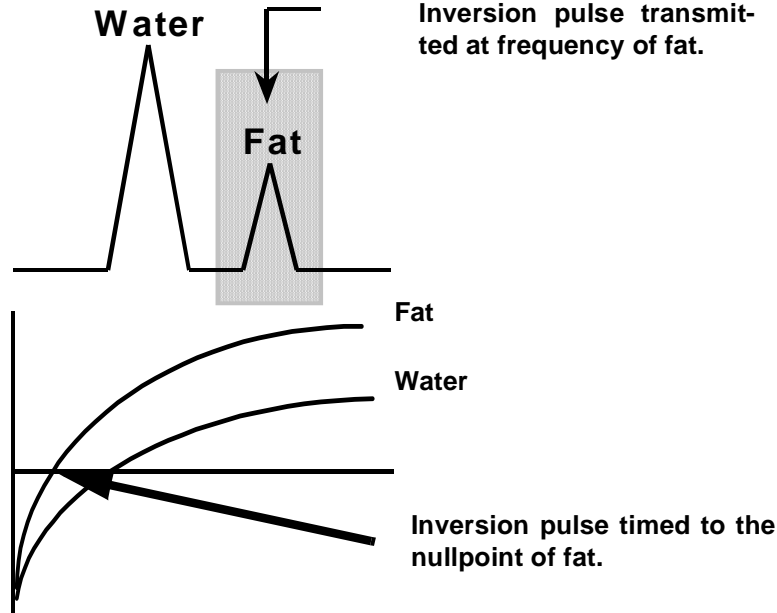
- The success of chemical saturation depends on the uniformity of the anatomy being scanned, and the coil being used. It works best with anatomy of interest at isocenter and a small FOV.
- Saturation pulses take time to apply and increase the SAR. Therefore, saturation pulses can reduce the number of slices available.
- Site or patient specific inhomogeneities may be unavoidable even at isocenter and can result in uneven suppression.

NOTE: For additional information on Chemical SATs refer to Volume 1, Chapter 7.

**Spectral Inversion at Lipids**

Spectral Inversion at Lipids (SPECIAL) uses an inversion pulse transmitted at the frequency of fat and timed to the null point of fat. This results in a signal produced from protons bound in

water and a decreased signal from nuclei precessing at the frequency of fat.



The fat spectral sensitive pulse is applied once per set of slice encodings. There is a slight increase in scan time to account for the inversion pulse. This increase in scan time is much shorter than the increase that would occur if a FAT SAT pulse was used. The inversion pulse is considered a "smart" technique because it optimizes the inversion pulse flip angle based on the prescribed TI, TR, and flip angle.

NOTE: SPECIAL is available with 3D FRGE and 3D Fast TOF sequences.

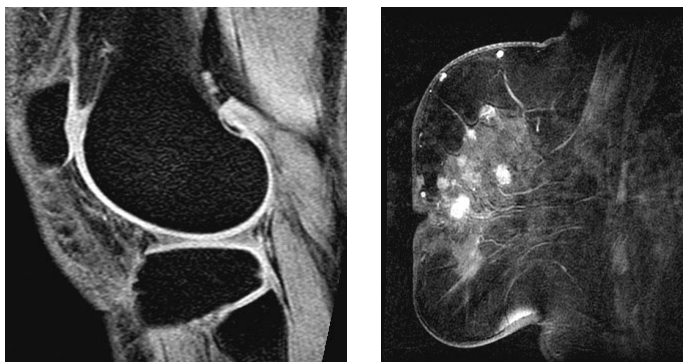
NOTE: If SPECIAL is selected on the User CV page, FAT SAT needs to also be selected.

USER CONTROL VARIABLES				
			Minimum	Maximum
CV6	Turbo Mode (0=off, 1=on)	0.00	0	1
CV10	SPECIAL (0=off, 1=on)	1.00	0	1

### Applications

- Use SPECIAL to suppress fat with a small increase in acquisition time.

The following images are examples of sequences acquired with SPECIAL.



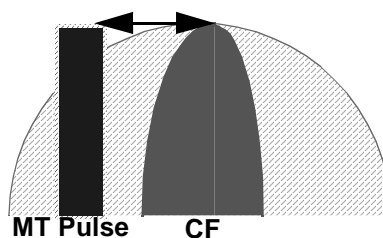
**Something to Think About...**

- There is a slight increase in scan time to account for the inversion pulse that is applied once every 64 slice encodings. This increase in scan time is much shorter than the increase that would occur if a FAT SAT pulse was used.
- SPECIAL supports manual tuning for center frequency adjustment but does not support manual tuning for flip angle adjustment.

**Magnetization Transfer**

Magnetization Transfer (MT) improves contrast between blood flow and surrounding tissue by saturating tissues containing significant amounts of protein. This is achieved by applying a large saturation pulse off center frequency.

MT takes advantage of an energy exchange process that occurs between bound fat and unbound water nuclei.



Approximate signal saturation to expect in tissues when using MT:

- Skeletal muscle, 60%
- White brain matter, 40%

- Gray brain matter, 30%
- Blood, 15 percent

NOTE: MT is available with 3D TOF and SE sequences.

- In 3D TOF with MT, the RF pulse is applied 1200Hz from center frequency and cannot be modified.
  - 3D TOF with MT is compatible with ramped RF pulses. Ramped RF pulses apply a linear-increase RF flip angle throughout the 3D imaging volume.
- In SE with MT, the RF pulse produces user-selectable flip angles and has a user selectable frequency offset accessed from the User Control Variables screen.

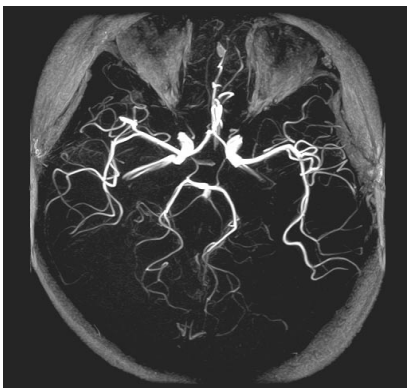


NOTE: Images are annotated MT.

NOTE: The type-in command is **MGT** and is not case sensitive.

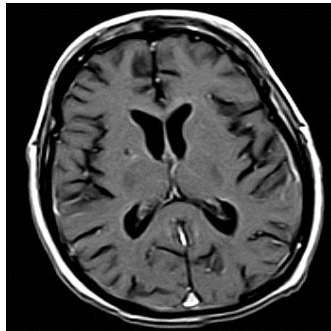
### Applications

- Use MT to improve contrast between blood flow and surrounding tissue in 3D TOF imaging.

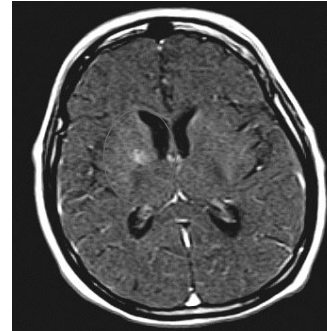


MT preparation techniques have been in routine clinical use in MR Angiography as a means of suppressing non-vascular signal (brain parenchyma) relative to vascular blood.

- Use MT with SE to reduce signal from tissues with high protein content and increase the conspicuity of pathology or gadolinium enhanced structures.



SE with no MT



SE with MT

**Something to Think About...**

- The minimum TR is increased in 3DTOF sequences with MT.
- SE MT is only compatible with transmit and receive coils.
- MT cannot be used for imaging patients whose weight is less than 22 pounds (10 kg).
- The off-resonance RF pulse increases peak SAR, which requires increasing minimum TR when using FC and spatial saturation pulses.

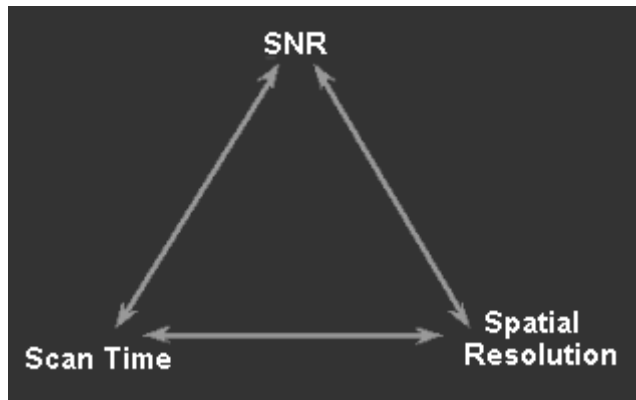
**Blood Suppression**

Blood Suppression uses an inversion recovery preparation pulse to null signal from blood to obtain "black blood" cardiac images. It is available with FSE-XL and FSE-XL IR acquisitions.

NOTE: For information on the Blood Suppression feature, refer to chapter Cardiac Pulse Sequences, Volume 2.

## Options to Balance SNR

All imaging options affect SNR in some way; however, VBw is the most frequently adjusted parameter used to compensate for other factors that reduce SNR.



NOTE: The integrated SNR indicator allows you to understand the SNR impact of various parameter changes to assure more optimal scan prescriptions.

## Additional Imaging Options

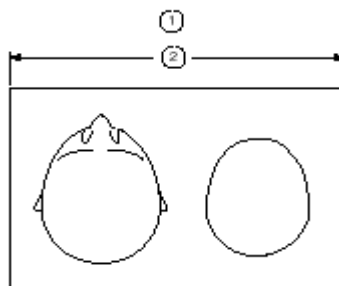
There are also other imaging options available for use while scanning to help improve your image quality and efficiency. These include the following:

- Phase Offset Multi-Planar
- Full Echo Train
- Extended Dynamic Range
- Sequential
- Multi Phase
- SmartPrep
- Multi-Station
- Real-Time

### Phase Offset Multi-Planar

Phase Offset Multi-Planar (POMP) doubles the slice coverage by exciting two slice locations at the same time. Multiple RF pulses are used to excite two adjacent slice locations at once,

using a pulse combining two frequency bands that are out of phase with one another.



1. POMP Reconstruction
2. Acquisition FOV and phase steps are doubled to provide K-space for reconstruction.

During reconstruction, the slices are phase shifted from each other and separate to create two images. In order to achieve this, the acquired FOV is doubled in the phase direction and the NEX is halved to maintain the same imaging time.

<u><b>What You Select</b></u>	<u><b>What the System Acquires</b></u>
Desired FOV	Doubles the FOV in the phase direction
Desired Phase Matrix Value	Doubles the Phase Matrix to maintain resolution
Desired NEX	Cuts the NEX in half to maintain scan time

NOTE: POMP is compatible with SE sequences only.

NOTE: The images are annotated PM.

NOTE: The type-in command is `PO` and is not case sensitive.

### Applications

Use POMP to increase the number of slice locations on short TR T1W sequences instead of increasing the TR and reducing contrast.

### Something to Think About...

- POMP is incompatible with:
  - Sequential option.
  - A phase FOV less than one.
  - Square Pixel option.

- NPW option.
- 0.5 and 0.75 NEX.
- An uneven number of slices.
- When POMP and Flow Comp are combined, the Flow Comp gradient is only applied to the second echo. Therefore, the early echo is not compromised.
- Not recommended for studies where wraparound can be a problem.
- Two-echo maximum.
- Images may exhibit flatter contrast. Use TR and TE values that enhance T1 contrast when POMP is used.
- Increased motion artifacts may occur because POMP halves the selected NEX and, therefore, decreases the benefits from motion averaging when NEX values are less than one.
- Resp Comp with POMP is only compatible with one or two NEX.
- Aliasing and motion artifacts from one slice may be propagated across POMP images in the phase direction.
- If POMP is used with ECG gating, there are two sets of images with the same timing annotation. This is because two images are acquired for each excitation.

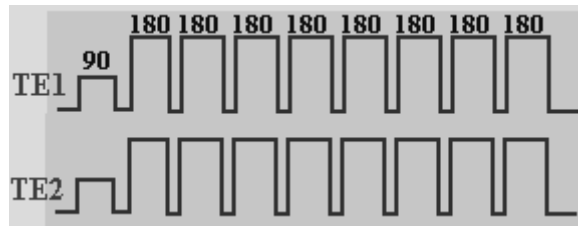
## Full Echo Train

Full Echo Train (ET) is available when the pulse sequence is FSE and two echoes are selected. The full ET method completes all echo trains for effective TE1 before effective TE2 is initiated. The phase encoding process is altered to place the central phase encodings at the selected effective TE1 or TE2.



**8 ETL Split Echo Train**

When two echoes are selected, the system automatically splits the echo train.



When 2 echoes are selected, Full Echo Train must be selected to acquire full trains of each echo.

**8 ETL Full Echo Train**

The resulting contrast of using a Full ET is similar to that of a single echo acquisition for a long TR/short TE and long TR/long TE. A full ET is always used for single echo, FSE acquisitions.

NOTE: Full ET is only available when two echoes are selected.

NOTE: Images are annotated ET.

NOTE: The type-in command is **FU** or **FT** and is not case sensitive.

**Applications**

Use a full echo train when more effective contrast weighting is desired on a dual echo acquisition.

**Something to Think About...**

- The resulting contrast may be more varied than desired. An alternative is to acquire two separate acquisitions, each with an effective TE and ET programmed to produce the desired contrast and time results.

**Extended Dynamic Range**

Extended Dynamic Range (EDR) is an imaging enhancement technique that allows 32 bit data processing instead of the conventional 16 bits to slightly improve SNR.

NOTE: Compatible with virtually all pulse sequence and imaging options.

NOTE: The images are annotated ED.

NOTE: The type-in option is **DR** or **EDR** and is not case sensitive.

**Applications**

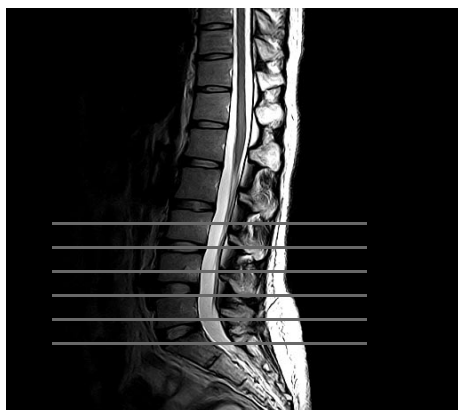
Improves SNR in some applications, such as 3D acquisition imaging.

### Something to Think About...

- EDR uses twice as much memory as a conventional acquisition, which can limit the number of locations per acquisition.
- EDR may cause auto pause to engage if a large number of slices are prescribed.
- The system prompts for EDR after prescan if the system determines EDR improves SNR.

## Sequential

Sequential is a data acquisition mode that collects one image at a time, in a numerical order. All of the excitation pulses (number of phase steps x NEX x TR) are delivered for one location before the process is repeated at another location.



2D Sequential acquires all data from one slice before going to the next slice.

The total number of slices equals the number of acquisitions.

Scan Time = TR x Phase Matrix x NEX x Slices

NOTE: Sequential is compatible with GRE/SPGR, 2DTOF, and IR pulse sequences.

NOTE: Images are annotated Sq.

NOTE: The type-in command is **SE** and is not case sensitive

### Applications

- Use sequential during 2D acquisitions to eliminate cross-talk between slices.
- Use sequential for breath-hold abdominal or chest scans.
- Use sequential for quick localizer scans.

### Something to Think About...

- Acquiring a number of 2D sequential scans through an area may take longer than a 3D acquisition. Always

compare the scan times of both acquisition modes and the tradeoffs between 2D and 3D to make a decision that best fits the patient's needs.

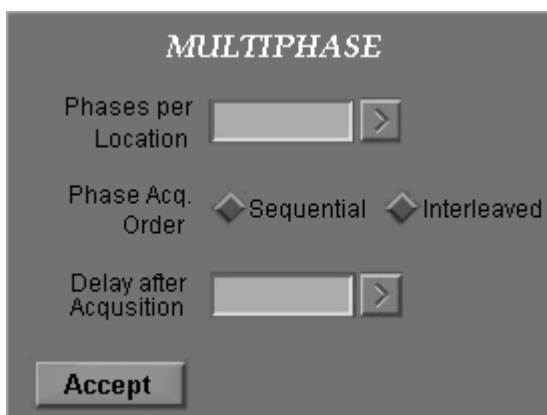
### Multi Phase

The Multi Phase imaging option allows imaging of the same slice locations or volume using the same imaging parameters.

The **Multi Phase Screen** icon in the Additional Parameters area becomes active when Multi Phase is selected in the imaging options.



The Multiphase screen appears when the **Multi Phase Screen** icon is selected.



The following additional parameters become available:

- Phases per Location
  - Indicates the number of phases to be acquired at one location.
- Acquisition Order (Interleaved or Sequential)
  - In interleaved mode, the system acquires the first phase at each location (pass 1) and then goes back and acquires the second phase at each location. Interleaved is recommended for contrast studies.
  - In sequential mode, the system acquires all of the slices at the first slice location (pass 1) before moving on to the

second (pass 2). Sequential is recommended for kinematic range of motion studies.

- Delay after Acquisition
  - Indicates the length of delay after every acquisition. The system resumes scanning automatically after the prescribed delay.
  - Locs Before Pause may be selected from the Acquisition Timing area instead of programming a delay after acquisition from the Multi Phase Screen.

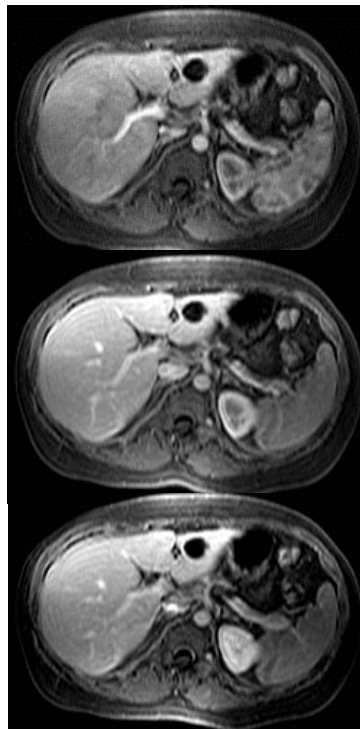
NOTE: Multi Phase is available with the following pulse sequences:

- FGRE
- Fast GRE TOF
- SPGR
- Fast SPGR TOF
- Fast TOF
- EPI

### **Applications**

- Use Multi Phase for joint motion studies of the knee, TMJ, and wrist.
- Use Multi Phase for dynamic contrast studies.

The following figure is a series of images acquired with Multi Phase.



**First Phase**

**Second Phase**

**Third Phase**

**Something to Think About...**

- The (slices/location) x (number of slices) cannot exceed 512.
- Images acquired at a single location with multiple phases (SSMP) may appear shifted upon display. This is most noticeable when these images are loaded into a paging-loop mode.

NOTE: For additional information on the Multi Phase Additional Parameter, refer to the chapter Scan Rx Desktop, Volume 1.

**SmartPrep**

SmartPrep Infusion Angiography (IA) is an imaging technique that uses a tracking pulse sequence to continuously monitor the MR signal coming from a user prescribed volume of interest in the patient to detect contrast arrival and automatically begin the acquisition.

NOTE: For information on SmartPrep, refer to the chapter, Triggering CEMRA with SmartPrep.

### **Multi-Station**

Multi-Station, also known as SmartStep, is a feature that provides automatic table movement and switching of coils between stations. SmartStep is used with 3D Fast TOF GRE/SPGR and 3D Fast GRE/SPGR.

NOTE: For information on the Multi-Station feature, refer to the chapter Bolus Chasing with SmartPrep.

### **Real-Time**

Real-Time, or iDrive, option is a real-time interactive acquisition that can be used for navigating through patient anatomy for rapid visualization, monitoring temporal physiological events. Real-time interactive images can also be used for directly prescribing scan planes of other series in the exam.

NOTE: For information on Real-Time Imaging, refer to the chapter Imaging Real-Time with iDrive.

This page intentionally left blank.

## Chapter 2

# Gating and Triggering

Where Am I?



## Introduction

This chapter contains information needed for successful Cardiac Gating and Triggering, Peripheral Gating, and Respiratory Gating and Triggering on your MR system. It provides a foundation that enables you to make decisions about when to use gating and triggering to eliminate the effects of heart and breathing motion. This chapter highlights key concepts and contains step-by-step instructions to help you learn how to:

- Place Electrodes and Route the ECG Cable
- Set up the Gating Control
- Regulate Contrast with Cardiac Gating
- Place the Respiratory Bellows and Route the Tubing
- Set up the Respiratory Gating Control
- Regulate Contrast with Respiratory Gating

In addition, this chapter answers the following questions:

1. How does gating and triggering eliminate the effects of cardiac and respiratory motion?
2. What is the difference between gating and triggering?
3. What types of gating and triggering are available?
4. How are trigger signals detected?
5. How does the gating control affect gating?
6. How do you regulate contrast with cardiac gating?
7. How do you regulate contrast with respiratory gating?
8. What are some frequently asked questions when performing a gated examination?



**CAUTION: Performing ECG and peripheral cardiac gated exams requires thorough knowledge of gating and surface coil safety issues. Please refer to the safety chapter in Volume 1.**

---

# About... Gating and Triggering

This section presents the concepts necessary to successfully complete the cardiac/respiratory gating and triggering processes. Specifically, you need to understand:

- Types of Gating and Triggering
- Gating, Triggering, and CINE Data Acquisition
  - Gating
  - Triggering
  - Cine Acquisitions
- ECG Waveform
  - P-Wave
  - P-R Interval
  - QRS Complex
  - ST Segment
  - T-Wave
  - R-R Interval
  - Diastole and Systole
- ECG Leads
- Peripheral Sensor
- Respiratory Gating and Triggering
  - Respiratory Gating
  - Respiratory Triggering
- Cable Connection Ports
- ECG Lead Placement
- Respiratory Bellows
- Gating Control
  - Waveform Display
  - Cardiac Sweep Rate
  - Lead Display
  - Cardiac Trigger Level
  - Cardiac Trigger Level Annotation
  - Audio Trigger Volume
  - Gating Reset and
- Combined Cardiac and Respiratory Gating/Triggering Screen
- Combined Cardiac and Respiratory Gating/Triggering

- Standard CINE Screen
- Frequently Asked Cardiac Questions

## Types of Gating and Triggering

The Signa system provides ECG, peripheral and respiratory gating and triggering. This allows the same data to be collected at the same points of the cardiac and/or respiratory cycle for each repetition of the pulse sequence. The benefit is that the motion is always the same and is essentially "frozen" —allowing motion artifacts to be reduced, or sometimes eliminated.

- ECG Gating/Triggering uses a signal generated by the electrical impulses of the heart.
  - Reduces pulsatile cardiac motion by synchronizing data acquisition to the cardiac cycle.

**NOTE:** ECG Gating/Triggering and Cardiac Gating/Triggering are used interchangeably in this document.

- Peripheral Gating/Triggering uses a signal generated by the mechanical flow of blood in the vascular bed.
  - Reduces pulsatile cardiac motion by synchronizing data acquisition to the cardiac cycle.
- Respiratory Gating/Triggering uses a signal generated by the motion of the abdominal wall.
  - Reduces respiratory motion by synchronizing data acquisition to the quiet period of the respiratory cycle.

**NOTE:** Combined cardiac and respiratory gating is allowed for FastCard GRE/SPGR, 3D Fast GRE/SPGR, 3D Fast TOF, and Fast 2D PC.

- CINE acquisitions use the cardiac waveform to perform retrospective processing of the image data.
  - Executes pulse sequences continuously rather than waiting for triggers.

## Gating, Triggering, and CINE Data Acquisition

Cardiac Gating/Triggering and Respiratory Gating/Triggering function in the same manner. The difference is the signal used in the process: the cardiac waveform or the respiratory waveform.

The pulse sequence determines whether the system uses gating or triggering, however, Respiratory Triggering is not available for most sequences. It is not necessary to remember which process is used with which sequence. Choose the desired pulse sequence and select Cardiac or Respiratory

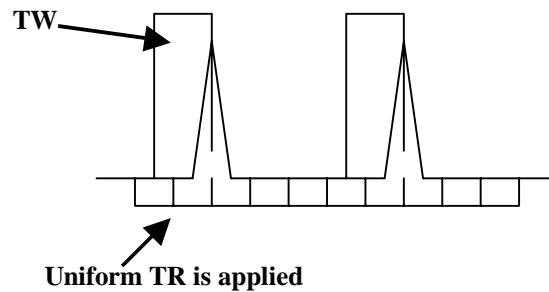
Gating/Triggering at the Imaging Options window and the system automatically performs the appropriate process.

CINE is an acquisition that uses the cardiac waveform to retrospectively process image data. FastCINE acquisitions are set up at the Cardiac screen. If Respiratory Triggering is selected, then set up at the Combined Cardiac and Respiratory Gating/Triggering Screen. The screen is accessed from the Additional Parameters area of the Scan Rx Desktop. CINE acquisitions use the CINE screen (accessed in the Additional Parameters of the Scan Rx Desktop when CINE is the selected Scan Mode).

### Gating

Gating monitors the cardiac or respiratory cycle, but does not use a trigger to initiate RF application. RF is applied throughout the cycle at the defined TR time, and data is acquired when the desired physiological event occurs.

#### Cardiac Gating



- A Trigger Window is programmed to stop data acquisition and allow the system a window in which to look for and detect the next R-wave.
- RF is applied at the defined TR time throughout the cardiac cycle, including the TW. The RF is applied asynchronous to the cardiac cycle.
- TR is uniform; it does not change as the cardiac cycle changes. Uniform TR is beneficial for short TR acquisitions.
- FastCard, FastCINE, 3D Fast GRE/SPGR, 3D Fast TOF, and Fast 2D PC may use cardiac gating.

## Respiratory Gating

Respiratory gating uses the respiratory waveform to determine the point at which data acquisition is to take place and TR is applied continuously throughout the respiratory cycle.

- TR is applied at the defined TR time throughout the entire respiratory cycle, however, data acquisition takes place only during the data acquisition window.
- Data acquisition is begun when a user-defined Trigger Point is reached.
- Continuous RF application provides more uniform image contrast and is better suited to short TR acquisitions.
- Gating is performed in FastCard, 3D Fast GRE/SPGR, 3D Fast TOF and Fast 2DPC.
- Requires you to define Trigger Point and Trigger Window at the Combined Cardiac and Respiratory Gating/Triggering Screen.

**NOTE:** See the section "Combined Cardiac and Respiratory Gating/Triggering Screen" for details on the parameters used in cardiac and respiratory gating/triggering.

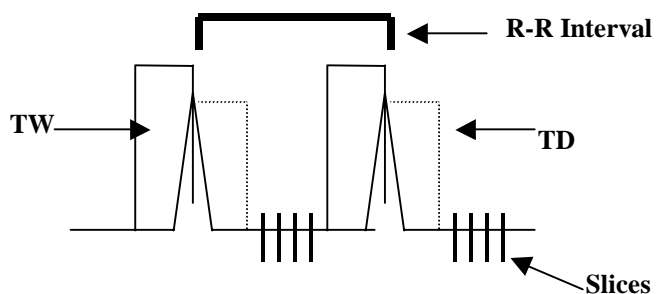
## Triggering

Triggering is a technique that turns RF application and image acquisition on and off based on a trigger detected within the cardiac or respiratory cycle. The trigger window is set as a percentage of the cardiac (or respiratory) cycle.

Triggering synchronizes data acquisition with the waveform cycle, and all image data is acquired at the same phase in the cycle for each slice prescribed.

### Cardiac Triggering

The following figure shows cardiac triggered data acquisition.



- A Trigger Window is programmed at the end of the cardiac cycle, halting data acquisition and allowing the system time to detect the next trigger (the R-wave in cardiac triggering).
- After the R-wave is detected, a Trigger Delay occurs and data acquisition begins. RF application and data acquisition are initiated following detection of the trigger.
- Data acquisition is synchronized to the cardiac cycle. RF is not applied and data acquisition does not take place during the TW or the TD. TR is based on the R-R interval.
- Because triggering is synchronized to the cardiac cycle, TR can be nonuniform if the cycle timing varies, e.g., if the heart rate decreases or increases.
- At longer TRs, the effects of non-uniform TR (e.g., image contrast inconsistencies) decrease.
- Spin Echo (SE), Fast Spin Echo (FSE), and Multi-Planar 2D Gradient Echo (GRE), Spoiled Gradient Echo (SPGR) sequences may use cardiac triggering.

### **Respiratory Triggering**

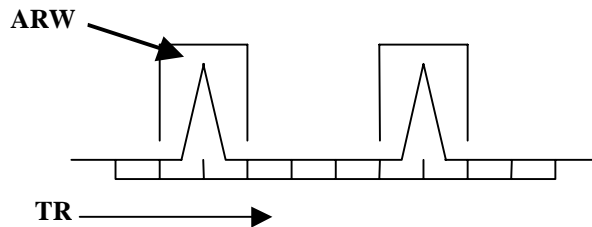
Respiratory triggering works in the same fashion as cardiac triggering, using the respiratory cycle to initiate RF application and data acquisition.

- A point in the respiratory cycle, defined as the Trigger Point, is used to initiate RF application and data acquisition.
- Data acquisition and RF application does not take place during the Trigger Window.
- Triggering is synchronous to the respiratory cycle and is most applicable to long TR applications.
- Due to long TRs that generally result from respiratory triggering (based on the patient's respiratory rate), it is not usually possible to achieve TR values used to obtain T1 image contrast.
- Respiratory triggering is used in FSE sequences.
- The following values are defined at the Combined Cardiac and Respiratory Gating/Triggering Screen: the number of Respiratory Intervals, Trigger Point, Trigger Window, and Inter-Sequence Delay.

**NOTE:** See the section "Combined Cardiac and Respiratory Gating/Triggering Screen" for details on the parameters used in cardiac and respiratory gating/triggering.

## CINE Acquisitions

CINE acquisitions are neither gated nor triggered as defined above. In a CINE acquisition, the cardiac cycle is monitored and data acquisition takes place throughout the cycle.



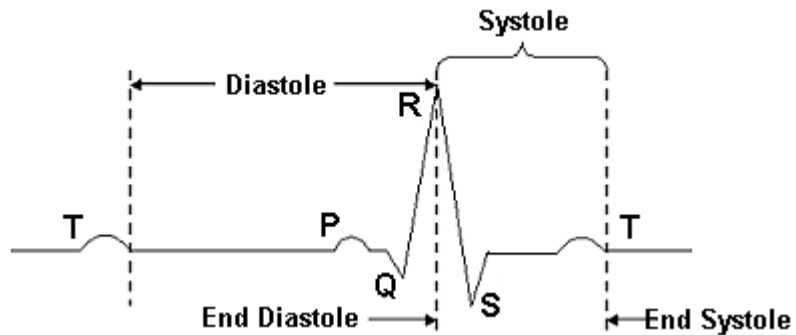
- Data is collected continuously throughout the cardiac cycle.
- Image data is retrospectively sorted to place the acquired data synchronous to the averaged cardiac cycle.
- An Arrhythmia Rejection Window (ARW) is defined at the Combined Cardiac and Respiratory Gating/Triggering Screen. If an R-wave occurs outside the ARW, the image data collected during that period is discarded. This data must be collected again, resulting in extended scan time.
- CINE acquisitions can be performed utilizing a CINE or FastCINE pulse sequence.

**NOTE:** See the section "Combined Cardiac and Respiratory Gating/Triggering Screen" for details on the parameters used in CINE acquisitions.

## ECG Waveform

Electrical impulses cause the heart to contract and, therefore, blood to flow throughout the body. An electrocardiogram, or ECG, is a map of the electrical activity of the heart.

The following illustration of the ECG waveform shows the pattern of the P, Q, R, S, and T waves of the cardiac cycle.



The ECG waveform represents the electrical activity of the heart that correlates to heart motion:

- Cardiac contraction is called systole.
- Cardiac relaxation is called diastole.

Three waveform elements are critical to cardiac gating: P-wave, QRS complex, and T-wave.

- The P-wave represents depolarization of the atria and results in contraction or systole of the atria. This contraction is not normally seen in FastCard acquisitions, due to the application of the TW.
- The QRS complex represents depolarization of the ventricles and results in contraction or systole of the ventricles.
- R-wave is used for triggering because of its strong electrical signal and correlation of the muscle activity of the heart. The R-R interval is the time between the peak of one R-wave and the peak of the next. Each R-R interval represents the length of one cardiac cycle.
- The T-wave represents re-polarization of the ventricles and results in relaxation or diastole of the ventricles.

### P-Wave

The P-wave represents depolarization of the atria and results in contraction or systole of the atria. A normal P-wave is no more than 3 mm high and 0.12 seconds in duration. It is difficult, and sometimes impossible, to see the P-wave on an ECG acquired when the patient is in the bore of the magnet.

### **P-R Interval**

This is the time between the onset of the P-wave and the onset of the QRS complex. The normal PR interval is 0.12 to 0.20 seconds. Anything greater than 0.20 seconds is abnormal.

### **QRS Complex**

The QRS complex represents the depolarization of the right and left ventricles. A normal QRS complex is about 0.08 to 0.11 seconds in duration. A longer complex may indicate a ventricular conduction defect, such as a left bundle branch block.

### **ST Segment**

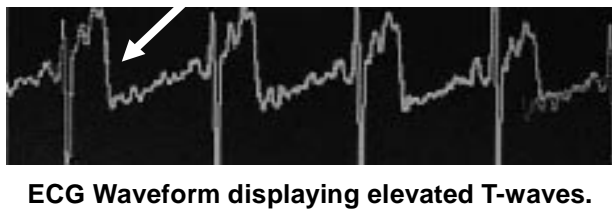
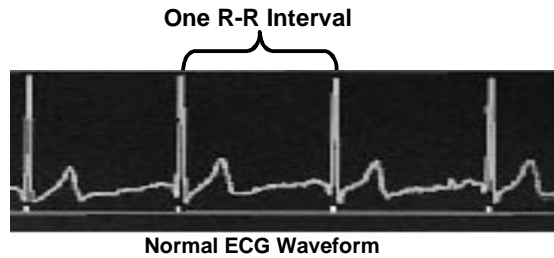
The ST segment represents the time between the completion of a depolarization and the beginning of repolarization of the ventricle. An elevated or depressed ST segment could indicate ischemia or an infarction.

### **T-Wave**

The T-wave represents the recovery phase after ventricular contraction. In cases of heart injury, the T-wave may be inverted. Flowing blood in the body makes an artifact in the ECG that obscures the normal T-wave when the patient is inside the magnet, rendering the STR segment invalid for evaluation of infarction or ischemic events.

### R-R Interval

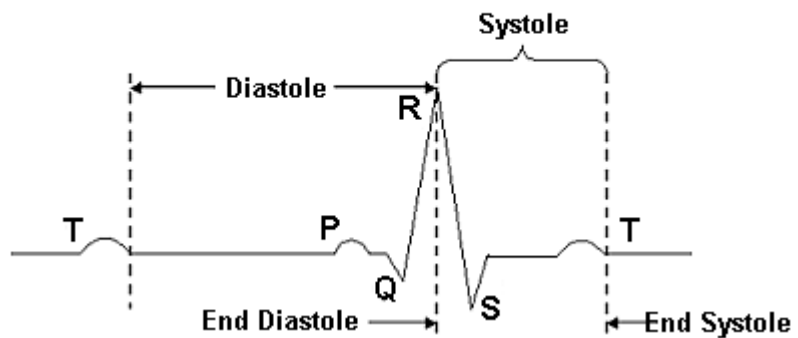
The R-R interval represents the time between one heartbeat and the next, based on the R-wave of the QRS complex.



### Diastole and Systole

In addition to the components of the ECG waveform, the phases of the cardiac cycle play an important role in cardiac gating.

- Diastole is the period between the end of the T-wave and the peak of the following R-wave. It is during diastole that the ventricles fill with blood.
- Systole is the remaining portion of the cardiac cycle. It is the period between the R-wave's peak and the end of the T-wave when the heart is contracting and expelling blood.



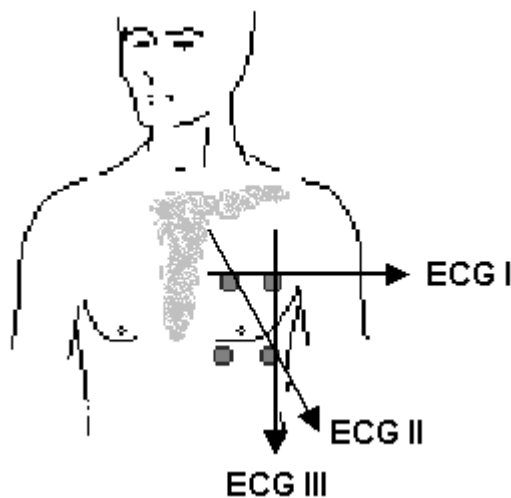
**NOTE:** There is a difference between electrical diastole and mechanical diastole. Electrical end-diastole occurs at the P-wave. Mechanical end-diastole occurs at the R-wave. The illustration above shows mechanical end-diastole. Mechanical diastole is used in Signa cardiac imaging.

## ECG Leads

The electrical activity of the heart is detected by measuring the voltage difference between electrodes attached to the patient. Each lead represents the anatomy connected by two electrodes. MR cardiac gating uses a three-lead technique that consists of four electrodes and four lead-wires:

- The white electrode/lead wire is positioned for the right arm.
- The black electrode/lead wire is positioned for the left arm.
- The red electrode/lead wire is positioned for the left leg.
- The green electrode/lead wire is positioned for the right leg.

Recommended electrode placement is anterior as shown in the illustration below, however, slight adjustments to these positions may be needed based on the patient's body habitus and the extent of cardiac disease.



ECG I measures the voltage between the right arm and the left arm.

**NOTE:** ECG II and III are measured signals while ECG I represents a calculated signal (calculated from the average of the sums of ECG II and ECG III.)

ECG II measures the voltage between the right arm and the left leg.

ECG III measures the voltage between the left arm and the left leg.



**WARNING:** This waveform can only be used for cardiac gating and should not be used for patient monitoring. The patient's condition may not be reflected, resulting in improper emergency treatment.



**WARNING:** Do not use expired or dried electrodes. They do not properly conduct the signal, which can lead to image degradation, create intermittent triggering, and can cause burns to the patient.



**CAUTION:** Patient and cable positioning tips.

- **Position the cable in a fashion such that the cable is not looped and a minimum length of cable remains within the bore of the magnet. A feet first patient orientation is recommended, as this position allows for the cables to be routed in this fashion more easily.**
- **Place the patient in the center of the table to reduce the possibility of patient burns.**
- **Keep all cardiac cables from touching the patient, the coil cables, or the magnet bore. Cables need to exit the bore down the center of the table.**
- **Make certain the lead wires and cables are undamaged.**
- **Keep the surface coils and their cables away from the ECG cables and wires.**

Something to Think About...

- The T-wave may increase in height once the patient is in the magnet because of physiological effects of the magnetic field. Repositioning the electrodes, positioning

- the patient feet-first, or using another lead selection, may minimize this effect.
- Eliminate as many noise sources as possible, including ECG cable motion, patient movement, and breathing motion artifacts if the patient is in a head first position and the ECG cable rests on the patient's abdomen.
  - When prescribing a series, complete the gating window in Additional Parameters area after the patient has been placed in the magnet. This diminishes the chances of a heart rate increase (common for some people as they first move into the magnet), which may result in a reduction in the number of slices allowed per acquisition.
  - Attach electrodes no more than 5 to 10 minutes before a scan.
  - Do not press on the center portion of the electrode. This can flatten the conductive gel and electrical impulse detection which may result in intermittent or missing QRS detection.

## Peripheral (photo-pulse) Sensor

Peripheral gating uses a photopulse sensor that detects the blood flow in the vascular bed. The photopulse waveform represents blood flow, not the electrical activity of the heart. Peak blood flow occurs at the peak of the waveform.



### Something to Think About...

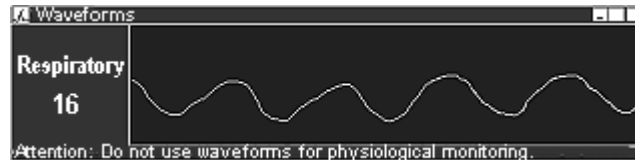
- Make sure the anatomy where the sensor is placed remains cool and dry during the entire exam.
- Attach the sensor to a toe or finger with minimal callous to insure a good reading.
- Keep the cable entering the magnet bore to a minimum.
- Keep the sensor and cable out of the area being imaged.

- Ask the patient to keep the sensor very still during the study. To minimize sensor motion, rest the patient's arms at his/her sides, rather than on the chest or stomach.
- Keep the photosensor away from isocenter to minimize the RF or gradient interference.
- Do not loop the cable.

## Respiratory Gating and Triggering

Respiratory gating and triggering uses a bellows sensor that detects the motion of the abdominal wall. The respiratory waveform represents the excursion of the abdominal wall throughout the course of inspiration and expiration. The waveform is a pattern of the patient's breathing.

A respiratory interval is defined as the maximum inspiration to the next maximum inspiration. This is know as one respiratory cycle. Maximum inspiration occurs at the peak of the waveform.



## Respiratory Gating

- Respiratory gating continuously applies RF at the defined TR time. Continuous application of RF results in a more uniform contrast and short TRs can be used.
- Data acquisition occurs only during the data acquisition window.
- Only the Trigger Point and Trigger Window are defined.
- Data acquisition is generally performed during the quiescent (most quiet) period of the respiratory cycle. This is at end-expiration/beginning-inspiration, the "valley" of the cycle.
- Respiratory gating is performed in FastCard, FastCINE, Fast2D PC, 3D Fast GRE/SPGR, 3D Fast TOF, and SmartPrep IA.

## Respiratory Triggering

- A Trigger Window is used for detection of a Trigger Point.
- Data acquisition stops during the Trigger Window.
- Triggering is synchronous to the respiratory cycle.
- Number of Respiratory Intervals, Trigger Point, Trigger Window, and Inter Sequence Delay are defined.
- Data acquisition is generally performed during the quiescent (most quiet) period of the respiratory cycle. This is at the end-expiration/beginning-inspiration, the "valley" of the cycle.
- FSE can use respiratory triggering.

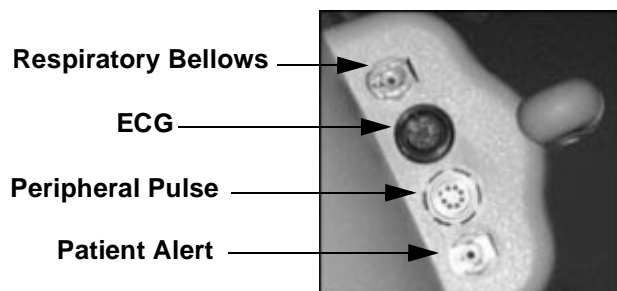


**WARNING: The respiratory bellows is intended for use solely in acquiring MR images using respiratory compensation/triggering, not for physiological monitoring.**

## Cable Connection Ports

The gating cables and respiratory bellows are connected to the Physiologic Acquisition Controller (PAC). The PAC may or may not be visible on every system, but the connections are always found on or near the magnet enclosure.

New style magnets are equipped with cable connection ports as seen in this illustration. These are connectors only; the PAC is located behind the magnet enclosure. The ECG cable, Peripheral Pulse cable, Respiratory Bellows, and the Patient Alert cable plug into these ports. Each cable has a unique connector and cannot be accidentally plugged into the wrong port.



There is a cable routing device attached to the PAC unit that is designed to keep the cables separated.



The cable routing device separates the cables.

Older style magnets are likely to be equipped with the PAC located on the floor, attached at the front of the magnet enclosure. The cables attach to the ports in the same fashion as seen above, but the Patient Alert system does not attach to the PAC.

Regardless of the device on your system, the connection ports are used to collect triggering information for cardiac and respiratory data acquisition.

## ECG Lead Placement

Proper preparation of the patient and placement of the ECG leads are an integral part of any cardiac gated acquisition. If either of these procedures is done improperly, the ECG waveform may not be detected accurately. This can affect the results of the exam in terms of poor image quality, and even the inability to complete a cardiac gated exam due to lack of a proper cardiac waveform for detection of the triggers.

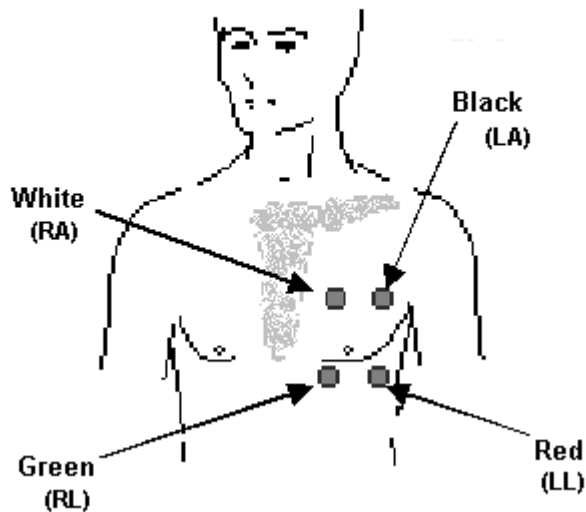
Measuring a voltage difference (or potential) between two points creates the ECG trace, or waveform. For example, ECG II measures the voltage difference between the right arm and the left leg.

There are three ECG leads from which to choose:

- ECG I: Right arm (white) to left arm (black).
- ECG II: Right arm (white) to left leg (red).
- ECG III: Left arm (black) to left leg (red).

**NOTE:** ECG II and III are measured signals while ECG I represents a calculated signal (calculated from the average of the sums of ECG II and III).

**The patches should be no further than 10 - 15cm apart.**



The following are important tips for ECG lead placement:

- Anterior placement is recommended for electrode placement.
- Avoid placing the electrodes over bony areas such as the sternum or clavicle. Bone can interfere with signal detection.
- For women with large breasts, the left breast should be raised and the red electrode placed as close to the position indicated in the ECG lead placement illustration.
- The electrodes should not be placed more than 10 to 15 cm apart.
- The left leg (red) electrode placement is important in that care should be taken to place that electrode over the apex of the heart.
- On normal volunteers, ECG II generally provides the best signal.
- The heart may present in a different orientation within the thorax of a patient with heart disease. In these patients, ECG I or III may provide the best signal.

Something to Think About...

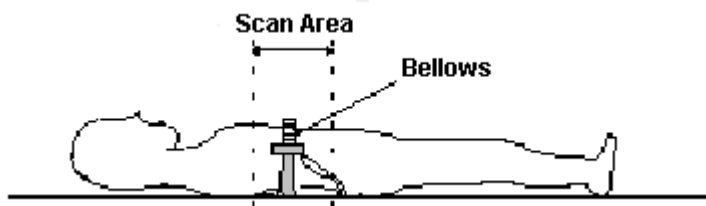
- Should the ECG signal degrade during data acquisition, Signa automatically switches to another lead (trigger type selection). The system switches from ECG II to ECG III, or from ECG III to ECG II.
- If there is a problem with the LL (left leg/red) electrode or lead wire, neither ECG II nor ECG III provides a good trace. The ECG I trace is calculated from the sums of ECG II and III, therefore, the ECG I trace is also affected. It may be necessary to check the electrode and lead attachment followed by reinitializing cardiac gating.
- If the waveform is not a clean trace, cycle through the leads on the Gating Control window. Visually inspect the traces to find the best waveform. As the lead selection is changed, click the **[Update]** button to display the R-peak amplitude. Use the combination of a visual inspection of the waveform and the R-peak amplitude to determine the best lead for gating. Performing only a visual inspection of the waveform is not sufficient because Signa autoscales the waveform even if the R-peak amplitude is very low. A high R-peak amplitude in combination with a "clean" waveform ensures successful of triggers.
- **DO NOT rely on Auto for lead selection.** Auto chooses the lead that has the strongest signal, but not necessarily the lead that produces the best waveform. The signal could be strong due to noise in the waveform.

## Respiratory Bellows Placement

The respiratory bellows is a sensor that detects the motion of the abdominal wall. The respiratory bellows is used in Respiratory Gating/Triggering and Respiratory Compensation.

**NOTE:** For details on Respiratory Compensation, refer to the chapter Optimizing Images with Imaging Options.

The following figure illustrates the placement of the respiratory bellows in reference to the scanning area.



The respiratory bellows are placed over the area being scanned, where the greatest breathing motion occurs on the patient. The bellows are fastened with Velcro® straps. Placement of the bellows should be snug but stretched as little as possible.

- The bellows should expand and contract with the patient's breathing. Expansion should be  $\frac{1}{2}$  to 1 inch.
- The signal may not be detected if the bellows is too loose.
- If the bellows is too tight, the system sets the respiratory gain too high and the signal may not be detected accurately.



Correctly stretched bellows.

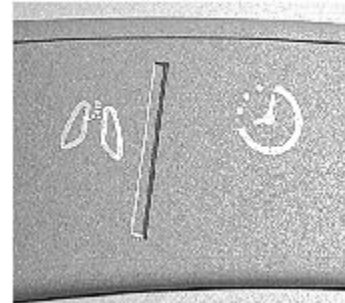
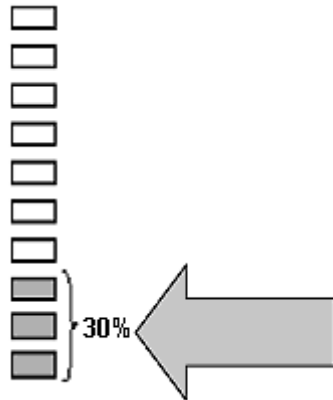


Breathing signal may not be detected with bellows set too loose.



Stretching the bellows too tight results in the gain set too high.

There is a respiratory LED on the magnet enclosure. If the respiratory signal is adequate, the LED should rise and fall with patient's breathing. The LED should move over the bottom one-third of the display.



The illuminated amplitude of the LED display should be 30% of the window.

The LED on your system may be as seen in the illustration on the left or the right.

Something to Think About...

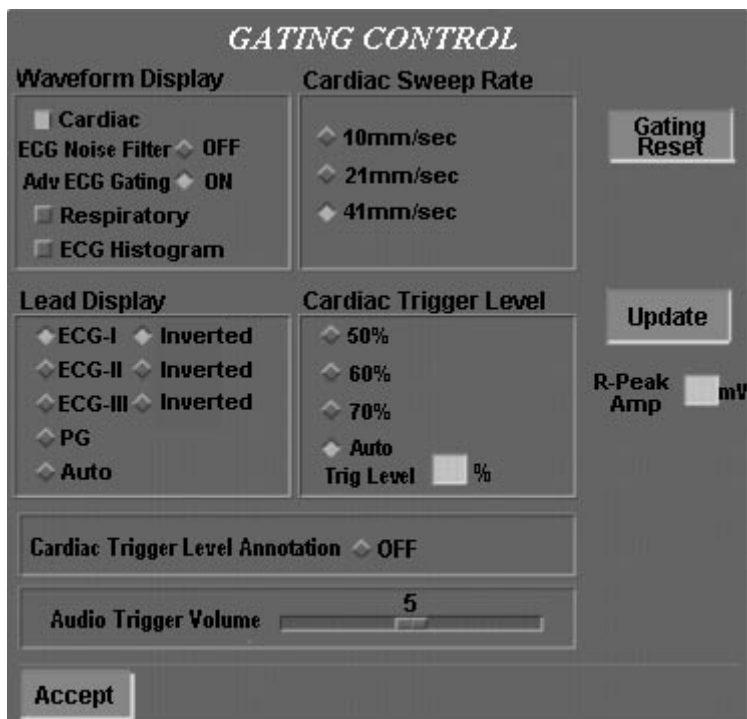
- Do not detach the respiratory bellows from the connection port. Unplugging the bellows allows air to enter the tubing, decreasing the system's ability to detect a change in air pressure when attached to the patient.
- Deep breaths, coughing, movement, and talking affects the signal. The waveform exhibits all of these conditions.

## Gating Control

The Gating Control window is used to set-up parameters used for display of the cardiac and respiratory waveforms, selecting the gating algorithm to be used by Signa, and to change the lead selection during data acquisition. This section provides the following information on the Gating Control window:

- Waveform Display area details all the items in the Waveform Display and Cardiac Sweep Rate area of the Gating Control window.
- Lead Display area details ECG/PG lead selection and ECG inversion.
- Cardiac Trigger Level area details adjustment of the trigger level for detection of the R-wave, and includes details on Cardiac Trigger Level Annotation and Trigger Volume.
- Gating Reset and R-peak Amplitude areas detail the use of these features.

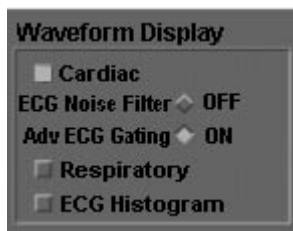
The following figure is the Gating Control window.



## Waveform Display

The Waveform Display portion of the Gating Control window is used to:

- Display the Cardiac and/or Respiratory waveforms.
- Display an ECG Histogram.
- Define the gating algorithm for cardiac gating, Advanced ECG Gating ON or OFF.
- Turn the ECG Noise Filter ON or OFF.

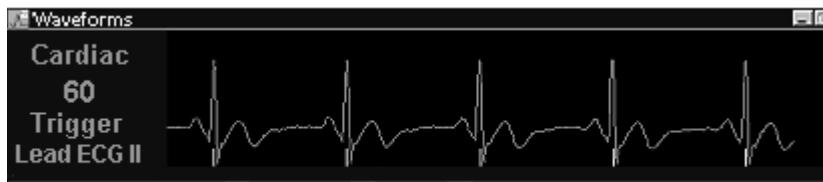


The cardiac waveform, respiratory waveform, and the ECG histogram are displayed when the appropriate toggle button is depressed.

- Cardiac displays the waveform for the selected ECG lead or for Peripheral Gating.
- Respiratory displays the waveform for the respiratory bellows.
- ECG Histogram displays a graph representing the variation in the patient’s heart rate as compared to the expected trigger time.

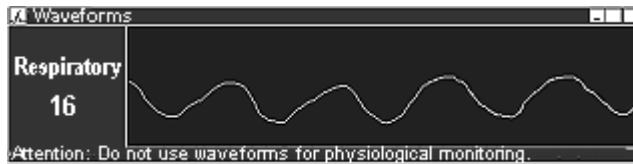
### Cardiac Waveform

When Cardiac is selected, the cardiac waveform is displayed on the PC monitor. A numeric value, displayed in Beats per Minute (bpm), appears to the left of the waveform display. The speed at which the waveform is displayed can be adjusted by defining the Cardiac Sweep Rate.



## Respiratory Waveform

When the Respiratory is selected, the respiratory waveform is displayed on the PC monitor. A numeric value, display in Breaths per Minute (bpm), appears to the left of the waveform display.

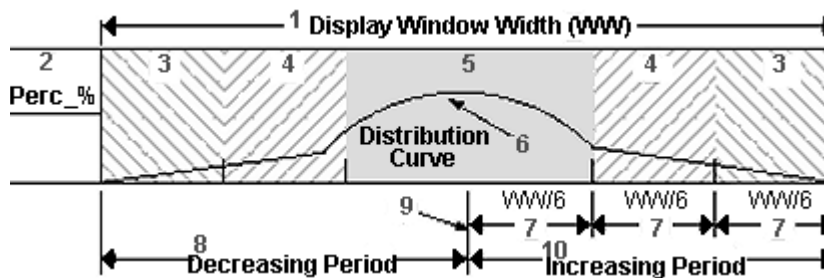


The sweep rate for the respiratory waveform is 5 mm/sec., and this rate cannot be changed.

## ECG Histogram

Select the ECG Histogram to display a graph representing the variation in the patient's heart rate as compared to the expected time of trigger throughout the data acquisition.

This graph is updated, automatically and continually, as the scan progresses. When the scan is over, the graph is frozen.



The table below describes the labels of the graph.

- |    |   |
|----|---|
| 1  | Display Window Width.   |
| 2  | Percent - % - a percentage of normally occurring triggers during acquisition. |
| 3  | Increase/Decrease of 2 - 3 Scan Trigger Windows.                              |
| 4  | Increase/Decrease of 1 - 2 Scan Trigger Windows.                              |
| 5  | Increase/Decrease of 0 - 1 Scan Trigger Windows.                              |
| 6  | Distribution Curve.   |
| 7  | 1/6 of the window width.  |
| 8  | Decreasing Period.  |
| 9  | Heart period used for scan marker at middle of window.                        |
| 10 | Increasing Period.  |

- The center point of the graph is the "heart period" which is a value corresponding to a single, R-R Interval. For example, a scan using 60 bpms has a 1,000 ms R-R Interval, therefore, the center point indicates a heart period of one second.
- The markers on each side of the center point indicate one Trigger Window. For example, with a select bpm of 1,000 ms and a 10% Trigger Window, each of these markers indicates an increase or decrease of 100 ms.
- Values outside the three Trigger Windows are not plotted, but are included in the percentage calculation, a calculation of the triggers that lie within the 0 to 1 Trigger Window range. This is an indication of the percentage of normally occurring triggers during acquisition. The higher the percentage, the better the image quality.
- As the scan progresses, the system plots the heartbeats it detects. Heartbeats occurring within one Trigger Window of the heart period are plotted between the first markers on either side of the center point. Those detected outside of the one Trigger Window time frame are plotted outside the appropriate marker.
- For example, if a heartbeat falls outside the first marker on the left, it may have been detected during acquisition of a slice because the patient's heart rate increased. The effective TR has then changed and can affect image quality.
- If a heartbeat falls outside the first marker on the right, the patient's heart rate probably decreased. This is not as drastic an image quality problem, since no acquisition was taking place at the time. Ideally, the graph is centered over the middle mark, with the "bell" spread evenly on each side within the first Trigger Window markers.

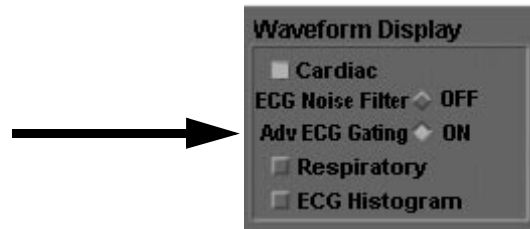
Something to Think About...

- ECG Histogram - When heartbeats fall consistently on one side of the center point, it is a good indication that the heart rate selected during scan prescription was inaccurate.

**Signa Gating Algorithms: Advanced ECG Gating ON and OFF**

A cardiac gating algorithm is a process used by Signa to identify the correct portion of the QRS complex (cardiac waveform) to be used for cardiac gating or triggering. Two algorithms are

available: Advanced ECG Gating ON, and Advanced ECG Gating OFF.

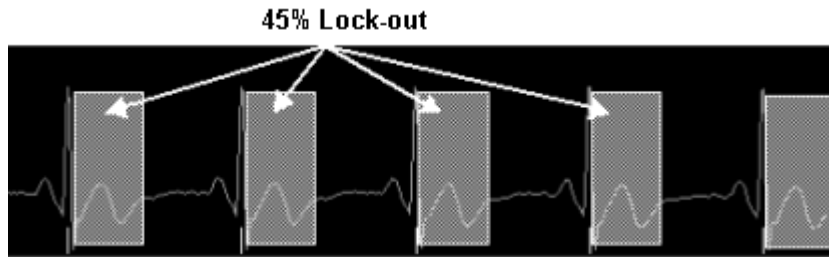


- Advanced ECG Gating ON is the default setting upon entering the Gating Control window. Advanced ECG Gating may improve trigger detection in ECG Gated/Triggered exams.
  - Advanced ECG Gating observes both positive slope and the amplitude to detect which component of the QRS complex is the correct trigger (the R-Wave). Advanced ECG Gating contains a stringent test for matching known slope and amplitude during the first 45% of the waveform after a recognized R-wave. The slope is measured during cardiac initialization. It is critical that the patient remain outside of the magnet, and stay still and quiet during cardiac initialization. This test helps reduce false triggering on T-waves and gradient noise.
  - Advanced ECG Gating may not always be the best choice for a patient with a bigeminy or couplet waveform. Advanced ECG Gating ON could effectively double the heart rate in these patients because Advanced ECG Gating does not employ a "lock-out" window (see Advanced ECG Gating OFF for more information on the lock-out window). For patients with a bigeminy or couplet waveform, it is recommended to turn Advanced ECG Gating off.

**NOTE:** Advanced ECG Gating is not compatible with PG.

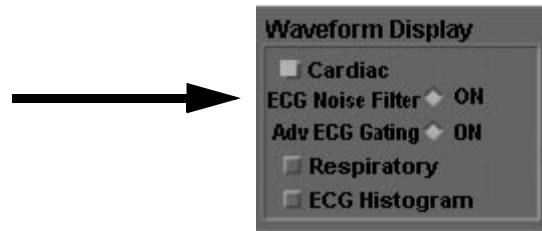
- With Advanced ECG Gating turned off, the system reverts to the standard gating algorithm. The trigger is now detected solely by looking for the peak within the QRS complex that has the greatest, positive amplitude.
  - This mode contains a "lock-out" window of 45% of the R-R Interval. This means after an R-Wave has been detected, Signa does not look for another R-Wave for 45% of the estimated R-R Interval. This gating algorithm

is suitable for patients with a bigeminy or couplet waveform, and patients with significant T-swell.



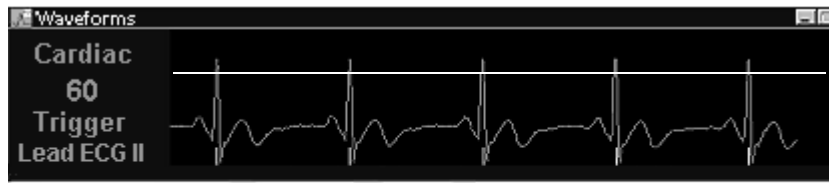
### ECG Noise Filter

The ECG Noise Filter helps reduce the effect of gradient noise on the ECG signal.



Turning on the ECG Noise Filter results in an increase in the minimum Trigger Delay (set at the Combined Cardiac and Respiratory Gating/Triggering Screen). In addition, when the ECG Noise Filter is on and is used in conjunction with Advanced ECG Gating, the Trigger Delay is increased further. There is approximately 18 ms from the time the R-wave is generated and trigger detection.

For these reasons, using the ECG Noise Filter for all cardiac gated exams is not recommended. Use the ECG Noise Filter in instances when the correct trigger is not properly detected. Trigger detection is indicated by the tic marks displayed at the bottom of the ECG waveform.



Watch for these tic marks. Tic marks indicate the trace is triggering.

## Cardiac Sweep Rate

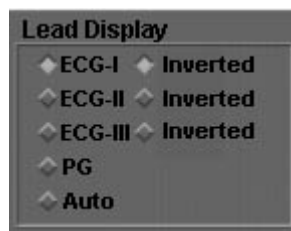
The sweep rate at which the cardiac or peripheral waveform is displayed can be defined. Choose from 10, 21, or 41 mm/sec for the sweep rate. The default is 41 mm/sec.



The sweep rate can be changed at any time, without affecting a scan in progress. This adjusts the cardiac sweep rate only; it does not affect the sweep rate for the respiratory waveform.

## Lead Display

The Lead Display area of the Gating Control window provides selections for ECG and Peripheral waveform display, inversion of the ECG waveform, and changing the selected gating lead during data acquisition.



## ECG Lead Selection

The ECG lead used for waveform display is defined by selecting the toggle button associated with the desired lead: ECG-I, ECG-II, ECG-III, or PG (Peripheral Gating).

When Cardiac is selected at the Waveform Display area, the waveform associated with the selected ECG lead is seen on the waveform display window. The display updates as selections are made and allows you to determine which lead is producing the best signal.

Even though an ECG lead is selected at the Gating Control window, you must define the Trigger Type (lead) at the Combined Cardiac and Respiratory Gating/Triggering Screen during scan set-up. Once this has been done, the lead selection can be changed from either the Gating Control window or the

Combined Cardiac and Respiratory Gating/Triggering Screen. This can be done at any point in the scan set-up process or during data acquisition. When the lead selection is changed, the waveform display updates to reflect the change. **The MOST RECENT ECG lead selection is the lead used for data acquisition.**

Something to Think About...

- **DO NOT rely on Auto for lead selection.** Auto chooses the lead with the strongest signal, but does not necessarily choose the lead with the best waveform. The signal may be strong due to noise.
- Because the lead selection can be changed from both the Gating Control window and the Combined Cardiac and Respiratory Gating/Triggering Screen during series prescription, view the waveforms and verify the lead selection at the Gating Control window after the series has been downloaded.

### ECG Inversion

ECG Inversion is initiated via toggle buttons labeled Inverted, located in the Lead Display area of the Gating Control window. ECG Inversion provides the ability to invert the orientation of the cardiac waveform associated with each selection.

**NOTE:** An alternative method of inverting the waveform is to swap the red (LL) and white (RA) leads.

The following are features of ECG Inversion:

- ECG Inversion can be performed real-time during an ECG Gated exam.
- Any one, or all three, ECG lead waveforms can be inverted.
- It is possible to invert a waveform that has been selected via "Auto" lead selection.
- The functions of Trigger Level and R-peak Amplitude operate in the same fashion whether ECG Inversion is on or off.
- Selecting Gating Reset does not alter the selection of waveform orientation.
- Download of a new series does not alter the selection of waveform orientation.
- Ending an exam does not alter the selection of waveform orientation.

- Performing a TPS Reset or a system reboot turns off all ECG Inversion selections, returning the waveform displays to the non-inverted state.

**NOTE:** If a TPS reset is needed, close the Gating Control window before the reset is initiated.

Applications of ECG Inversion:

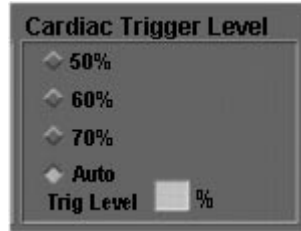
- Not all systems are equipped with the ECG Inversion feature. If the Inverted toggle buttons and labels are not on the Gating Control window, the system is not equipped with the feature.
- Use ECG Inversion if electrodes have been improperly placed on the patient and the resulting waveform is inverted. In this case, the exam can be completed without removing the patient from the magnet and repositioning the ECG leads.
- Use ECG Inversion when electrode placement and/or hemodynamic effects alter the shape of the ECG waveform significantly. In these situations, triggering off of the Q or S portions of the inverted cardiac waveform may allow a study to be completed without removing the patient from the magnet and repositioning the electrodes.
- It is important to remember, in with Advanced ECG Gating turned off, Signa needs to "see" the positive amplitude of the R-wave in order to trigger. With Advanced ECG Gating turned on, Signa needs to "see" the positive slope of the R-wave and the positive amplitude of the R-wave.

## **Cardiac Trigger Level**

Cardiac Trigger Level allows adjustment of the trigger threshold the system uses to "look" for triggers.

The Cardiac Trigger level is expressed as a percent of the QRS complex. The amplitude of the signal must rise above the defined threshold to be detected. The default Trigger Level is

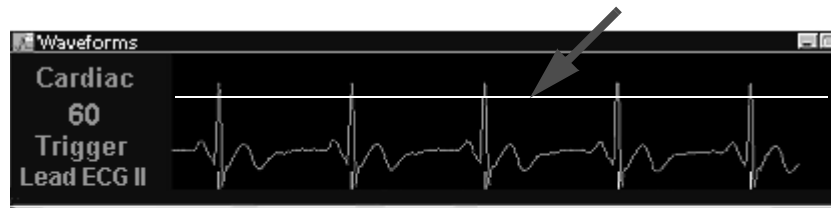
Auto, which set the trigger level to 65% for ECG Gating and 50% for PG.



The Trigger Level can be decreased if the waveform is good but triggers are being missed. Increase the Trigger Level if the system is triggering off of T-waves (or P-waves). The available range is 30% to 90% and the Trigger Level can be changed at any time during scan set-up, prescan, or data acquisition.

To understand the cardiac trigger level, imagine a line running horizontally across the waveform. With the cardiac trigger level set at 50%, that line runs through the center of the display window. Any part of the QRS complex above that line is seen by the system as a potential trigger.

Imaginary Trigger Level line @ 65%

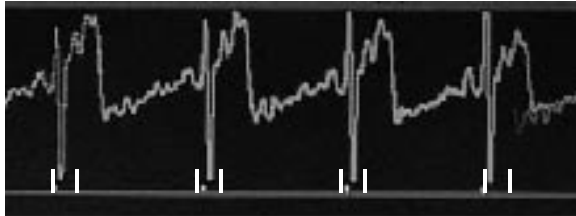


Watch for these tic marks. Tic marks indicate the trace is triggering.

The tic marks at the bottom of the waveform indicate where the system is "seeing" a trigger. Every tic mark is a potential trigger. If tic marks display at the wrong portion of the waveform, adjust the Cardiac Trigger Level. Increasing the trigger level decreases the range in which the system looks for triggers. Decreasing the trigger level increases the range.

It does not matter if it is an R-wave or T-wave or another variation of the patient's ECG waveform. An abnormal wave could be used as a trigger, starting data acquisition at an incorrect point in the cardiac cycle.

The following illustration shows a waveform with tic marks annotating both R-waves and T-waves.



### Tips for Adjusting the Gating Trigger Level in ECG Gating

If triggers are not being detected properly:

- Lower the Trigger Level to 50%.
- Confirm that the tic marks appear on the waveform.
- If no tic marks are seen, reduce the Trigger Level to 45%.

**NOTE:** It is possible to set the Trigger Level to a value that is too low. When this occurs, the system can trigger off T-waves resulting in a heart rate that appears to be double the actual heart rate.

- When Advanced ECG Gating is turned on, defining the Trigger Level sets the sensitivity measurement of R-wave detection. Increase the Trigger Level to reduce false triggers and decrease the trigger level to reduce missed triggers. (Advanced ECG Gating is not available in PG.)
- If too many triggers are detected (e.g., the system is posting triggers under T-waves);
  - Increase the Trigger Level to a value above 65%.
  - Confirm the tic marks are seen only under the desired R-waves.

### Cardiac Trigger Level Annotation

Cardiac Trigger Level Annotation turns on a visual horizontal marker indicating the location of the trigger level in relation to the waveform display.

Cardiac Trigger Level Annotation  OFF

### Audio Trigger Volume

Audio Trigger Volume allows adjustments of the audio signal that indicates trigger detection. Moving the slider to the right increases volume. The range is from 0 (off) to 10.



### Gating Reset and Update R-peak Amplitude

Gating Reset re-initializes the gating sub-system.



Select the **[Gating Reset]** button if:

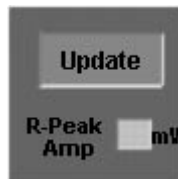
- The waveform is noisy.
- Triggers are being missed.
- The waveform is inverted.
- The system is unable to find valid triggers due to patient activity, such as sudden motion.

**NOTE:** Gating Reset does not correct for problems caused by inadequate lead connections.

Something to Think About...

- When Advanced ECG Gating is on, Gating Reset should be performed with the patient completely outside the bore of the magnet. This eliminates the effects of the magnetic field on the waveform. It is only necessary to do this with Advanced ECG Gating turned on because this mode "looks" at both slope and amplitude of the waveform.
- Gating Reset has no effect during data acquisition. Reset gating before scanning begins.
- Check the ECG signal after advancing the patient to the scanning plane and before beginning data acquisition.

Update R-peak Amplitude provides a measurement of the R-wave peak amplitude. This value is measured in millivolts (mV) and indicates whether the signal is adequate for gating.



Use R-peak Amplitude while prepping the patient to determine if there is sufficient cardiac signal with the current lead selection. The amplitude should also be checked prior to initiating data acquisition.

The recommended minimum amplitude is 1.0 mV. If the amplitude is below 1.0 mV, repeat the patient preparation procedure and/or reposition the electrodes.

In some patients (those with heart failure for example), it may not be possible to obtain an R-peak amplitude at the desired level of 1.0 mV. In these instances, it is important to note that gating success may be severely compromised.

## Combined Cardiac and Respiratory Gating/Triggering Screen

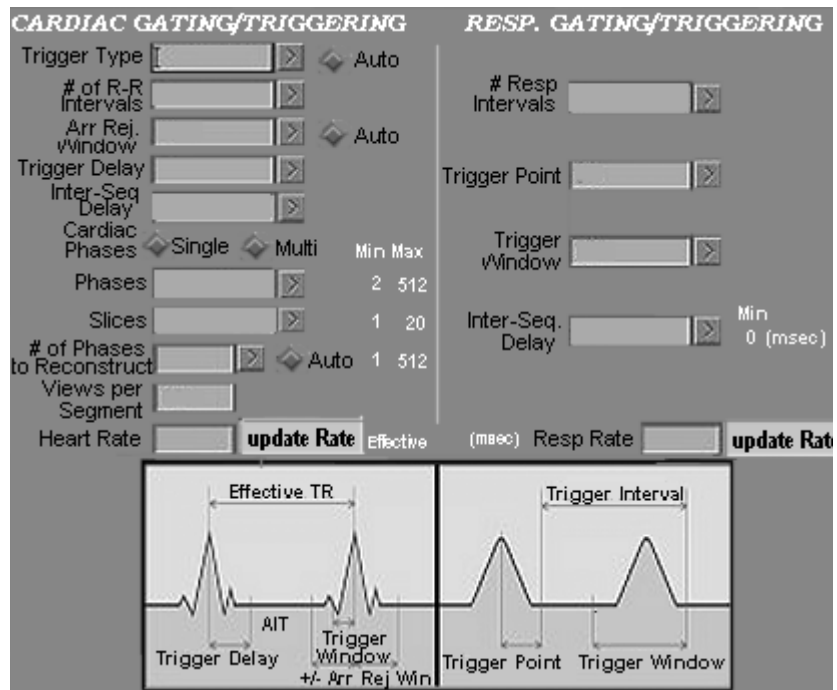
The Combined Cardiac and Respiratory Gating/Triggering Screen is used to enter gating/triggering parameters. This screen is accessed from the Additional Parameters area of the Scan Rx Desktop.

**NOTE:** Parameters for CINE sequences (not FastCINE) are set at the CINE screen, which becomes available when the selected Scan Mode is Cine.

The **Gating/Triggering** icon in the Additional Parameters area becomes available when Cardiac Gating/Triggering or Respiratory Gating/Triggering is selected at the Imaging Options window.



The Combined Cardiac and Respiratory Gating/Triggering Screen appears after selecting the **Gating/Triggering** icon in the Additional Parameters area.



Combined Cardiac and Respiratory Gating/Triggering Screen

## Cardiac Gating/Triggering Parameters

The Combined Cardiac and Respiratory Gating/Triggering Screen is used to control parameters for cardiac gating/triggering.

**CARDIAC GATING/TRIGGERING**

Trigger Type  >  Auto

# of RR Interval  >

Arrhythmia Rejec. Window  >  Auto

Trigger Delay  >

Inter Seq. Delay  >

Cardiac Phases  Single  Multi

Phases  >

Slices  >

# of Card. Phases to Reconstruct  >  Auto

Views per Segment

Heart Rate

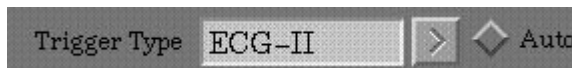
The following table describes the functions of the Cardiac Gating/Triggering window parameters.

Selection	Description
<b>Trigger Type</b>	Defines the gating sensor used on the patient: ECG I, ECG II, and ECG III are the lead selections when electrodes are attached to the patient; PG is available for use with the PG sensor.
<b># of RR Interval</b>	Used to set the effective TR for the sequence. The R-R Interval is set to SE, FSE, FSE with Blood Suppression, and MPGR. The R-R Interval must be 2 x RR for FSE-IR with Blood Suppression.
<b>Trigger Window or Arrhythmia Rejection Window</b>	Defines the size of the Trigger Window or the Arrhythmia Rejection window. Trigger Window for FastCard, Fast 2D PC, FSE, SE, and MPGR sequences. Arrhythmia Rejection Window for FastCINE, 3D FGRE/SPGR, and 3D Fast TOF.
<b>Cardiac Phases Single or Multi</b>	Defines whether single-phase or multiple-phase images are acquired for each slice in cardiac gated SE and FSE acquisitions.
<b>Phases:</b>	In Multi Phase, this defines the number of phases of the cardiac cycle to be acquired at the same slice location.

<b>Slices</b>	In Multi Phase, the number of slice locations to be acquired when Multi is performed. This is automatically entered with the number of slice locations prescribed at the Scanning Range area.
<b># of Card Phases to Reconstruct</b>	Defines the number of cardiac phases to obtain in FastCINE acquisitions. Select the <b>[Auto]</b> button to perform FastCard.
<b>Inter-Seq Delay</b>	Selects the time, in msec., between each slice location or cardiac phase.
<b>Views per Segment</b>	In FastCard and FastCine, the number of K-space lines acquired per cardiac phase during one R-R period.
<b>Heart Rate [update Rate]</b>	Acquires an update of the patient's current heart rate in bpm and displays the value.

**Trigger Type**

Select ECG I, ECG II, or ECG III when cardiac gating with electrodes attached to the patient. PG is for use with the Peripheral Gating Sensor.



- ECG gating is recommended for the most accurate trigger detection for cardiac imaging. With peripheral gating, there is a delay from the actual trigger to when it is detected in the extremity.
  - In ECG Gating/Triggering, observe the waveforms from each lead (ECG I, II, and III). Select the lead that produces the least noise and the highest R-wave.
  - If a lead loses signal during data acquisition, Signa automatically switches to an alternate lead. If ECG II loses signal, Signa switches to ECG III. If ECG III loses signal, Signa switches to ECG II.
- ECG I is a calculated signal based on the average sums from ECG II and III. Therefore, If ECG I is lost, Signa checks II and III to locate a valid signal to continue the sequence. If a valid signal is not found, the sequence aborts.
  - The loss of signal from ECG I is commonly caused by a problem with the LL (red) electrode or the LL lead wire.
- A new lead can be selected from the Gating Control window after the series has been downloaded or during data acquisition. This can be done before data acquisition has started or during data acquisition.
  - An ECG series does not need to be Copy and Pasted to change the lead selection. Once a gated sequence is complete, simply open the Gating Control window and

make the lead change. Selecting Scan again at this point repeats the series with the new lead selection.

- The lead selection can be changed from PG to ECG (and vice versa) after the series download or during data acquisition. If your system is equipped with 8.4 software (or higher), when changing from ECG to PG, the ECG cable does not need to be disconnected at the magnet enclosure.
- **Do not rely on Auto for lead selection.** Auto chooses the lead with the strongest signal. This is not necessarily the best waveform; the signal could be strong as the result of noise. Observe all leads and choose the waveform that results in the most accurate trigger.

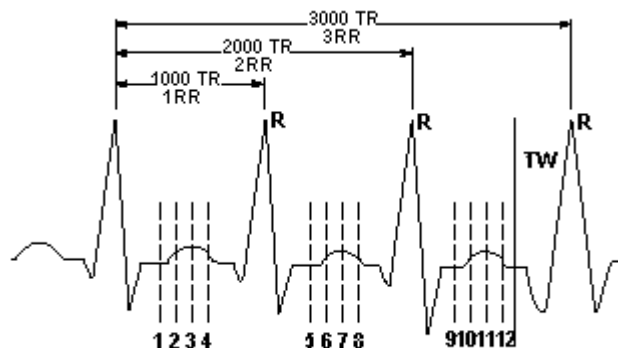
### Number of R-R Interval

The Number of R-R Interval is used to set the effective TR for SE, FSE, FSE with Blood Suppression, and MPGR sequences.



- The time between R-peaks and the R-R Interval together determine the effective TR. The effective TR is determined by  $(60,000 \div \text{Heart Rate})$ .

For example,  $60,000 \div 60 \text{ bpm} = 1000 \text{ ms}$ . The effective TR is 1000 ms when 1 RR is selected, 2000 ms with 2 RR, and so on.



The above illustration shows the R-R Intervals for a heart rate of 60 bpm and the effective TR at 1 RR, 2 RR, and 3 RR. Twelve slice locations are seen, indicating how they might be acquired across three R-R Intervals achieving an effective TR of 3000 ms. The TW is indicated prior to the fourth R-wave.

- Select the number of R-R Interval that yields an effective TR within the appropriate range for the desired contrast. The effective TR is displayed to the right of this text box.
  - The Number of R-R Interval is available for SE, FSE, and Multi-Planar Gradient Echo (MPGR).
  - In FSE with Blood Suppression, 2 x RR is automatically selected. This text box is also used in FGRET-MP, but does not affect the TR in these sequences.
  - Increasing the R-R Interval increases the effective TR, increase SNR, increase scan time, increase PD or T2-weighted contrast, and increase the maximum number of slices per acquisition.
  - The Effective TR is based on the patient's heart rate and you cannot control the actual TR value other than via the number of R-R Interval selection.
  - 2 x RR is required for FSE-IR with Blood Suppression.
  - 1 x RR is generally used for MPGR sequences.

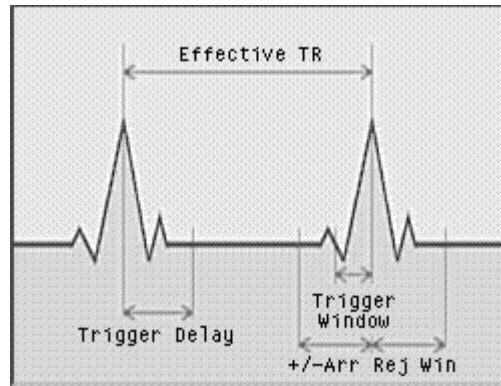
**Trigger Window/Arrhythmia Rejection Window**

The label for this text box varies with the pulse sequence selected. Trigger Window is the selection for Gated SE, FSE, MPGR, FastCard, 2D Fast PC, FGRET, and Spiral sequences. Arrhythmia Rejection Window is seen for FastCINE, Gated 3D Fast GRE/SPGR, and 3D Fast TOF.

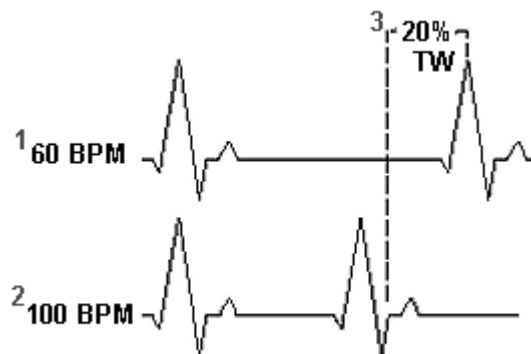
- **Trigger Window**

When the pulse sequence is SE, FSE, MPGR, FastCard, or 2D Fast PC, this selection is labeled Trigger Window. In a FastCard sequence, the text box is not available until Perform Arrhythmia Rejection is turned on at the User CV screen. For details on the use of Arrhythmia rejection with FastCard, see the section titled "Perform Arrhythmia Rejection."





- The TW instructs the system when to stop acquiring data and to begin "looking" for the next R-wave trigger. The window includes a period of time, set as a percentage of the R-R interval, before the expected trigger.
- Define the TW based on the regularity of the heart rhythm. Larger values are generally used as the heart rate becomes more irregular.



A patient with a 60 bpm heart rate (1) and a 20% Trigger Window (3) defined. The heart rate increases to 100 bpm (2) and the next trigger occurs before the Trigger Window. A trigger is missed and it is possible that data acquisition was taking place when that trigger (R-wave) occurred.

- When a trigger occurs too soon due to an increase in the heart rate, image data is not collected as expected following the missed trigger. Scan time extends in order to obtain the missed image data.
- Should a trigger occur before the TW, data acquisition may still be taking place. In this instance, data is being acquired at an unexpected point in the cardiac cycle resulting in a decrease in image quality.
- A TW from 0 to 50 is allowed.

- Auto allows the system to determine the TW value. The system determines the TW based on the imaging options selected. It is recommended that Auto be selected then add 5% to the Auto TW value. This seems to provide an optimal TW for most patients.
- For most patients, an 18 to 20% TW removes much of the risk of missed triggers.
- Patients with greatly fluctuating heart rates may require a TW of 30 to 40%.
- As the TW increases, the maximum number of slices allowed decreases (because the AIT decreases), but the probability of missing an R-wave decreases. The AIT is the time frame within the cardiac cycle in which the system is able to collect image data.
- FastCard and Fast 2D PC sequences can be performed with or without a TW. See "Perform Arrhythmia Rejection" below for details.

- **Perform Arrhythmia Rejection and FastCard**

- Arrhythmia Rejection can be turned on or off at the User CV screen when FastCard GRE/SPGR or Fast 2D PC is the selected pulse sequence. The User CV screen is accessed in the Additional Parameters area of the Scan Rx Desktop. Arrhythmia Rejection is turned off by default. When Arrhythmia Rejection is turned on, the trigger window text box at the Combined Cardiac and Respiratory Gating/Triggering Screen becomes available.
- When Arrhythmia Rejection is performed, a trigger detected prior to the TW stops data collection until a trigger is detected as expected.

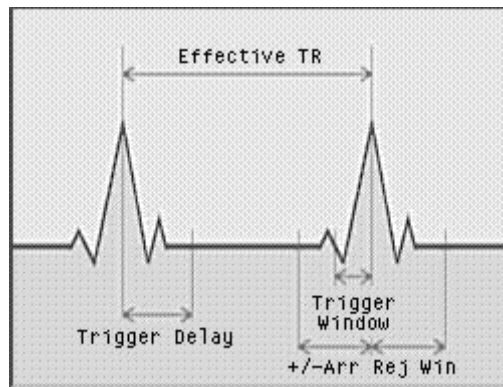
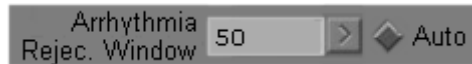
**NOTE:** The RF application continues to maintain uniform TR application and image contrast.

- With Arrhythmia Rejection turned on, if more than four arrhythmias occur in a scan less than 25 seconds long, the scan aborts. For scan times longer than 25 seconds, up to ten arrhythmia are allowed. Should a scan abort due to the occurrence of too many arrhythmia, a message is posted.
- Arrhythmia Rejection cannot be turned on when either one VPS or one cardiac phase to reconstruct is set at the Card/Resp screen.

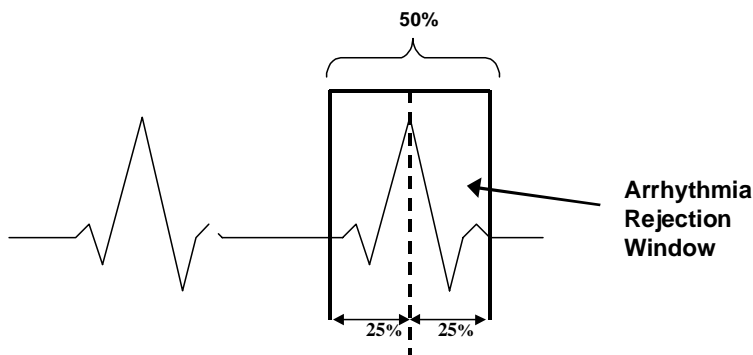
- **Arrhythmia Rejection Window**

An Arrhythmia, as interpreted by the system, is a trigger detected outside the Arrhythmia Rejection Window (ARW)

when data acquisition is active. The ARW is a percentage of the R-R Interval, in which image data is discarded if a trigger is detected. The ARW includes a window of time before and after the expected trigger.



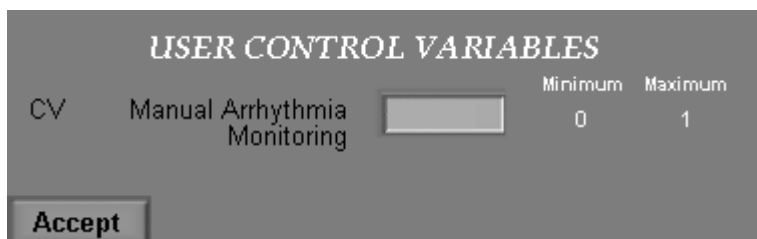
- The size of the window is defined as a percentage of the R-R Interval, outside of which the system rejects data if a trigger is detected.



- Typically, the ARW is double the TW value for the same patient. This is because the ARW takes place before and after the expected trigger, while the TW is a period of time after the expected trigger.
- Widening the window is recommended for patients with irregular heart rates. If too many rejections occur, the acquisition aborts (when Manual Arrhythmia Monitoring is off.) See the section "Manual Arrhythmia Monitoring" for more details.
- **Manual Arrhythmia Monitoring**
  - The FastCINE and FastCINE-PC User CV screen provides the ability to turn off arrhythmia monitoring

for these sequences. This can be useful when scanning patients with erratic heart rates.

- The FastCINE and FastCINE-PC sequences automatically monitor the occurrence of triggers (R-waves) during data acquisition. If too many triggers are detected outside of the Arrhythmia Rejection Window, the scan aborts. Up to 8 Arrhythmia (triggers outside the window) are allowed for scans shorter than 25 seconds, and up to 20 are allowed for scans longer than 25 seconds. You have the option to turn off this automatic monitoring to avoid scan aborts. This is done at the CV screen.

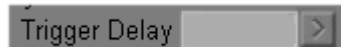


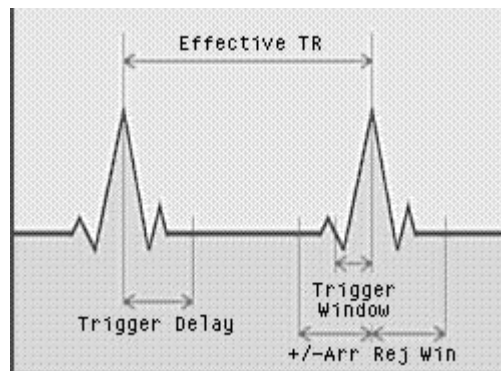
- Leave this value at the default, "0," to allow the system to automatically monitor arrhythmia. Enter "1" to enable Manual Arrhythmia Monitoring. When Manual Arrhythmia Monitoring is enabled, monitor the occurrence of arrhythmia yourself (or manually).
- Manual Arrhythmia Monitoring prevents a scan from aborting. It does not turn off Arrhythmia Rejection. Therefore, if triggers are detected outside the rejection window, the data obtained during that cycle is discarded and must be obtained again. This increases scan time.

**NOTE:** Scans may abort if too much time elapses between successive R-waves even when Manual Arrhythmia Monitoring is on. This can occur in patients with extremely erratic heart rates.

### Trigger Delay

Trigger Delay (TD) determines the delay time from detection of the R-wave (the trigger) to the start of data acquisition.

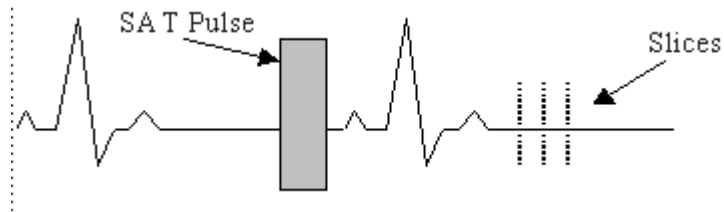




- The **Minimum** selection sets the minimum possible delay of 13 to 15 ms. The minimum is the absolute minimum which is required by the system to detect the trigger and initiate data acquisition.
- The **Recommended** selection sets the recommended delay as calculated by the system based on the imaging options and sets the delay for the best image quality.
- The **Trigger Delay** text box can be used to manually enter a delay time longer than minimum.

#### Something to Think About...

- The TD can be used to image at a particular moment in the cardiac cycle. For example, set the delay to obtain images during the diastolic portion of the cardiac cycle.
- Increasing the TD results in a reduction of the AIT and a decrease in the number of slices allowed. The AIT is the time frame within the cardiac cycle in which the system is able to collect image data.
- As the TD increases, image data is not collected during the early portion of the cardiac cycle.
- The combination of minimum trigger delay and SAT can create a band of small hash marks in the image. These hash marks follow the phase direction and increase in intensity as the TD is increased.
- Using the recommended trigger delay, when SAT pulses are used, (including Fat and Water SAT), places the temporal pre-saturation pulse closer to the excitation pulse making the SAT pulse more effective. The excitation pulse occurs after the trigger is detected.



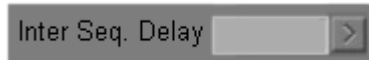
Select Minimum and the SAT pulse is applied before the expected trigger.



Select Recommended and the SAT pulse is applied following the trigger. SAT is more effective.

**Inter-Sequence Delay**

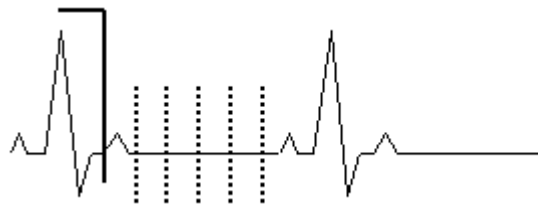
Inter-Sequence Delay (ISD) sets the time, in milliseconds, between each slice location or cardiac phase.



The **Minimum** selection sets the minimum possible delay between slices.



- The **Even Spacing** selection calculates the delay required to evenly space slices within the AIT.



- The ISD text box can also be used to manually enter any value larger than the minimum.
- The ISD affects the number of slices that can be acquired. As the ISD increases, the AIT decreases and the number of slices allowed decreases.

### Available Imaging Time

The Available Imaging Time (AIT) is the time frame in which data acquisition can take place. The AIT affects the maximum number of slices that can be acquired.

- The AIT is not selected directly, but is affected by the R-R Interval, TW or ARW, and TD.

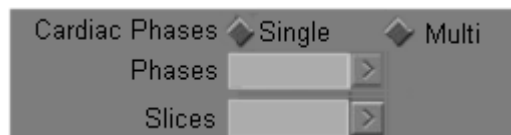
$$\text{AIT} = (\text{R-R Interval} - \text{TW}) - \text{TD}$$

- The AIT and the Minimum ISD determine the maximum number of slices allowed.

$$\# \text{ of Slices} = \frac{\text{AIT}}{\text{MinInterSeqDelay}}$$

### Cardiac Phases

Cardiac Phases determines if slice locations are acquired at one or more phases of the cardiac cycle. The cardiac phases buttons are available when the pulse sequence is SE and MPGR. Either Single or Multi can be selected. Only Single is available is FSE sequences.

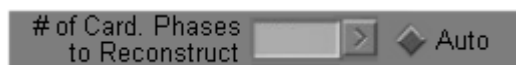


- **Single** allows acquisition of several slice locations. Each slice is acquired at a unique phase of the cardiac cycle and each slice is acquired at only that phase.
- **Multi** acquires one or more slice locations with each slice represented by multiple phases of the cardiac cycle.
- If slice locations have been prescribed at the Scanning Range area, Multi is available for SE and MPGR sequences when 1 x RR is selected at the **# of R-R Interval** text box. Once Multi is toggled on, the Phases text box is available.
  - The **Phases** text box sets the number of cardiac phases to be acquired at each slice location.
  - The maximum number of phases depends on the patient's heart rate and the number of slices prescribed.

- Once the phases have been defined, the **Slices** text box is automatically filled with the number of slices prescribed at the Scanning Range area. This number cannot be changed.
- The number of phases divided by the number of slices must equal 1, 2, or 3. A message posts if the phases entered are incorrect.
- Multi is not allowed with FSE sequences.

### Number of Cardiac Phases to Reconstruct

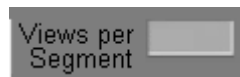
This text box is available for FastCard and FastCINE sequences. A numerical value here enables a FastCINE sequence, while selecting Auto results in a FastCard sequence.



- When FastCard-SPGR (or FastCard-GRE) is selected, upon opening the Card/Resp screen, a numerical value is seen in the **# of Card. Phases to Reconstruct** text box. If this text box is left at the default value, or another numerical value is entered, the sequence is a FastCINE sequence. In FastCINE sequences, the maximum number of phases is shown to the columns to the right of the text box.
- To perform a FastCard sequence, choose FastCard-SPGR (or FastCard-GRE) and click **Auto** at the Card/Resp screen. The maximum number of phases is calculated and obtained automatically.
- The maximum number of phases is affected by the VPS.

### Views Per Segment

Views per Segment (VPS) is the number of K-space lines acquired per cardiac phase during one R-R period.



**NOTE:** This parameter is available when FastCard, Fast 2D PC, and FastCINE sequences are selected.

- A view is a discrete step in the phase encoding gradient. SE sequences collect one view per slice per TR period. FSE collects many views per TR period based on the ETL. FastCard (and FastCINE and 2D PC) collect multiple views per TR.

- The multiple views are then grouped, or segmented. These segmented views contribute to create one phase image. A phase image is a temporal look at a slice, i.e., a look at that slice at some point in time.
  - In Brief:
    - Multiple views are collected per TR.
    - Multiple views are defined to per segment.
    - One segment is used to create one phase image.
    - The number of segments is not defined, but is a function of the R-R Interval and the value set for the VPS.
  - With this in mind:
    - Decreasing VPS improves temporal resolution. As the VPS decreases, there are a smaller number of views contributing to an image.
    - Increasing VPS decreases the overall scan time because the required number of views needed to fill K-space is increased per TR, filling K-space more quickly.
    - Increasing the VPS reduces the number of cardiac phase images allowed. This is because acquisition time is used to collect views rather than cardiac phases. The trade-off is temporal resolution for speed.

The following chart can be used as a guide for setting the VPS in order to obtain optimal temporal resolution and image quality based on the patient's heart rate.

<b><i>Heart Rate (bpm)</i></b>	<b><i>Views Per Segment (VPS)</i></b>
≤ 60	8
61 - 95	6
96 - 125	4
126 - 155	2
> 156	1

### Heart Rate/Update Rate

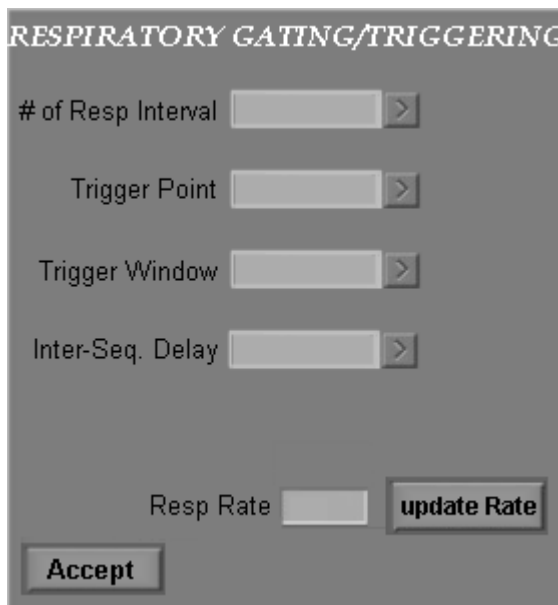
Heart Rate/Update Rate acquires and displays the current heart rate. The heart rate is displayed in bpm.



- If appropriate to the pulse sequence, the Effective TR is displayed. The effective TR is based on the heart rate and the number of R-R Intervals defined.
- Update the heart rate before beginning the data acquisition to insure accurate triggering.

### Respiratory Gating and Triggering Parameters

The Combined Cardiac and Respiratory Gating/Triggering Screen is used to control parameters for respiratory gating/triggering

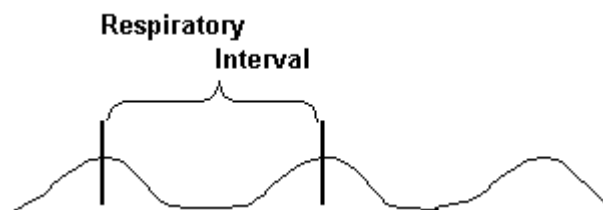


The following table describes the selections available on the Respiratory Gating/Triggering Screen.

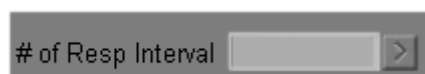
<b><u>Selection</u></b>	<b><u>Description</u></b>
<b># of Resp Interval</b>	Selects the desired pulse sequence repetition time. Specified in multiples of the respiratory rate. The effective TR is displayed to the right of this text box and is based on the number of respiratory interval selected.
<b>Trigger Point (%)</b>	Selects the point in the respiratory cycle at which scanning begins. Specified as a percentage of the respiratory cycle.
<b>Trigger Window</b>	The period in the respiratory cycle reserved for trigger detection. During this period, the system waits for the next maximum inspiration peak, which initiates a new sequence of data acquisition. Increasing the TW decreases the number of slices that may be prescribed.
<b>Inter-Seq Delay</b>	Specified in milliseconds: -[Minimum] sets the minimum Inter Seq Delay as specified by the PSD. -[Even Spacing] specifies an even spacing delay value. -[Other] allows the user to type in an Inter-Seq Delay value.
<b>Resp Rate [update Rate]</b>	Acquires an update of the patient's current respiratory rate in breaths per minute and display the value.

### Number of Respiratory Intervals

A respiratory interval is defined as the time from maximum inspiration to the next maximum inspiration. This is known as one respiratory cycle.



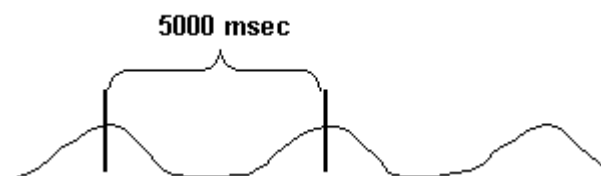
- The Number of Respiratory Intervals selects the pulse sequence repetition time, or Effective TR.



- This value is specified in multiples of the respiratory rate. For example: 1 RR, 2 RR, 3 RR.

- The effective TR is displayed to the right of this text box and is based on the number of Respiratory Intervals selected.

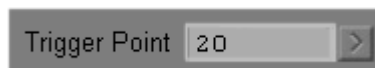
For example, if one respiratory cycle occurs every 5,000 milliseconds, the Effective TR for 1 RR is 5,000 milliseconds. To increase the Effective TR and the number of slices, select a multiple of the respiratory cycle (Resp x 2, Resp x 3, etc.) at the **# of Resp Intervals** text box.



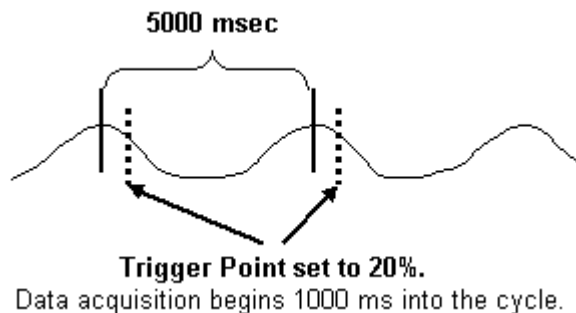
- To determine the time span from peak to peak, divide 60,000 by the respiratory rate (in Breaths per Minute).
- The number of respiratory intervals is available with FSE sequences.

### Trigger Point

The Trigger Point (TP) is the point in the respiratory cycle at which imaging begins. The goal is to set the TP (along with the TW) so that the imaging window occurs at the quiescent portion of the cycle.



For example, if the respiratory cycle is 5,000 ms from maximum inspiration to the next maximum inspiration, and a TP of 20% is selected, the data collection begins 1,000 ms after maximum inspiration occurs.



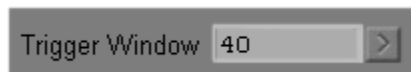
- TP is set as a percentage of the respiratory cycle.
- The TP does not have to be set at peak inspiration, but can be set at any point in the respiratory cycle.

- The TP does not affect available imaging time. It is simply the point at which data acquisition is to begin.
- A range of 10% to 50% is allowed.

**NOTE:** For details on determining the TP, see "Setting the Trigger Point and Trigger Window."

### Trigger Window

Trigger Window (TW) is the period from the end of the data acquisition window to the beginning of the next data acquisition window, or the TP. The TW is the time set aside to stop data collection and allow for variations in the breathing pattern before the next trigger point occurs.



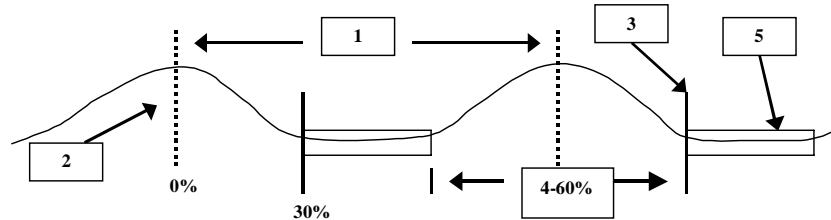
- TW is simply the time the system stops imaging to "look for" the next maximum inspiration point to start the next cycle.
- The TW is set as a percentage of the respiratory cycle.
- TW should be greater or equal to TP.
- Increasing the TW decreases the number of locations allowed because the available imaging time decreases.
- If the respiratory cycle shortens, images might be acquired in the TW. If the respiratory cycle shortens by more than the TW, the next respiratory TP could be missed.
- A range of 10% to 50% is allowed.

**NOTE:** For details on determining the TW, see "Setting the Trigger Point and Trigger Window."

### Setting the Trigger Point and Trigger Window

The following diagram is an example for determining the data acquisition window in respiratory gating/triggering. The TP and TW determine the location of the data acquisition window.

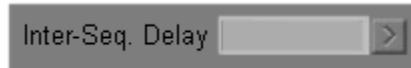
Typically, the goal is to set the TP and TW so that the imaging window occurs at the quiescent portion of the cycle.



- 1 The entire respiratory cycle takes place from peak inspiration to peak inspiration. This time period is considered 100%.
  - 2 Peak inspiration, the beginning of the cycle, is 0%.
  - 3 The Trigger Point, defined by you, tells the system when data acquisition should begin and is expressed as a percentage of the total respiratory cycle. In this example, when 30% of the cycle completes, data acquisition begins.
  - 4 The Trigger Window, defined by you, tells the system at which point in the respiratory cycle data acquisition should not take place. This value is calculated based on the TP and the point in the cycle data acquisition is to stop. See the following explanation for determining the size of the TW.
  - 5 The data acquisition window is the time period when image data is collected.
- To determine the TW in the above illustration:
    - Determine the point in the cycle at which data acquisition is to begin. This is the TP.
    - Determine the point at which data acquisition is to stop. In this example, it is at approximately 70%.
    - Subtract, 100% - 70%. This is the total cycle minus the end point of the data acquisition window; 30%.
    - Add that 30% to the non-acquisition time of the next cycle. In other words, add the TP value of 30%. This combines the non-acquisition time from the end of the first cycle and the beginning of the next cycle. The result is a total TW time of 60%; 30% + 30%. Enter this value as the TW.
  - Although the data acquisition window is generally at the quiescent point of the cycle, it is possible to set the TW and TP to place the data acquisition window at any point in the cycle, such as peak inspiration. To obtain this in the above diagram, the TP would be set at 90% and the TW at 80%.

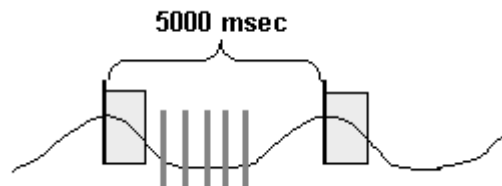
### Inter-Sequence Delay

Inter Sequence Delay (ISD) determines how image acquisition is spread across the available imaging time.

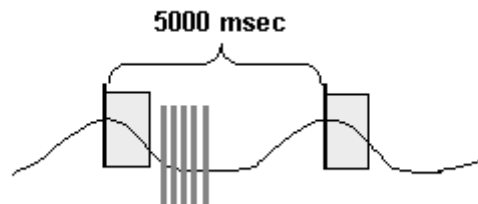


The ISD defines the time in milliseconds between each slice location in the respiratory cycle.

- **Even** spacing spreads slice acquisition time evenly across the available imaging time.



- **Minimum** spacing images as quickly as possible within the available imaging time.



- Type in the ISD value if minimum or even spacing is not desired. The type-in value must be larger than the minimum spacing value.

### Available Imaging Time

Available Imaging Time (AIT) determines the maximum number of slice locations allowed. AIT is not selected directly, but is affected by the respiratory interval and TW.

The AIT acquisition window is generally placed at the quiescent portion of the respiratory cycle to reduce phase ghosting.

## Combined Cardiac and Respiratory Gating/Triggering

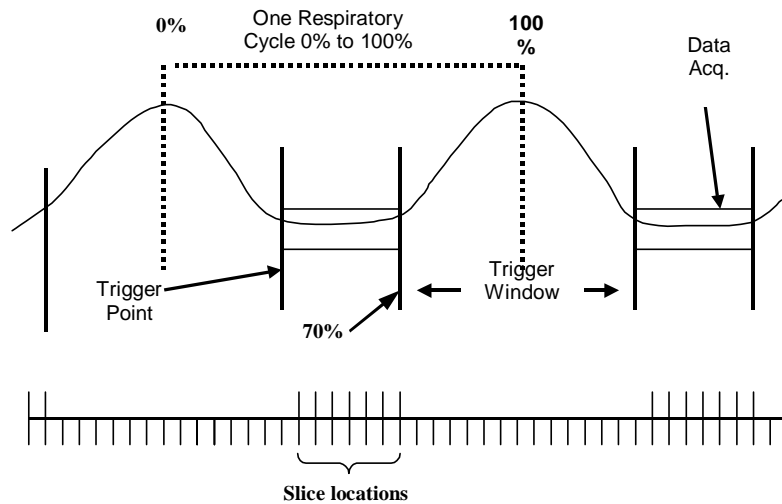
Some sequences are better acquired utilizing a breath-hold technique, such as in cardiac imaging. Breath-held acquisitions eliminate artifacts caused by respiratory motion. However, there may be patients who cannot hold their breath. In these cases, respiratory gating/triggering is recommended.

When needed, respiratory gating/triggering can be performed simultaneously with cardiac gating/triggering. The following pulse sequences allow the use of combined cardiac and respiratory gating/triggering: in 3D Fast GRE, FastCard, and FastCINE sequences.

Both cardiac and respiratory parameters must be entered at the Combined Cardiac and Respiratory Gating/Triggering Screen. Respiratory gating is performed, while triggering is the cardiac process used.

Respiratory parameters defined are TP and TW. These parameters determine the data acquisition window. When the system determines the data acquisition window has been reached (based on the respiratory cycle), data is collected in the same fashion as a cardiac gated sequence.

If a valid ECG trigger is detected within the respiratory data acquisition window, scanning begins. When the end of the data acquisition window is reached, scanning stops. Note that RF application is continuous, being applied at the TR time throughout the entire respiratory cycle, even when the data acquisition window is closed.



In the illustration above, the data acquisition window opens at 30%, the TP. If a cardiac trigger is detected within the data acquisition window, scanning begins. In this example, seven slice locations are acquired before the end of the data acquisition is reached at the start of the T W, 70%. When the data acquisition closes, scanning stops until the next TP is reached and the acquisition window opens again.

#### Something to Think About...

- Scanning is only started if a valid ECG trigger is detected during the respiratory data acquisition window.
- Both ECG and PG can be used.
- The scan terminates if a respiratory cycle is not lost and cannot be detected within 10 seconds. This prevents the sequence from being caught in continuous loop "looking" for the correct conditions to begin data acquisition.
- In Cardiac Gated/Triggered 3D sequences, Loop Order can be defined at the User CV screen. Loop order tells the system to run in either a normal or reverse loop order: "0" for Reverse Loop Order OFF, which is the default for 3D sequences; "1" for Reverse Loop Order ON.

The loop order defines how the phase and slice encoding views are applied, thereby affecting the data acquisition time window. As the data acquisition time window shortens, images exhibit decreased blurring from motion such as cardiac motion.

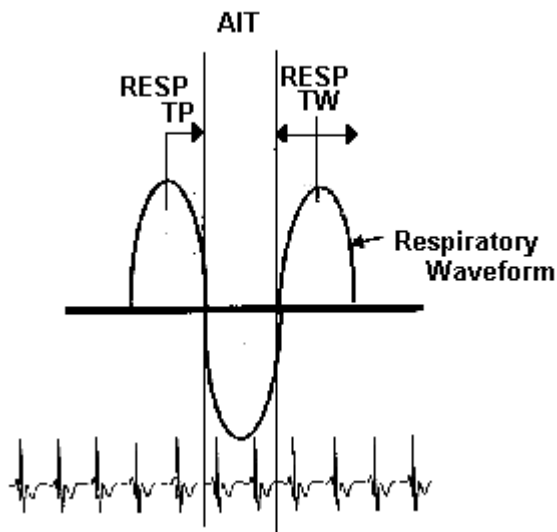
Although Reverse Loop Order OFF (the default) provides the shortest data acquisition time window (and less image blurring

due to motion), when Reverse Loop Order is off, it is difficult to obtain scan times for breath-hold sequences. To perform breath-hold sequences, considering turning Reverse Loop Order ON, "1." Alternatively, use combined cardiac and respiratory gating/trigging with Reverse Loop OFF.

### Combined Cardiac and Respiratory Gating/Triggering Guide

The following charts can be used to determine possible TP and TW values to be used for combined cardiac and respiratory gating/trigging in FastCard and FastCINE sequences. Three charts are provided, one each for obtaining image data within 2, 2.5, or 3 R-R Intervals of the cardiac cycle. Increasing the number of R-R Intervals acquired in the data acquisition window decreases scan time but is likely to degrade image quality.

The following illustration is provided to help your understanding of what is taking place when using combined cardiac and respiratory gating/trigging in a FastCINE sequence.



In the waveform above, the TP and TW are set to capture 2.5 R-Rs in each available AIT of the respiratory cycle.

The objective of the following charts is to help you prescribe the correct respiratory TP and TW in order to obtain image data at the most quiescent period of the respiratory cycle.

Each chart is labeled with the approximate number of R-R Intervals to be included in the AIT of the respiratory cycle. This is shown as  $N = 2$ ,  $N = 2.5$ , and  $N = 3$ . The Heart Rate values run horizontally, and the Respiratory Rate runs vertically. Find the intersection of the patient's heart rate and respiratory rate on the desired chart. The percent value shown at that intersection is entered as the Respiratory TP on the Combined Cardiac and Respiratory Gating/Triggering Screen. Multiply the TP value times two to obtain the Respiratory TW.

**N = 2.0 Trigger Point Table**

**NOTE:** Trigger Window = Trigger Point x 2

<b><u>Heart</u> Rate</b>	<b><u>40</u></b>	<b><u>45</u></b>	<b><u>50</u></b>	<b><u>55</u></b>	<b><u>60</u></b>	<b><u>65</u></b>	<b><u>70</u></b>	<b><u>75</u></b>	<b><u>80</u></b>	<b><u>85</u></b>	<b><u>90</u></b>	<b><u>95</u></b>
<b>Resp Rate</b>												
<b>10</b>	25%	28%	30%	32%	33%	35%	36%	37%	38%	38%	39%	39%
<b>11</b>	23%	26%	28%	30%	32%	33%	34%	35%	36%	37%	38%	38%
<b>12</b>	20%	23%	26%	28%	30%	32%	33%	34%	35%	36%	37%	37%
<b>13</b>	18%	21%	24%	26%	28%	30%	31%	33%	34%	35%	36%	36%
<b>14</b>	15%	19%	22%	25%	27%	28%	30%	31%	33%	34%	34%	35%
<b>15</b>	13%	17%	20%	23%	25%	27%	29%	30%	31%	32%	33%	34%
<b>16</b>	10%	14%	18%	21%	23%	25%	27%	29%	30%	31%	32%	33%
<b>17</b>	8%	12%	16%	19%	22%	24%	26%	27%	29%	30%	31%	32%
<b>18</b>	5%	10%	14%	17%	20%	22%	24%	26%	28%	29%	30%	30%
<b>19</b>	3%	8%	12%	15%	18%	21%	23%	25%	26%	28%	29%	30%
<b>20</b>	0	6%	10%	14%	17%	19%	21%	23%	25%	26%	28%	29%
<b>21</b>	0	3%	8%	12%	15%	18%	20%	22%	24%	25%	27%	28%
<b>22</b>	0	1%	6%	10%	13%	16%	19%	21%	23%	24%	26%	27%
<b>23</b>	0	0	4%	8%	12%	15%	17%	19%	21%	23%	24%	26%
<b>24</b>	0	0	2%	6%	10%	13%	16%	18%	20%	22%	23%	25%
<b>25</b>	0	0	0	5%	8%	12%	14%	17%	19%	21%	22%	24%

**This table is continued on the next page.**

**N = 2.0 Trigger Point Table (continued)**

NOTE: Trigger Window = Trigger Point x 2

<b><i>Heart Rate</i></b>	<b><i>100</i></b>	<b><i>105</i></b>	<b><i>110</i></b>	<b><i>115</i></b>	<b><i>120</i></b>	<b><i>125</i></b>	<b><i>130</i></b>	<b><i>135</i></b>	<b><i>140</i></b>	<b><i>145</i></b>	<b><i>150</i></b>
<b>Resp Rate</b>											
<b>10</b>	40%	40%	41%	41%	41%	42%	42%	43%	43%	43%	43%
<b>11</b>	39%	40%	40%	40%	42%	41%	42%	42%	42%	42%	43%
<b>12</b>	38%	39%	39%	40%	41%	40%	41%	41%	41%	42%	42%
<b>13</b>	37%	38%	38%	39%	40%	40%	40%	40%	41%	41%	41%
<b>14</b>	36%	37%	37%	38%	39%	39%	39%	40%	40%	40%	41%
<b>15</b>	35%	36%	36%	37%	38%	38%	38%	39%	39%	40%	40%
<b>16</b>	34%	35%	35%	36%	37%	37%	38%	38%	39%	39%	39%
<b>17</b>	33%	34%	35%	35%	36%	36%	37%	37%	38%	38%	39%
<b>18</b>	32%	33%	34%	34%	35%	36%	36%	37%	37%	38%	38%
<b>19</b>	31%	32%	33%	33%	34%	35%	35%	36%	36%	37%	37%
<b>20</b>	30%	31%	32%	33%	33%	34%	35%	35%	36%	36%	37%
<b>21</b>	29%	30%	31%	32%	33%	33%	34%	34%	35%	36%	36%
<b>22</b>	28%	29%	30%	31%	32%	32%	33%	34%	34%	35%	35%
<b>23</b>	27%	28%	29%	30%	31%	32%	32%	33%	34%	34%	35%
<b>24</b>	26%	27%	28%	29%	30%	31%	32%	32%	33%	33%	34%
<b>25</b>	25%	26%	27%	28%	29%	30%	31%	31%	32%	33%	33%

**N = 2.5 Trigger Point Table**

**NOTE:** Trigger Window = Trigger Point x 2

<b>Heart Rate</b>	<b>40</b>	<b>45</b>	<b>50</b>	<b>55</b>	<b>60</b>	<b>65</b>	<b>70</b>	<b>75</b>	<b>80</b>	<b>85</b>	<b>90</b>	<b>95</b>
<b>Resp Rate</b>												
<b>10</b>	19%	22%	25%	27%	29%	31%	32%	33%	34%	35%	36%	37%
<b>11</b>	16%	19%	23%	25%	27%	29%	30%	32%	33%	34%	35%	36%
<b>12</b>	13%	17%	20%	23%	25%	27%	29%	30%	31%	32%	33%	34%
<b>13</b>	9%	14%	18%	20%	23%	25%	27%	28%	30%	31%	32%	33%
<b>14</b>	6%	11%	15%	18%	21%	23%	25%	27%	28%	29%	31%	32%
<b>15</b>	3%	8%	13%	16%	19%	21%	23%	25%	27%	28%	29%	30%
<b>16</b>	0	6%	10%	14%	17%	19%	21%	23%	25%	26%	28%	29%
<b>17</b>	0	3%	8%	11%	15%	17%	20%	22%	23%	25%	26%	28%
<b>18</b>	0	0	5%	9%	13%	15%	18%	20%	22%	24%	25%	26%
<b>19</b>	0	0	3%	7%	10%	13%	16%	18%	20%	22%	24%	25%
<b>20</b>	0	0	0	5%	8%	12%	14%	17%	19%	21%	22%	24%
<b>21</b>	0	0	0	2%	6%	10%	13%	15%	17%	19%	21%	22%
<b>22</b>	0	0	0	0	4%	8%	11%	13%	16%	18%	19%	21%
<b>23</b>	0	0	0	0	2%	6%	9%	12%	14%	16%	18%	20%
<b>24</b>	0	0	0	0	4%	7%	10%	13%	15%	17%	18%	20%
<b>25</b>	0	0	0	0	0	2%	5%	8%	11%	13%	15%	17%

**This table is continued on the next page.**

**N = 2.5 Trigger Point Table (continued)**

NOTE: Trigger Window = Trigger Point x 2

<b><i>Heart Rate</i></b>	<b><i>100</i></b>	<b><i>105</i></b>	<b><i>110</i></b>	<b><i>115</i></b>	<b><i>120</i></b>	<b><i>125</i></b>	<b><i>130</i></b>	<b><i>135</i></b>	<b><i>140</i></b>	<b><i>145</i></b>	<b><i>150</i></b>
<b>Resp Rate</b>											
<b>10</b>	38%	38%	39%	39%	40%	40%	40%	41%	41%	41%	42%
<b>11</b>	36%	37%	38%	38%	39%	39%	39%	40%	40%	41%	41%
<b>12</b>	35%	36%	36%	37%	38%	38%	38%	39%	39%	40%	40%
<b>13</b>	34%	35%	35%	36%	36%	37%	38%	38%	38%	39%	39%
<b>14</b>	33%	33%	34%	35%	35%	36%	37%	3%	38%	38%	38%
<b>15</b>	31%	32%	33%	34%	34%	35%	36%	36%	37%	37%	38%
<b>16</b>	30%	31%	32%	33%	33%	34%	35%	35%	36%	36%	37%
<b>17</b>	29%	30%	31%	32%	32%	33%	34%	34%	35%	35%	36%
<b>18</b>	28%	29%	30%	30%	31%	32%	33%	33%	34%	34%	35%
<b>19</b>	26%	27%	28%	29%	30%	31%	32%	32%	33%	34%	34%
<b>20</b>	25%	26%	27%	28%	29%	30%	31%	31%	32%	33%	33%
<b>21</b>	24%	25%	26%	27%	28%	29%	30%	31%	31%	32%	33%
<b>22</b>	23%	24%	25%	26%	27%	28%	29%	30%	30%	31%	32%
<b>23</b>	21%	23%	24%	25%	26%	27%	28%	29%	29%	30%	31%
<b>24</b>	20%	21%	23%	24%	25%	26%	27%	28%	29%	29%	30%
<b>25</b>	19%	20%	22%	23%	24%	25%	26%	27%	28%	28%	29%

**N = 3.0 Trigger Point Table**

**NOTE:** Trigger Window = Trigger Point x 2

<b><u>Heart</u> Rate</b>	<b><u>40</u></b>	<b><u>45</u></b>	<b><u>50</u></b>	<b><u>55</u></b>	<b><u>60</u></b>	<b><u>65</u></b>	<b><u>70</u></b>	<b><u>75</u></b>	<b><u>80</u></b>	<b><u>85</u></b>	<b><u>90</u></b>	<b><u>95</u></b>
<b>Resp Rate</b>												
<b>10</b>	13%	17%	20%	23%	25%	27%	29%	30%	31%	32%	33%	34%
<b>11</b>	9%	13%	17%	20%	23%	25%	26%	28%	29%	31%	32%	33%
<b>12</b>	5%	10%	14%	17%	20%	22%	24%	26%	28%	29%	30%	31%
<b>13</b>	1%	7%	11%	15%	18%	20%	22%	24%	26%	27%	28%	29%
<b>14</b>	0	3%	8%	12%	15%	18%	20%	22%	24%	25%	27%	28%
<b>15</b>	0	0	5%	9%	13%	15%	18%	20%	22%	24%	25%	26%
<b>16</b>	0	0	2%	6%	10%	13%	16%	18%	20%	22%	23%	25%
<b>17</b>	0	0	0	4%	8%	11%	14%	16%	18%	20%	22%	23%
<b>18</b>	0	0	0	1%	5%	8%	11%	14%	16%	18%	20%	22%
<b>19</b>	0	0	0	0	3%	6%	9%	12%	14%	16%	18%	20%
<b>20</b>	0	0	0	0	0	4%	7%	10%	13%	15%	17%	18%
<b>21</b>	0	0	0	0	0	2%	5%	8%	11%	13%	15%	17%
<b>22</b>	0	0	0	0	0	0	3%	6%	9%	11%	13%	15%
<b>23</b>	0	0	0	0	0	0	1%	4%	7%	9%	12%	14%
<b>24</b>	0	0	0	0	0	0	0	2%	5%	8%	10%	12%
<b>25</b>	0	0	0	0	0	0	0	0	3%	6%	8%	11%

**This table is continued on the next page.**

**N = 3.0 Trigger Point Table (continued)**

NOTE: Trigger Window = Trigger Point x 2

<b><i>Heart</i></b>	<b><i>100</i></b>	<b><i>105</i></b>	<b><i>110</i></b>	<b><i>115</i></b>	<b><i>120</i></b>	<b><i>125</i></b>	<b><i>130</i></b>	<b><i>135</i></b>	<b><i>140</i></b>	<b><i>145</i></b>	<b><i>150</i></b>
<b>Rate</b>											
<b>Resp</b>											
<b>Rate</b>											
<b>10</b>	35%	36%	36%	37%	38%	38%	38%	39%	39%	40%	42%
<b>11</b>	34%	34%	35%	36%	36%	37%	37%	38%	38%	39%	41%
<b>12</b>	32%	33%	34%	34%	35%	36%	36%	37%	37%	38%	40%
<b>13</b>	31%	31%	32%	33%	34%	34%	35%	36%	36%	37%	39%
<b>14</b>	29%	30%	31%	32%	33%	33%	34%	34%	35%	36%	38%
<b>15</b>	28%	29%	30%	30%	31%	32%	33%	33%	34%	34%	38%
<b>16</b>	26%	27%	28%	29%	30%	31%	32%	32%	33%	33%	37%
<b>17</b>	25%	26%	27%	28%	28%	30%	30%	31%	32%	32%	36%
<b>18</b>	23%	24%	25%	27%	27%	28%	29%	30%	31%	31%	35%
<b>19</b>	22%	23%	24%	25%	26%	37%	28%	29%	30%	30%	34%
<b>20</b>	20%	21%	23%	24%	25%	26%	27%	28%	29%	29%	33%
<b>21</b>	19%	20%	21%	23%	24%	25%	26%	27%	28%	28%	33%
<b>22</b>	17%	19%	20%	21%	23%	24%	25%	26%	26%	27%	32%
<b>23</b>	16%	17%	19%	20%	21%	22%	23%	24%	25%	26%	31%
<b>24</b>	14%	16%	17%	19%	20%	21%	22%	23%	24%	25%	30%
<b>25</b>	13%	14%	16%	17%	19%	20%	21%	22%	23%	24%	29%

## Standard CINE Screen

CINE is an optional GRE acquisition that acquires data continuously throughout the cardiac cycle. CINE scans employ a short TR GRE pulse sequence that produces a bright blood and dark myocardium image with fairly high contrast. CINE images are acquired using retrospective gating techniques.

CINE is allowed when CINE is selected as the MODE in the Imaging Parameters area. Either GRE or SPGR can be selected at the Pulse Sequence window.

**NOTE:** CINE is not the same sequence as FastCINE.

When CINE is selected as the scan mode, the **Cine Screen** icon is available in the Additional Parameters area.



Selecting the **Cine Screen** icon opens the Cine Screen.

*CINE*

Trigger Type	<input type="text"/>	<input type="checkbox"/> Auto	Heart Rate	<input type="text" value="73"/>	<input type="button" value="update"/>
Locs per Acquisition	<input type="text"/>	Min Max	(BPM)		
		1 4			
# of Phases to Recon	<input type="text"/>	1 32	Effective TR	44 (msec)	

The following table describes the functions of the parameters on the Cine Screen.

<b><u>Selection</u></b>	<b><u>Description</u></b>
<b>Trigger Type</b>	Defines the gating sensor used on the patient. ECG I, ECG II and ECG III are the lead selections when electrodes are attached to the patient. PG is for use with the Peripheral Gating sensor.
<b>Heart Rate</b> (update bpm)	Acquires an update of the patient's current heart rate in beats per minute and displays the value.
<b>Locations per Acquisition</b>	Selects the number of slice locations to acquire in each acquisition. Up to 64 images per acquisition with 16 contiguous scan locations are allowed.
<b># of Cardiac Phases to Reconstruct</b>	Defines the number of cardiac phases to obtain. Up to 32 phases per cardiac cycle for each slice are allowed.

## Trigger Type

Select ECG I, ECG II, ECG III when cardiac gating with electrodes attached to the patient. PG is for use with the Peripheral Gating sensor and is allowed in CINE.

- ECG gating is recommended for the most accurate trigger detection for cardiac imaging. With PG, there is a delay from the actual trigger to when it is detected in the extremity.
- In ECG Gating/Triggering, observe the waveform from each lead (ECG I, II and III). Select the lead that produces the least noise and the highest R-wave.
- If a lead loses signal during data acquisition, Signa automatically switches to an alternate lead. If ECG II loses signal, Signa switches to ECG III. If ECG III loses signal, Signa switches to ECG II.
- A new lead can be selected from the Gating Control window after the series has been downloaded or during data acquisition. This can be done before data acquisition has started or during data acquisition.

An ECG series does not need to be Copy/Pasted to change the lead selection. Once a gated sequence is complete, simply open the Gating Control window and make the lead change. Selecting Scan again at this point repeats the series with the new lead selection.

- The lead selection can be changed from PG to ECG (and vice versa) after series download or during data acquisition. When changing from ECG to PG, the ECG cable does not need to be disconnected at the magnet enclosure.
- **DO NOT rely on Auto for lead selection.** Auto chooses the lead with the strongest signal. This is not necessarily the best waveform; the signal could be strong as a result of noise. It is recommended that you observe all leads and choose the waveform that results in the most accurate trigger.

### Locations per Acquisition

The number of locations per acquisition affects scan time, the effective TR, and contrast between blood and muscle tissue. As the number of locations/acquisition increases, the effective TR increases and blood/tissue contrast decreases.

- For example, prescribe eight slice locations and a 25 ms TR.
  - Select two locations per acquisition. Four acquisitions take place, acquiring two slices in each acquisition. The effective TR is 50 ms.
  - Select four locations per acquisition. Two acquisitions take place, acquiring four slices in each acquisition. The effective TR is 100 ms. This scan is performed in half the time as 2 locations per acquisition, and the longer TR decreases the contrast between blood and tissue.
- Consider two slice locations per acquisition to produce images exhibiting the best compromise between image quality and scan time.

### Number of Cardiac Phases to Reconstruct

The number of phases to reconstruct determines the temporal resolution of the image reconstruction process. The temporal resolution of the image reconstruction process can be independent of the temporal resolution of the acquisition.

- If too few phase images are reconstructed, portions of the cardiac cycle are not sampled.
- If too many images are reconstructed, Flow Analysis cannot use the excess information to obtain calculations and, consequently, the images are a waste of disk space and processing time.

- The time between phase images is roughly equal to the R-R interval divided by the number of phases to be reconstructed.
- The actual delay after trigger of each image varies from acquisition to acquisition. Usually, the first image occurs at 33 ms and each subsequent image follows at the interval calculated above.
- Each phase image is interpolated from the two data points closest to the desired time for the phase image to occur.
- The SNR is the same regardless of the number of phases to be reconstructed. Each image is a snapshot in time during the cardiac cycle.
- As the number of phases reconstructed is reduced, the larger the portion of the R-R interval the individual phase image represents.
- Image quality may deteriorate reconstructed phases increases. Sixteen is a typical number and a compromise between image quality and the need for an adequate number of phases.

**NOTE:** Refer to Volume 2 for details on CINE sequences.

## Frequently Asked Cardiac Questions

### **Why are my acquisitions taking longer than expected?**

This may be an indication that the scan may not be triggering correctly. Confirm that the gating tic marks can still be seen on the ECG waveform during data acquisition. If the tic marks are not seen, before the next breath-hold acquisition, try opening the Gating Control window and adjusting the trigger level up or down to produce more consistent triggering. (Remember, Auto trigger sets the level at 65%).

### **What do I do if the R-wave is inverted?**

If the R-wave is inverted, click the **Inverted** button at the Gating Control window (if this option is available on your system).

If ECG Inversion is not available on your system or inversion does not correct the problem, it may be necessary to swap the position of the leads for the right arm and the left leg.

**NOTE:** If the MRE gating system is being used, unplug the gating cable from the PAC connection ports, wait several seconds, and then reconnect the cable. This often corrects the problem.

**At T-swell has doubled the heart rate. How can I compensate for the T-swell?**

When the patient is advanced into the MR scanner, contamination of the ECG waveform causes the T-wave to elevate. The ECG records the electric potential from the heart net dipole. The T-wave swells due to a blood flow dipole that is created by the main magnetic field, perpendicular to the flowing blood. There are several things that you can try to work around this.

- If scanning with Advanced ECG Gating ON, turn it OFF. Sometimes the lock-out window (used when Advanced ECG Gating is off) helps eliminate the effects of T-swell.
- Auto lead selection searches for the largest delta between the R-wave and the T-wave. Switch to Auto on the Gating Control window, and see which lead Signa recommends. Try using the lead selected by Auto.
- Increase the trigger level on the Gating Control window. Auto trigger sets the level at 65%.

**How does changing the lead selection on the Gating Control window impact data acquisition?**

The Gating Control allows the scanning lead selection to be changed, either while scanning, or between acquisitions of the same series. It permits this in the following fashion:

- When scan parameters are chosen for a series, whichever lead is chosen on the Combined Cardiac and Respiratory Gating/Triggering Screen in the Additional Parameters area of the scan page, is the lead that Signa uses when it scans that series.
- Once Prepare to Scan is selected and that series is downloaded, the status changes from RXD in the Rx Manager to ACT. The lead may now be changed on the series that you are about to scan, simply by changing it on the Gating Control window. This may be done either before the scan is started, or during the scan acquisition.
- This feature means that you no longer have to do Copy and Paste, View and Edit a series that you want to repeat with a different lead selection. Once the acquisition is completed,

simply open the Gating Control, change the lead to the one that you want, and click the **[Scan]** button again.

As soon as the next series is downloaded from the Rx Manager (by clicking the **[Prepare to Scan]** button), Signa scans whichever lead selection was made on the Gating window in the Additional Parameters area of the scan page.

### **Must the ECG cable be disconnected if I switch the Lead Selection, at the Gating Control window, to PG?**

On systems equipped with Signa CV/i 8.4 software (or higher):

- The ECG Gating cable does not need to be disconnected when switching from ECG to PG. It is only necessary to select PG as the Lead Display from the Gating Control window. Making this selection tells Signa that PG is to be performed.
- After selecting PG at the Gating Control window, PG must also be selected at the Combined Cardiac and Respiratory Gating/Triggering Screen (accessed from the Additional Parameter's area of the Scan Rx Desktop) during series prescription.

On Signa Systems equipped with LX 8.3.5 software (and below), and Signa OpenSpeed:

- The ECG cable must be disconnected from the connection port on the magnet enclosure to perform PG.

### **What if I have a good waveform, but I am still missing triggers?**

1. Check the Arrhythmia Rejection Window (the Trigger Window if applicable). The window may be too small and triggers are being missed due to fluctuation in the heart rate.
2. If performing combined cardiac and respiratory gating/triggering, check the Respiratory TP and TW. The AIT may be too small. The lower the sum of the TR and TW, the greater the AIT.
3. If the waveform is good but triggers are still missing, try opening the Gating Control window and reducing the trigger

level to 50%. (Auto trigger is the default, and sets the trigger level at 65%.) The range is 30 - 90%.

4. Confirm that tic marks are now appearing on the trace. If not, the trigger level may need to be further reduced (e.g., 45%).

**NOTE:** If the trigger level is reduced to a value that is too low, triggering may occur off the T-wave. At this point, the patient's heart rate would appear to double.

5. If the ECG Trace is still noisy, make sure that Advanced ECG Gating is turned on at the Gating Control window and also turn ECG Noise Filter on.
6. With the patient outside of the gantry, wait approximately 10 to 15 seconds for gating to initialize. The Cardiac Initializing message disappears when complete.
  - The ECG Noise Filter is used in conjunction with Advanced ECG Gating. Use of the noise filter results in a greater delay (approx. 18 ms) from the time the QRS complex is generated and Signa detects the signal.
  - The use of ECG Noise Filter can often improve gating results.
  - If the trace now looks good, confirm that it is triggering (that is, check that there is a little white tic mark appearing under each R-wave passing across the screen).
  - If there still is a good waveform and there are no tic marks indicating a trigger, try turning Advanced ECG Gating off.

7. If you are still having trouble obtaining a good trace or triggers, click the **[Gating Reset]** button.

Remember, if Advanced ECG Gating is on, Gating Reset should be performed with the patient outside the bore of the magnet. This ensures accurate measurement of the R-wave slope.

- Advanced ECG Gating can take 10 to 15 seconds to initialize.
8. If, at this point, the ECG trace is still noisy or missing triggers, consider repositioning the electrodes and/or lead placement.

# How to Optimize Gating and Triggering

This section provides the step-by-step instructions for setting up and optimizing scans with cardiac and respiratory gating/triggering. Specifically, it describes how to perform:

- Cardiac Gating/Triggering
  - Place Electrodes and Route the Cable
  - Set up the Gating Control Parameters
  - Regulate Contrast with Cardiac Gating
- Respiratory Gating/Triggering
  - Place Bellows and Route the Tubing
  - Set up the Gating Control Parameters
  - Regulate Contrast with Respiratory Gating

**In Brief: Place Electrodes and Route the Cable**

1. If necessary, shave the chest.
2. Prepare the patient.
3. Attach the electrodes to the patient over the prepared area.
4. Position the patient and route the gating cable.
5. Connect the electrodes to the leads.
6. Position the coil.
7. Route the cable and attach the gating cable into the connection port.
8. Instruct the patient to stay **VERY STILL**.

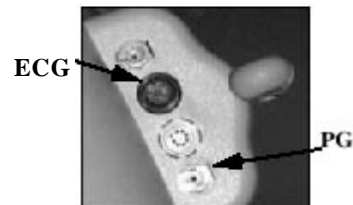
## Cardiac Gating/Triggering

### Place Electrodes and Route the Cable

Use this procedure to prepare your patient for a gated cardiac examination. To perform a successful MR ECG gated exam, it is very important to follow these steps for proper ECG lead placement and cable routing.

1. If necessary, shave the chest.
2. Prepare the patient.
  - Use an appropriate ECG electrode abrasive gel (e.g., Nuprep®) on the area where the electrodes are placed. Apply the gel to a cotton swab or gauze and rub lightly on the skin.
  - Remove the excess gel when complete. Make sure the skin is completely dry before attaching the electrodes.
3. Attach the electrodes to the patient over the prepared area.
  - Anterior placement is recommended and should be used when possible.
  - Use non-metallic, (MR compatible) pre-gelled electrodes.
  - DO NOT use expired electrodes.
  - DO NOT use electrodes that have been removed from the package for a long period of time. The gel dries over time and this results in high impedance and subsequently, a poor ECG trace.
  - If available, use an impedance meter to check the contact impedance with the patient outside the magnet. Recommended contact impedance is in the order of approximately 10 K.
4. Position the patient on the table.
  - Use feet first orientation whenever possible.
5. Connect the electrodes to the leads.
  - The white electrode/lead wire is positioned for the right arm.
  - The black electrode/lead wire is positioned for the left arm.
  - The red electrode/lead wire is positioned for the left leg.
  - The green electrode/lead wire is positioned for the right leg.

6. Position the coil, if applicable.
  - The cardiac coil is recommended.
7. Route the cable down the center of the table and attach the gating cable into the connection on the Signa magnet enclosure (the PAC if applicable).



- The connection ports on your system may be a different style than those shown here, and located on the floor in front of the magnet enclosure.
8. With the patient on the table and the ECG leads connected, instruct the patient to stay **VERY STILL**.



**In Brief: Set up the Gating Control Parameters**

1. Click **[Gating Control]** in the **Rx Manager**.
2. Select **Cardiac**.
3. Click **[Update]**.
4. On the Cardiac waveform display, check the vertical tic marks indicating the "triggers."
5. Press **[Move to Scan]**.
6. View the signal from Lead I, Lead II, and Lead III.
  - Select the waveform that exhibits the least amount of noise and the highest R-peak.
  - Make sure the trigger tic marks appear.
  - If the system is missing triggers, refer to the detailed instructions for suggestions on improving trigger detection.
7. Reposition electrodes if the trace continues to be noisy or the system continues to miss triggers.

## Cardiac Gating/Triggering

### Set up the Gating Control Parameters

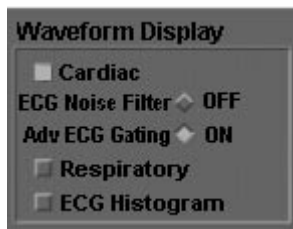
Use this procedure to set up the gating control for an ECG gated cardiac examination to minimize motion of the heart on your images.

1. Click **[Gating Control]**.



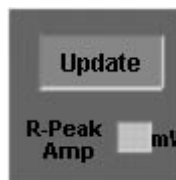
- Located in the Rx Manager.
- The Gating Control window appears.

2. Select **Cardiac**.



- The Cardiac waveform displays on the PC monitor.
- Advanced ECG Gating ON is the default when the window opens.
- A Cardiac Initializing message also appears. It takes 16 heartbeats, approximately 10 seconds, to complete initialization. The message disappears when initialization is complete.
  - **DO NOT move the patient into the bore of the magnet until initialization is complete and the message disappears.**

3. Click **[Update]**.



- Checks the current reading of the measured amplitude of the lead's signal R-peak.
- The calibrated value should be higher than 1.0 mV.

- If the R-peak Amp. is not greater than 1.0 mV, repeat the patient-prep procedure and/or reposition the electrodes.
  - Amplitudes of 1.0 mV may not be possible for patients with heart failure. Successful cardiac gating may be compromised in these situations.
4. On the Cardiac waveform display, check the vertical tic marks indicating the "triggers."



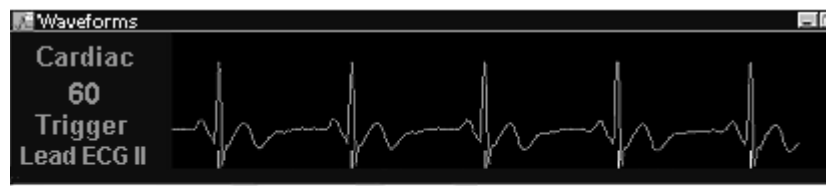
**Watch for these tic marks. Tic marks indicate the trace is triggering.**

- The small vertical lines at the bottom of the waveform (triggers) should appear beneath the R-waves.
  - The tic marks indicate a peak is detected and that peak is a potential trigger. During data acquisition, a peak may not be used as a trigger due to the occurrence of cardiac arrhythmias or incompatibility with the respiratory cycle when using combined cardiac and respiratory gating.
  - A tic mark beneath a T-wave indicates the system sees that peak as a potential trigger.
  - If tic marks are not seen, this indicates the system is not finding potential triggers.
5. Press **[Move to Scan]** only after the following has been completed:
- Cardiac initializing message disappears and the returned cardiac signal is acceptable.
  - The patient, leads, and coil have been rechecked.

6. View the signal from Lead I, Lead II, and Lead III to determine the waveform that results in the most accurate trigger.

**NOTE:** Lead selection can be made from either the Gating Control window or the Gating/Triggering Additional Parameters screen. The MOST RECENT lead selection is the lead used for data acquisition and also for the display waveform on the PC.

- Select the waveform that exhibits the least amount of noise and the highest R-peak with an amplitude of at least 1.0 mV.
  - Use the combination of the R-peak Amplitude and a visual inspection of the waveform to determine which is the best lead from which to gate.
- Make sure the trigger tic marks appear, indicating that the trace is triggering.
- If the system is missing triggers, try one of the following suggestions for improving trigger detection:
  - Reduce the Cardiac Trigger Level. Auto Trigger is the default and sets the trigger level at 65%.
  - If trace is good but triggers are still missing, reduce the trigger level to 50%. Confirm that tic marks are now appearing on the trace. If not, the trigger level may need to be reduced even more. (e.g., 45%).



**Watch for these tic marks. Tic marks indicate the trace is triggering.**

- If the trigger level is too low, triggering can occur off the T-wave and the patient's heart rate would appear to double.
- If the system is still noisy and missing triggers, continue with trying the following:
  - Make sure that Advanced EGG Gating is turned on. If it is off, turn it on and check the waveform again.

- If the waveform is noisy with Advanced ECG Gating ON, select **ECG Noise Filter** on the Gating Control window.
  - If the waveform is still noisy, click [**Gating Reset**].
    - If Advanced ECG Gating is on, make sure the patient is outside the bore of the magnet before selecting Gating Reset.
7. Reposition electrodes if the trace continues to be noisy or the system continues to miss triggers.

**NOTE: DO NOT rely on Auto for lead selection.** Auto chooses the lead that has the strongest signal but may not necessarily have the best waveform. The signal could be strong due to noise.

### In Brief: Regulate Contrast

1. Click the **Gating/Triggering**.
2. Select **Lead I, Lead II, or Lead III** in the **Trigger Type** text box.
3. Select the number of R-R Intervals in the **# of RR Interval** text box.
4. Select **Trigger Window**.
5. Select **Trigger Delay > Minimum** or **Recommended**.
6. Select **Inter-sequence Delay > Minimum** or **Even Spacing**.
7. Select the number of **Cardiac Phases**.
8. Select the **# Of Card. Phases to Reconstruct**.
9. Select the number of **Views per Segment**.
10. Click **[Update Rate]**.

## Cardiac Gating/Triggering Regulate Contrast with Cardiac Gating

Use this procedure to adjust the contrast of an image during a cardiac gated examination. The contrast parameters are found on the Gating/Triggering Screen in the Additional Parameters area.

1. Click **Gating/Triggering**.



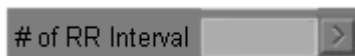
- Located in the Additional Parameters area.
- The Combined Cardiac and Respiratory Gating/Triggering Screen appears.

2. Select **Lead I, Lead II, or Lead III** in the **Trigger Type** text box.



- Determine the best signal; that is the least noise and the highest R-wave.
- Auto may not be the optimum lead for ECG Gating/Triggering. Observe all leads and choose the waveform that results in the most accurate trigger.

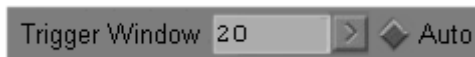
3. Select the number of R-R intervals in the **# of RR Interval** text box.



- Select a predefined value that yields an effective TR within the appropriate range for the desired contrast.
- The effective TR is displayed to the right of the text box.
- The more R-R intervals selected, the higher the effective TR. The higher the effective TR, the longer the scan time, the higher the SNR, the more T2-weighted contrast, and more slices.

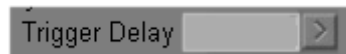
- To increase the effective TR and the number of slices, select a multiple of the cardiac cycle (RR x 2, RR x 3, etc.)
- For a MPGR, select **[1]** RR.
- For FSE-IR with Blood Suppression, select **[2]** RR.

4. Select **Trigger Window** by doing one of the following:



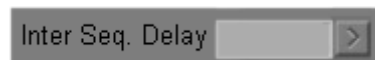
- Click **Auto** and the system selects the optimum TW based on the imaging options selected.
- Type in any value from 0 to 50.
  - For most patients, a 15% TW removes much of the risk of missed triggers. For anxious or excitable patients with greatly fluctuating heart rates, 20 to 30% may be required. As the TW increases, the number of slices decrease, and the probability of missing an R-wave decreases.

5. Select **Trigger Delay > Minimum** or **Recommended**.



- Select **Minimum** to set the minimum possible delay of 13 ms to 15 ms.
  - The minimum is the absolute minimum which is required by the system to detect the trigger and initiate data acquisition.
- Select **Recommended** to set the recommended delay as calculated by the system based on the imaging options.
  - Sets the delay for the best image quality.
- The text box can be used to manually enter a delay time longer than minimum.

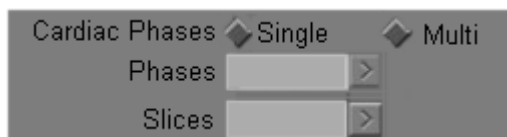
6. Select **Inter-Sequence Delay > Minimum** or **Even Spacing**.



- Select **Minimum** to space images as closely as possible.
  - The ISD increases, the number of slices decreases.

- Select **Even Spacing** to evenly space the slices within the AIT.
- The text box can be used to manually enter a delay time longer than minimum.

7. Select the number of **Cardiac Phases**.



**NOTE:** The cardiac phases buttons are available when the pulse sequence is SE and MPGR. Either Single or Multi can be selected. Only Single is available is FSE sequences.

- When scanning the heart, your selection is based on the clinical history and the radiologist's request.
- Typically, select **Single** for anatomy outside the heart or for a SE sequence.

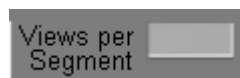
8. Select the **Number Of Cardiac Phases To Reconstruct**.



**NOTE:** This parameter is available for FastCard and FastCINE sequences.

- A numerical value enables a FastCINE sequence.
- Selecting **Auto** results in a FastCard sequence.
- The maximum number of phases is affected by the VPS.

9. Select the number of **Views per Segment**.



**NOTE:** This parameter is available when FastCard, Fast 2D PC, and FastCINE sequences are selected.

<i><b>Heart Rate (bpm)</b></i>	<i><b>Views Per Segment (VPS)</b></i>
≤ 60	8
61 - 95	6
96 - 125	4
126 - 155	2
> 156	1

10. Click **[Update Rate]**.



- Acquires and displays the current heart rate.
- Update the heart rate before beginning the data acquisition to insure accurate triggering.

**In Brief: Place Bellows and Route the Tubing**

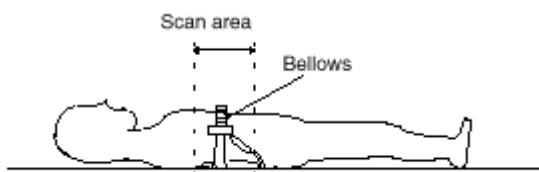
1. Ask the patient to remain still while proceeding with set-up, alignment, landmarking, and scanning.
2. Observe the motion of the patient's chest and abdomen during normal breathing.
3. Place bellows over the area being scanned.
4. Fasten bellows with the Velcro® straps.
5. Check LED on the magnet enclosure.
6. Make necessary adjustments if the patient is a very deep breather.
7. Route the bellows tubing down the center of the table.

## Respiratory Gating/Triggering

### Place Bellows and Route the Tubing

Use this procedure to prepare your patient for a respiratory gated/triggered examination. To perform a successful MR respiratory gated exam, it is very important to follow these steps for proper bellow placement and tube routing.

1. Ask the patient to remain still while proceeding with set-up, alignment, landmarking, and scanning.
  - Ask the patient to refrain from talking or moving.
  - This is especially important during the first 20 seconds of the scan when the system is evaluating the waveform.
2. Observe the motion of the patient's chest and abdomen during normal breathing.
  - Place your hands over these areas to determine where the greatest motion occurs during breathing.
3. Place the bellows over the area being scanned.
  - Place where the greatest breathing motion occurs.



4. Fasten the bellows with the Velcro® straps.
  - Make the bellows snug, but stretch it as little as possible.
  - The bellows should expand and contract with the patient's breathing.
    - Expansion should be ½ to 1 inch.
5. Once the bellows is in place, give the system about 60 seconds to stabilize, then check the respiratory LED on the magnet enclosure.
  - If the respiratory signal is adequate, the LED should rise and fall with patient's breathing. The LED should move over the bottom one-third of the display.

- If the LED consistently moves to the top of the LED display during normal breathing, the bellows is probably stretched too much and it should be loosened slightly.
  - If the LED does not move across the bottom one-third of the LED, the bellows may not be stretched enough. Tighten the bellows and make sure there is ½ to 1 inch expansion and contraction during patient breathing.
6. If the patient is a very deep breather, place a stiff foam pad or several folded sheets over the patient's abdomen, adjacent to the costal margin.
- Do not place the padding over bellows.
  - When the patient exhales, fasten standard wide compression bands tightly over the pad.
7. Route the bellows tubing down the center of the table to the connection ports.
- Be careful of the table and cradle edges.
  - Do not bend or kink the bellows. This results in loss of signal detection.

**In Brief: Set up the Gating Control**

1. Click **[Gating Control]**.
2. Select **Respiratory**.
3. View the signal on the PC monitor.
4. Verify that the trigger marks appear on the waveform.
5. Check the messages in the system status display area.

## Respiratory Gating/Triggering

### Set up the Gating Control

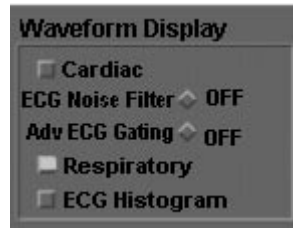
Use this procedure to set up the gating control for a respiratory gated/triggered examination to minimize breathing motion on the images.

1. Click **[Gating Control]**.



- Located in the Rx Manager.
- The Gating Control window appears.

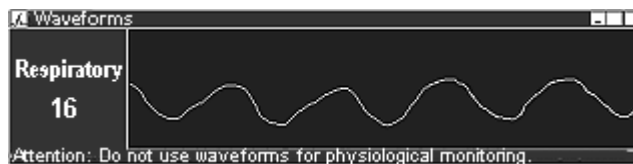
2. Select **Respiratory**.



- Displays the respiratory waveform on the PC monitor.

3. View the signal on the PC monitor.

- A numeric value appears at the left side of the waveform window indicating the number of breaths per minute.



The following figures are examples of a normal, high, and low gain settings on the waveform display.



**Normal Waveform Display**

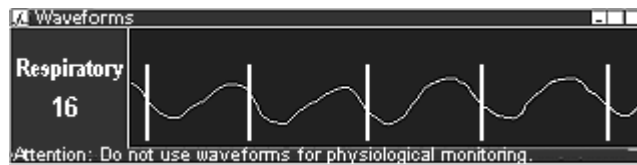


**Gain set too high.** If waveform gain is set too high, LEDs on the PAC or magnet enclosure reach the extreme of the indicator. Loosen the bellows.



**Gain is set too low.** If waveform gain is set too low, LEDs on the PAC or magnet enclosure reach the low end of the indicator. Reposition or tighten the bellows.

4. Verify that the trigger marks appear on the waveform.
  - This indicates the system is adequately detecting the respiratory pattern.



- The trigger marks appear when the respiratory parameters are entered at the Combined Cardiac and Respiratory Gating/Triggering Screen.
5. Check the messages in the system status display area.
    - "Resp OK" indicates the system is detecting the respiratory signal and the gain is properly set.
    - "Resp Missing" indicates signal is not being detected. This may be due to a kink or bend in the tubing, disconnected tubing or a leak in the tubing, or a change in the patient's breathing pattern. The patient's breathing may have quieted and the bellows need to be adjusted to compensate for the change.
    - Respiratory gating must indicate "Resp OK" before continuing with scan.

**In Brief: Regulate Contrast**

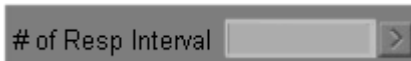
1. Click **Gating/Triggering**.
2. Select the number of Respiratory intervals in the **# of Resp Intervals** text box.
3. Select a **Trigger Point** to begin imaging in the valley of the waveform.
4. Select a **Trigger Window** larger than the **Trigger Point**.
5. Select the **Inter-Sequence Delay**.

## Respiratory Gating/Triggering

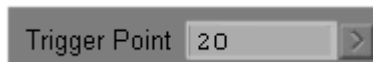
### Regulate Contrast with Respiratory Gating

Use this procedure to adjust image contrast during a respiratory triggered examination. Respiratory triggering is an imaging enhancement option designed to minimize ghosting artifacts from respiratory motion. The contrast parameters are found on the Gating/Triggering Screen in the Additional Parameters area.

1. Click **Gating/Triggering**.
  - The Combined Cardiac and Respiratory Gating/Triggering Screen appears.
  - The system automatically displays the patient's bpm in the **Resp Rate** text box.
2. Select the number of respiratory intervals in the **# of Resp Interval** text box.



- that yields an effective TR within the appropriate range for the desired contrast.
  - The more respiratory intervals selected, the higher the effective TR and SNR. Scan time, PD or T2-weighted contrast, and the number of slices also increase.
  - To increase the effective TR and the number of slices, select a multiple of the respiratory cycle (Resp x 2, Resp x 3, etc.)
3. Select a **Trigger Point** so that imaging begins in the valley of the waveform or quietest part of the respiratory cycle.



- As TP increases, images are acquired later in the respiratory cycle but do not affect AIT.
- A range of 10% to 50% is allowed.
- When performing combined cardiac and respiratory gating refer to the Trigger Point Table.

4. Select a **Trigger Window** greater than or equal to the TP.



- As TW increases, the number of slices decrease and the probability of missing a respiratory wave decrease.
- If the respiratory cycle shortens, images can be acquired in the TW. If the respiratory cycle shortens by more than the TW, the respiratory triggers are being missed.
- A range of 10% to 50% is allowed.

5. Select the **Inter-Sequence Delay**.



- As the ISD increases, the number of slices decrease.
- Select **Minimum** spacing to acquire images as quickly as possible within the available imaging time
- Select **Even** spacing to spread the slice acquisition time evenly across the available imaging time.
- Type in the ISD value if minimum or even spacing is not desired. The type-in value must be larger than the minimum spacing value.

This page intentionally left blank.

## Chapter 3

# Triggering CEMRA with SmartPrep

Where Am I?



## Introduction

This chapter explains the SmartPrep process. SmartPrep is the focus on automated bolus detection and acquisition triggering for contrast-enhanced MR angiography. This chapter contains key concepts as well as step-by-step instructions to help you learn how to:

- Prescribe and Scan the series
- Set the SmartPrep timing parameters
- Place the tracker
- Place the imaging volume

**NOTE:** SmartPrep is a purchasable imaging option.

In addition, this chapter answers the following questions:

1. What is SmartPrep Infusion Angiography (IA)?
2. How does SmartPrep detect a bolus?
3. What pulse sequence(s) is/are used?
4. What happens during a SmartPrep series?
5. How does centric K-space filling affect image contrast?
6. How does elliptic-centric K-space filling affect image contrast?
7. How does timing affect contrast?
8. What is the contrast mechanism in Contrast Enhanced MRA (CEMRA)?

---

# About... SmartPrep IA

This section presents the concepts necessary to successfully complete the SmartPrep IA process. Specifically you need to understand:

- Description of SmartPrep IA
- Tracker Volume
- Imaging Volume
- Threshold
- Phases of SmartPrep
- Centric K-space Filling
- Elliptic-centric K-space Filling
- Associated Imaging Options
  - Matrix ZIP
  - Slice ZIP
- SmartPrep Imaging Parameters
  - Maximum Monitor Period
  - Image Acquisition Delay
  - SPECIAL
  - Burst Scan Time/Turbo Mode
- Contrast Mechanism

## Description of SmartPrep IA

SmartPrep IA (Infusion Angiography) uses a tracking pulse sequence to continuously monitor the MR signal coming from a user prescribed volume of interest in the patient. As the signal increases, due to an injected contrast material (e.g., gadolinium), the pulse sequence checks to see if the signal amplitude exceeds a contrast dose-dependent threshold. When the measured signal exceeds the system defined and fixed threshold, the preselected protocol is automatically initiated. To maximize the image contrast at this point, K-space is filled in a centric order.

## Tracker Volume

SmartPrep uses a tracker volume, also called a tracker pulse, to monitor a region of interest for the arrival of a contrast bolus. The tracker volume is a three-dimensional object that is graphically prescribed and represented on the imaging screen by a cross bar. The purpose of this tracker volume is to monitor the selected region of interest for the arrival of a contrast bolus.

## Imaging Volume

An Imaging Volume is the area which is scanned. SmartPrep uses a three-dimensional imaging volume in order to acquire images.

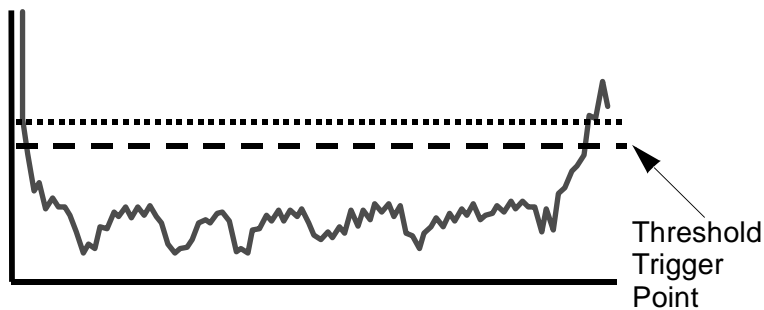
Let's briefly discuss some of the advantages and disadvantages for using this type of imaging acquisition. With three-dimensional volumetric imaging, data is acquired from the entire volume, instead of by separate slices. This means instead of exciting just one slice at a time, the entire imaging volume of tissue is excited. By acquiring images in this manner, you have the advantage of very thin slices being seen, thus improving the demonstration of very small lesions/vessels. Another good reason for using three-dimensional imaging is by exciting the entire volume, SNR is greatly improved, and fewer NEX may be used. Three-dimensional volume imaging can also be reconstructed to look at the images in any plane. A disadvantage to using this type of imaging is patient motion. Three-dimensional imaging is very sensitive to motion.

## Threshold

A threshold is defined as a level at which something occurs. SmartPrep uses this theory, by basing the level of change on the changes in pixel intensities. Your MR system uses two thresholds that differ by 5%. The amount entered for contrast determines the active threshold:

- The lower threshold is used for a bolus of 20cc or less. The system is looking for a 15% change in pixel intensity.
- The higher threshold is used for a bolus of greater than 20cc. The system is looking for a 20% change in pixel intensity
- Both use three standard deviations. This deviation check is meant to reduce the effect of respiratory induced

signal changes, which happen independent of contrast injection.



With the correct contrast amount entered, the system automatically chooses the correct threshold value. The tracker pulse monitors the signal intensity in the prescribed region of interest. When the contrast bolus arrives, the signal intensity in the region of interest increases. Once the signal intensity has increased enough to exceed the system defined minimum threshold, the acquisition is initiated.

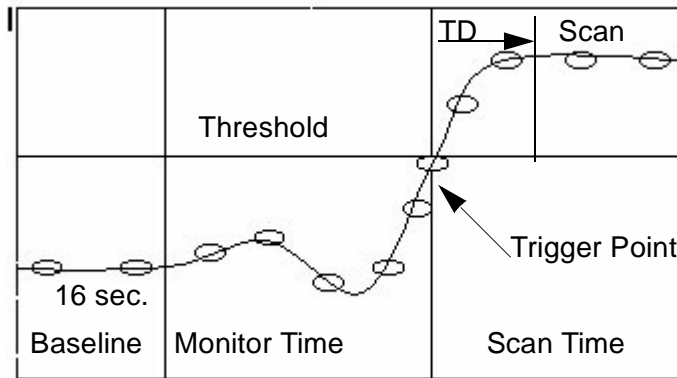
## Phases of SmartPrep

A SmartPrep acquisition consists of three phases:

- Baseline phase
- Monitor phase
- Scan phase

During the baseline phase your MR system samples the tracker volume to determine the threshold signal. No contrast is injected at this time. The baseline phase is then followed by the monitor phase, in which the system samples to "look" for the contrast bolus. Contrast is injected at the start of the monitor phase. Next, the final phase occurs, this phase is called the scan phase. During this phase the image data is acquired. A

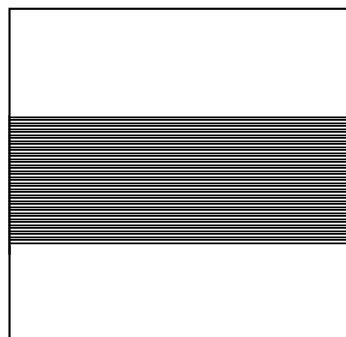
trigger delay may be included in this phase to allow time for patient breathing instructions.



**NOTE:** The scan phase is either triggered by the arrival of the contrast bolus or by the system default value, if no contrast is detected.

### Centric K-space Filling

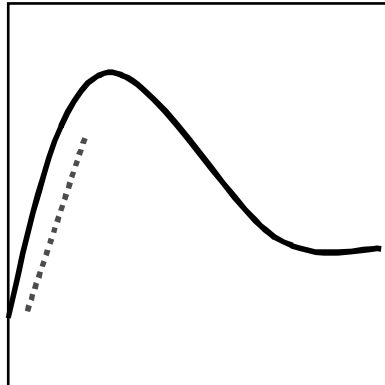
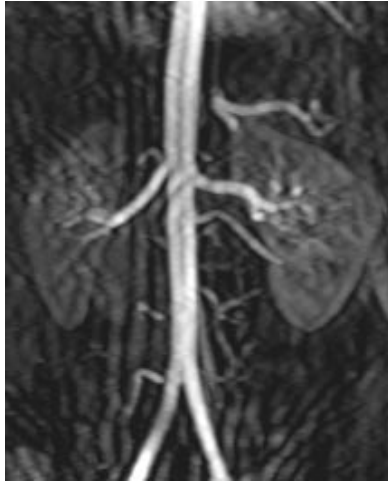
There are two different K-space filling options. The first of which is Centric K-space Filling. We know the center lines of K-space has the greatest effect on contrast/signal. Normally the outer lines of K-space fill first, these lines are responsible for resolution. SmartPrep defaults to centric K-space filling, where the center lines are filled first.



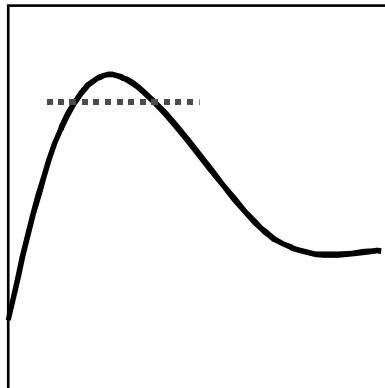
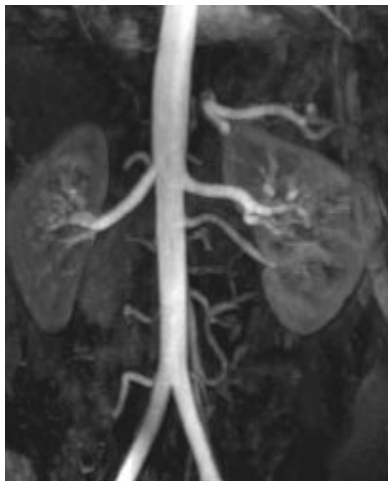
Centric K-space encoding fills center lines first.

The center lines of K-space should be acquired during peak contrast enhancement. If the center lines of K-space are filled during the steep slope of the contrast curve, "ringing" artifacts results.

This is due to the contrast changing dramatically from one line of K-space to another.

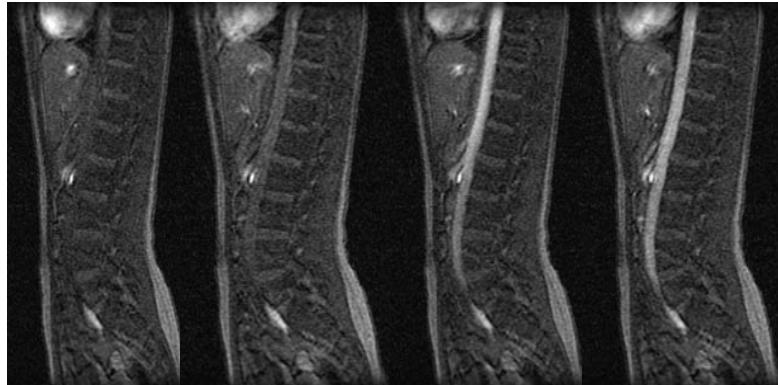


Center lines filled during steep portion of contrast.



Center lines filled during peak contrast.

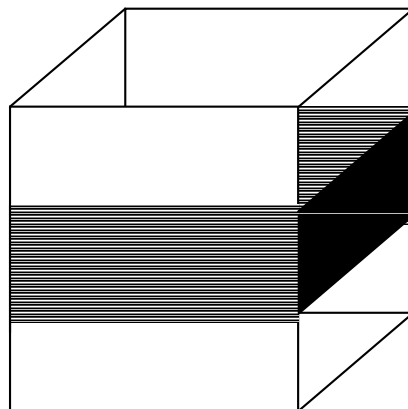
image acquisition should begin after the vessel has filled with contrast to optimize centric K-space filling.



Too Soon      Too Soon      Still too soon      Now

### Elliptic-centric K-space Filling

The option for filling K-space would be Elliptic-centric. This type of filling expands upon Centric filling. It still fills the center portion of K-space first, and now it also fills the center lines in the z-slice direction in a 3D volume. When used with SmartPrep you should notice an increase in contrast between IV contrast and background tissue. Elliptic-centric can also help decrease respiratory motion and patient motion artifacts in non-breath-hold 3D Fast TOF sequences.



Elliptic fills center lines and center slices first.

**NOTE:** Elliptic-centric filling is compatible with cardiac gating/triggering, SAT pulses, Fat or Water suppression, IR Prep and DE Prep.

The center lines should still be acquired during peak contrast enhancement, just as with centric filling, to prevent "ringing" artifact.

In order to turn Elliptic-centric on, you must first go to the **[User CV]** screen. Type in a '1' to turn it on or a '0' for off. The default value in this area is always '0' and centric K-space filling is then used.

## Associated Imaging Options

There are some imaging options that can be used in conjunction with SmartPrep. The most common ones are Matrix ZIP and Slice ZIP.

### Matrix ZIP

Matrix ZIP uses zero filling to reconstruct images in a 512x512 display format, even though image data was acquired using a different matrix format. By using Matrix ZIP, you can enhance existing resolution, without the cost of more time using higher matrixes.

**NOTE:** For more detail on Matrix ZIP see Volume 3 Chapter 1.

### Slice ZIP

Slice ZIP interpolates new slice locations in a three-dimensional volume. It is mainly used to smooth IVI projections for CEMRA sequences, and to reduce partial volume artifact due to the position of the anatomy within the slice.

**NOTE:** For more detail on Slice ZIP see Volume 3 Chapter 1.

## SmartPrep Timing Parameters

When SmartPrep is selected the **[User CV]** button contains parameters necessary for you to fill in. A brief description of these parameters are listed below. The parameters are Max. Monitor Period, Image Acquisition Delay, SPECIAL, Burst Scan Time/Turbo Mode and Elliptic-centric.

### Maximum Monitor Period

Max. Monitor Period is the user time allowed for the system to monitor the patient for the inflow of contrast. If for some reason,

the signal never reaches the system defined and fixed threshold, the system begins to scan when this pre-programmed time has passed. The suggested range is from 45 to 120 seconds.

**Something to Think About...**

- Use a longer Max. Monitor time for patients with poor cardiac output.
- Suggested Max. Monitor periods are ones which exceeds the expected contrast arrival time by 10% to 20%.
- The Max. Monitor Period should serve as a safety net not the primary triggering mechanism.

**Image Acquisition Delay**

Image Acquisition Delay is the programmed time delay that allows you to give patient breathing instructions. This time should generally be less than 9 seconds. The image acq. delay period starts when an audible switch of the gradients has begun.

**SPECIAL**

Spectral Inversion at Lipids (SPECIAL) is an optional fat suppression technique. It combines the idea of spectral selective excitation pulses with inversion recovery tissue nulling. How this plays out is a fat spectrally selective inversion pulse is applied once every 64 slice encodings. The TI time lapse is programmed to allow the fat net magnetization vector to relax to the null point. When fat has reached the null point, an excitation pulse is applied to protons bound in both fat and water. This results in a signal produced from protons bound in water and a decreased signal from fat. With SPECIAL the amplitude of the inversion pulse is based on the TR in order to keep fat suppressed.

**Something to Think About...**

- SPECIAL supports manual tuning for center frequency adjustment but does not support manual tuning for flip adjustment.
- There is a slight increase in scan time to account for the inversion pulse that is applied once every 64 slice encodings. Although this increase in scan time is much

shorter than the increase that would occur if a fat SAT pulse was used.

**NOTE:** For more detail on SPECIAL, see Volume 3 Chapter 1.

## **Burst Scan Time/Turbo Mode**

Burst Scan Time - (only available on EchoSpeed). It allows the system to temporarily scan at a faster rate to gain higher, but temporary, performance of shortest acquisition time possible. During Burst Scan Time, the gradients are driven harder than normal. There is usually a required "cool down" period immediately following the acquisition that is equal to the difference between the non-burst mode and the burst mode scan time. To know this option is on, input a '1' in the space provided. A '0' imputed in the space provided, means Burst Scan Time is turned off.

**NOTE:** The Burst Scan Time can be extended to a value that is longer than the scan time, up to 30 seconds.

Turbo Mode - (Only available on HiSpeed and EchoSpeed). It reduces the width of the RF pulse and allows shorter TR periods. Without Turbo Mode on the duration of the RF pulses is 1.6ms. With Turbo Mode on the duration of the RF pulses is 0.8ms. Therefore a reduction in scan times are noticed. To know that this option is on, input a '1' in the space provided. A '0' imputed in the space provided means Turbo Mode is turned off.

**NOTE:** Depending on the version of SmartPrep on your system you may or may not have the option of selecting Turbo Mode.

## **Contrast Mechanism**

We know SmartPrep is used in contrast-enhanced MR angiography. The contrast mechanism used in these procedures is gadolinium and not flow enhancement. Gadolinium has a T1 shortening effect, which shortens the T1 of blood from 1200ms to approximately 100ms. By using contrast, slice locations can be prescribed so the vessels run in plane and not through plane, resulting in fewer slice locations and shorter scan times.

# How to Use SmartPrep

This section provides the step-by-step instructions for using SmartPrep. Specifically, it describes how to:

- Scan with SmartPrep
  - Patient Preparation and Scan Set Up
  - Place the Tracker Volume
  - Place the Imaging Volume
  - Scan the series

## Scan with SmartPrep

### Patient Preparation and Scan Start Up

Use this procedure to setup a SmartPrep series. By using SmartPrep, the system prompts you when to begin giving contrast and automatically starts the scan for you. This takes the guesswork out of CEMRA timing, reducing the chances of missed boluses.

You should already know how to set-up a protocol for your system, only a brief review is explained. The rest of the procedure guides you through the SmartPrep setup process.

1. Select an appropriate coil.
  - Use SmartPrep for CEMRA of the carotids, thoracic aorta, abdominal aorta, celiac axis, SMA, renals, iliacs and lower extremity vessels.
  - See Volume 1, Chapter 3 for suggested coil positioning.
2. Make the patient comfortable and immobilize the area of interest with sponges.
3. As directed by the physician, set-up the patient IV catheter, and prepare the power injector (optional), according to your system specifications.
4. Landmark the patient and press the **[Move to Scan]**

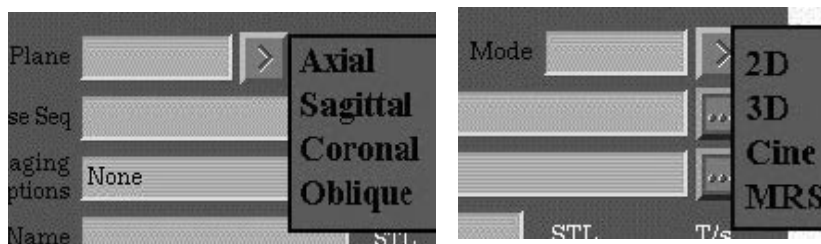


button.

5. Acquire an appropriate localizer series.

**NOTE:** Sometimes more than one localizer is needed to make sure proper volume coverage is included.

6. After localizer is reconstructed, click **[New Series]**.
7. Click **[Pt. Position]**. Select **Oblique, 3D**.



#### In Brief: Scan with SmartPrep

1. Select the appropriate coil.
2. Position the patient comfortably and immobilize the area of interest.
3. As directed by physician, set-up the patient IV catheter, contrast, saline and power injector (optional).
4. Landmark the patient and press **[Move to Scan]**.
5. Acquire an appropriate localizer series.
6. Click **[New Series]**. Then **[Pt. Position]**.
7. Select **Oblique, 3D** and **Fast TOF GRE** or **Fast TOF SPGR**.
8. Select **SmartPrep** and other appropriate on imaging options screen.

**NOTE:** Select **Multiphase** to capture both arterial & venous phases.

9. Complete the scan prescription. (Timing parameters, FOV, matrix and slice thickness).
10. Select **[User CV]** to enter SmartPrep imaging parameters.

### In Brief: Scan with SmartPrep Cont.

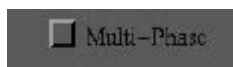
**NOTE:** Enter correct contrast dosage.

11. Select the appropriate series and image. Click **[Graphic RX]**.
12. Click **[Tracker]**.
13. Place tracker over the entry/main vessel.
14. Click **[Graphic Rx]**.
15. With the left mouse click on image. Angle 3D volume to desired position. Click **[Fallback]** if necessary. Then click **[Accept]** and **[Save Series]**.
16. Clear Message log.
17. Click **[Prepare to Scan]**, then **[Auto Prescan]**.
18. Click **[Scan]** and watch message window area.
19. Begin giving contrast when you see "Inject Contrast" message.
20. When you see the "Bolus Detected" message or hear the audible switch in the gradients, instruct the patient to hold his/her breath.

**NOTE:** You can prescribe a coronal orthogonal plane, just make sure volume includes the necessary imaging anatomy.

8. Select **Fast TOF GRE** or **Fast TOF SPGR** from the pulse sequences pull-down menu. Select **SmartPrep** from the imaging options menu.

**NOTE:** Select **Multiphase** if you want both the arterial and venous phase. See Volume 3 Chapter 1 for more detail on this option.



9. Complete the scan prescription
  - Select the scan timing parameters to minimize TR and TE.
  - Select FOV, matrix and slice thickness to balance spatial resolution and SNR.
  - Minimize scan time to allow for breath-held acquisitions.
10. Fill in the SmartPrep Imaging Parameters under the **[User CV]** button.
  - To ensure SPECIAL and Burst Scan Time/Turbo modes are on, a '1' should be entered in the space provided. To ensure these options are off, a '0' should be entered.

**NOTE:** Remember to enter the correct contrast dosage. See section on Threshold for more detailed information.

## Scan with SmartPrep Place the Tracker Volume

11. Select the appropriate series and image, then click **[Graphic RX]**.

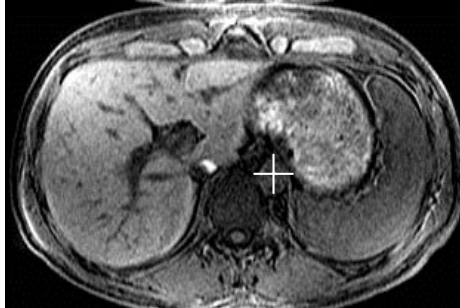
### Something to Think About...

- Sometimes it is best to use an axial slice to place the tracker. This way you can see the anterior and posterior portion of the vessel you are placing it in.
- Recommended typical tracker volume is 2x2x2cm. This helps to minimize tracker movement.

12. Once the Graphic RX screen appears, click **[Tracker]**.

13. Place the tracker pulse over the entry/main vessel by clicking left mouse button, no farther than 1/4 of the FOV above or below the center of the FOV.

**NOTE:** The tracker should be contained completely inside the vessel.



## Scan with SmartPrep

### Place the Imaging Volume

14. Click **[Graphic RX]** and the appropriate series and image.
15. Place the cursor in the image and click on the image. A 3D volume should appear.



**NOTE:** A midline slice is best for setting up your imaging volume, unless your patient is off center inside the magnet.

16. Make adjustments to the angle, if oblique plane is chosen, to insure proper coverage of anatomy. Click **[Fallback]** if necessary. Make sure the tracker is contained completely inside the imaging volume.

**NOTE:** Failure to include tracker completely inside the imaging volume results in SmartPrep failing to detect the bolus.


17. Click **[Accept]** when done.

## Scan with SmartPrep

### Scan the Series

18. Clear the message log. You can do this by simply left mouse clicking on the message window and clicking **[Clear]**. Click **[Save Series]**.
  19. Click **[Prepare to Scan]**, then **[Auto Prescan]**.
  20. Click **[Scan]** and watch the message window area.
- NOTE:** Do not inject contrast until prompted.
21. The first message to appear is "Acquiring Baseline Data." This message then is followed by "Inject Contrast." Now you can begin giving contrast.

Baseline Phase	Monitor Phase	Scan Phase
Do Not Inject	Inject	Breath Patient During Delay

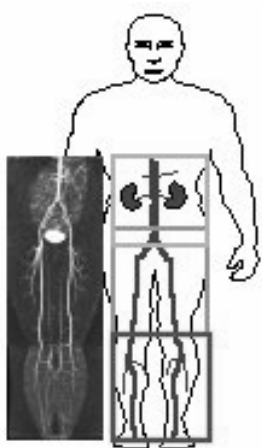


22. When the "Bolus Detected" message appears and/or you hear the audible switch of the gradients, instruct the patient to hold his/her breath. Allow scan to complete.

## Chapter 4

# Bolus Chasing with SmartStep

Where Am I?



## Introduction

This chapter explains the automated multi-station technique for contrast-enhanced peripheral vascular angiography. It contains the step-by-step instructions to help you learn how to:

- Localize multiple stations.
- Prescribe a contrast-enhanced series with SmartStep.
- Auto-PreScan multiple stations.
- Create a mask for subtraction.
- Scan the contrast-enhanced series (both arterial and venous phases).

In addition, this chapter answers the following questions:

1. What SmartStep is used for?
2. What is a meta-series?
3. How does elliptic-centric K-space filling affect image contrast?
4. What is Turbo mode?
5. What is masking?

---

# About... SmartStep

This section presents the concepts necessary to successfully complete the SmartStep process. Specifically you need to understand:

- Description of SmartStep
- Meta-series
- K-space Filling
- Turbo Mode
- SPECIAL
- Contrast Mechanism
- Image Characteristics

## Description of SmartStep

SmartStep (Multi Station) is a feature that provides automatic table movement and switching of prescribed coils between stations, including from body to phased array, and/or between phased array elements. SmartStep is used with 3D Fast TOF GRE/SPGR and 3D Fast GRE/SPGR.

## Meta-series

A Meta-series consists of multiple series linked together. You can link up to 4 series together, at one time. By doing so, the scanner automatically moves the table after each series to its next pre-determined point, as well as switch on and off the appropriate coils, you selected at the time of set-up.

**NOTE:** Once Multi-station is selected the system automatically creates the following meta-series, once the first series is saved. You can then edit the changes you want made to the parameters.

You have the ability to select scan parameters unique for each station, with the exception of plane, Scan Mode and Pulse Sequence. There is also an option to obtain mask and venous phase images. Up to 256 slice locations and 512 images per station are allowed.

**NOTE:** Maximum images allowed is dependant on system memory.

## K-space Filling

When using SmartStep in conjunction with SmartPrep, K-space is either filled centrally or Elliptic-centrally. (If SmartPrep is not used, K-space is filled linearly.) Both processes fill the center portion of K-space first. By doing so, the images have the best contrast possible.

**NOTE:** For more detailed information on Centric K-space and Elliptic-centric K-space filling, refer to the SmartPrep chapter.

## Turbo Mode

Turbo Mode - (Only available on HiSpeed and EchoSpeed). It reduces the width of the RF pulse and allows shorter TR periods. Without Turbo Mode on, the duration of the RF pulses is approximately 1.6 ms. With Turbo Mode on, the duration of the RF pulses is approximately 0.8 ms. Therefore, a reduction in scan times is noticed. To know that this option is on input a '1' in the space provided. A '0' inputted in the space provided, means Turbo Mode is turned off.

**NOTE:** Turbo 1 and Turbo 2 is now available on Hispeed and Echosped systems.

## SPECIAL

SPECIAL is Spectral Inversion at Lipids. This is a fat suppression technique. It uses a 180 inversion pulse to nullify the signal from fat.

SPECIAL is not compatible with Elliptic-centric K-space filling.

**NOTE:** For more detail on SPECIAL, see Volume 3, Chapter 1.

## Contrast Mechanism

SmartStep is used to chase a bolus of contrast down the lower extremities. In contrast-enhanced MRA, the mechanism is the T1 shortening effect of gadolinium and not flow enhancement. Gadolinium shortens the T1 of blood from 1200 ms to approximately 100ms. Consequently, slice locations can be

prescribed so that the vessels run in plane and not through plane.



Flow enhancement



Contrast enhancement

# How to Use SmartStep

This section provides the step-by-step instructions for using SmartStep. Specifically, it describes how to:

- Scan with SmartStep
  - Patient Preparation and Localizers Set Up
  - Set Up of AutoStep Series
  - Prescan Series
  - Scan Prescribed Series

## Scan with SmartStep

# Patient Preparation and Localizer Set Up

Use this procedure to setup a SmartStep series. By using SmartStep, the system automatically advances the table and starts the next prescribed series.

You should already know how to set-up a protocol for your system; only a brief review is provided. The rest of the procedure guides you through the SmartStep setup process.

**NOTE:** It is suggested that you use SmartPrep if you have it on your system. This takes the guesswork out of bolus timing.

1. Select the appropriate coil.
  - If using SmartStep for peripheral run-off either the body coil or a peripheral vascular coil.

**NOTE:** See coil chapter for specific coil safety.

2. Position the patient.
  - It is recommended that you position the patient feet first. This ensures that the patient's head is close to the magnet entrance, making it easier to give breathing instructions to the patient. Although you can also position the patient in the head first position.
  - The patient should bring his or her arms above their head during the scan to minimize a wrap-around artifact and for easy access to the IV site. If your patient cannot bring their arms above their head you can elevate them on cushions to also help minimize this artifact.
  - Elevate the patient's legs with sponges so that they are parallel to the table. (Not needed if using the PV Array coil.)
  - Placing respiratory bellows on the patient may also prove to be helpful in detecting when and how long a patient is suspending respiration, during breath holding techniques.

**NOTE:** See Working Safely chapter for specific patient safety.

### In Brief: Scan with SmartStep - Patient Preparation & Localizer Set Up

1. Select the appropriate coil. (PV Array coil preferably).
2. Position the patient.
3. As directed by physician, set-up the patient IV catheter, contrast, saline and power injector with enough KVO for 1 hour. (optional).
4. Landmark and press **[Move to Scan]** button.


**NOTE:** You may want to record middle and bottom station offsets, if you choose not to use the suggested offsets provided in the protocol. There may be coil cut off if the recommended offsets are not used.

5. Acquire the first station localizer series. Type-in "Top Loc" as series description.
6. Select **[Save Series]**, then **[AutoScan]**.
7. Select "Top Loc" series, right-click **[Copy/Paste]**. Select the new series and click **[View/Edit]**.

**In Brief: Scan with SmartStep - Patient Preparation & Localizer Set Up Cont.**

8. Change the coil type, series description (Mid Loc), and scanning range offset to I420.
9. Select "Mid Loc" series, right-click **[Copy/Paste]**. Select the new series and click **[View/Edit]**.
10. Change the coil type, series description (Bot Loc), and scanning range offset to I840.
11. Turn **[AutoScan]** off.
12. Check to ensure sufficient disk space. Click **[New Series]**.

3. As directed by the physician, set-up the patient IV catheter and prepare the power injector (optional), according to your system specifications.

4. Landmark the patient and press **[Move to Scan]**  .

- Landmark your first station only. This is the area you wish to start scanning first.
- You may use suggested off-sets for the remaining stations or after landmark is pressed, turn on the align light and record the location at the mid portion of patient's thigh, then record location at the mid portion of patient's calf.
- If recommended offsets are not used with the PV coil, images may result in coil cut-off.

5. Acquire the first station localizer series.

- Select appropriate coil type and enter "Top Loc" for series description.
- Select sagittal plane, 2D mode, and FSPGR, FSE or SE for pulse sequence.
- Input 256x128 for matrix, 1Nex, 45 FOV, 5 slice thickness, 0 for spacing and a scanning range of L150 to R150.

6. Click **[Save Series]** and then **[AutoScan]**. This initiates the series to start scanning.

7. While the first station is scanning highlight series 1, right-click **[Copy/Paste]**. Highlight the new series and click **[View/Edit]**.

8. Change coil type if necessary. Change series description to "Mid Loc". Change the scanning range to L200 to R200 and change inferior offset to I420. Click **[Save Series]**.

**NOTE:** Only use suggested inferior offset if your patient is in the PV Array coil.

9. While the second station is scanning highlight series 2, right-click **[Copy/Paste]**. Highlight new series and click **[View/Edit]**.

10. Change coil type if necessary. Change series description to "Bot Loc". Change inferior offset to I840. Click **[Save Series]**.

**NOTE:** Only use suggested inferior offset if your patient is using the PV Array coil.

- When the system finishes pre-scanning and scanning each series, turn **[AutoScan]** off.

**NOTE:** Not turning AutoScan off starts the next series before you have set up the entire metaserie.

- Check the disk space to ensure sufficient room for the contrast-enhanced series. If necessary archive previous exams and then remove them from system disk to ensure sufficient space. Click **[New Series]**.

**NOTE:** Less than 20 percent is considered insufficient disk space and may prevent entire series reconstruction. Images could be lost. Scanner may stop part way through exam. It would then have to be repeated, when contrast has flushed from patient's system.

## Scan with SmartStep

### Set Up of AutoStep Series

- Enter in the appropriate coil type to scan the first station. Enter "3D Top" for the series description. Select Oblique plane, 3D mode and fast 3D TOF SPGR for pulse sequence.

**NOTE:** The scanning plane for multi-stations (the first through the third station) must either be oblique or orthogonal. They cannot be mixed.

- Select imaging options: multi-station, ZIPx2, ZIP 512 and SmartPrep (optional). Choose Min. TE, 45 Flip angle, RBW 31.5, 45 FOV, 3 Slice Thickness, between 32-40 for the slice loc., 256x128 for matrix, 1 NEX, 0.8 phase FOV, and Auto-shim.

**NOTE:** All imaging options except multi-station are can be used, but not required. Selecting ZIP 1024 may require to much system memory, it is not recommended.

- Click **[Contrast]** and fill in the correct amount.
- From the **[Vascular]** Options Menu select collapsed image On and 0 projections. On the **[User CV]** Menu select 3 stations, 50 second monitor period, 5-8 second delay Elliptic Centric is **off**.
  - If SmartPrep is selected, please see SmartPrep chapter for explanation of User CV parameters and for instructions on placing tracker volume.

### In Brief: Scan with SmartStep - Set Up of AutoStep Series

- Make coil selection. Type "3D Top" for series description. Select Oblique, 3D mode and Fast TOF SPGR.
- Select imaging options.
- Click **[Contrast]** and fill in the correct amount.
- Select **[Vascular]** options menu, choose 0 projections. Select **[User CV]** menu, choose 3 stations, 50 sec. monitor period, 5-8 sec. delay and Elliptic Centric is **off**.
- Click **[Graphic Rx]**. Select **[Series]**, choose "Top Loc" series.
- Click on image to place 3D imaging volume on.
- Select and place tracker volume if needed. Select **[Save Series]**.
- Highlight the next meta-series and click **[View/Edit]**.
- Change coil type. Change series description to "3D Mid". Select **[User CV]**, turn elliptic-centric **On**. Select **[Graphic Rx]**, click **[Series]** and select Mid Loc series.

**In Brief: Scan with SmartStep - Set Up of AutoStep Series Cont.**

10. Click to place the 3D volume then click **[Fallback]**. Make any other imaging parameter changes.
11. Click **[Accept]** and **[Save Series]**.
12. Select the next station and click **[View/Edit]**.
13. Change coil type, series description to 3D Bot. Select **[User CV]**, turn elliptic-centric **On**.
14. Select **[Graphic Rx]**, click **[Series]** choose "Bot Loc" series.
15. Click to place the 3D volume then click **[Fallback]**. Make any other imaging parameter changes.
16. Repeat step 11.

- A maximum of 4 stations can be prescribed.
5. Select **[Graphic Rx]**. Once the graphic menu opens select **[Series]** and choose the "Top Loc" series.
  6. Choose mid-sagittal slice and place the cursor in the image and click on the image. A 3D volume should appear. Make adjustments to the angle to insure proper coverage of anatomy. Be careful to keep the center FOV "tick" mark at I/S 0mm.
  7. Select and place the tracker volume if needed. When done click **[Save Series]**. Now you should see this series has 3 meta-stations. (You may want to take another loc series of axials for better placement of tracker.)
- NOTE:** If using Smartprep Tracker is only placed on the first station. It only needs to signal for contrast once.
8. Highlight the next meta-series and click **[View/Edit]**.
  9. Change coil type if necessary. Change the series description to "3D Mid". Select **[User CV]**, turn elliptic-centric **On**. Select **[Graphic Rx]** and when menu opens click **[Series]** and select Mid Loc series.
  10. From the selected series pick an image that best shows the proper angle of both legs, adjust the angle and coverage as needed and after placing the 3D volume. Click **[Fallback]**. Use I/S offset of I420, if 45 FOV is used. Make any other imaging parameter changes if necessary.
  11. When done, click **[Accept]** then **[Save Series]**.
  12. Highlight the next station and click **[View/Edit]**.
  13. Change coil type if necessary. Change the series description to "3D Bot". Select **[User CV]**, turn elliptic-centric **On**. Use I/S offset of I840 if 45 FOV is used.
  14. Select **[Graphic Rx]** and when menu opens click **[Series]** and select "Bot Loc" series.
  15. From the selected series pick an image that best shows the proper angle of both legs, adjust the angle and coverage as needed and after placing the 3D volume. Click **[Fallback]**.

### In Brief: Scan with SmartStep - Prescan the Series

1. Select series 3D Bot, click **[Prepare to Scan]** then **[Auto Prescan]**.
2. Select series 3D Mid, click **[Prepare to Scan]** then **[Auto Prescan]**.
3. Select series 3D Top, click **[Prepare to Scan]** then **[Auto Prescan]**.

Use I/S offset of 1840, if 45 FOV is used. Make any other imaging parameter changes if necessary.

16. Repeat step 11.

## Scan with SmartStep Prescan the Series

1. Now you are ready to prescan the saved series. Highlight the series labeled 3D Bot click **[Prepare to Scan]** and **[Auto Prescan]**.
2. Highlight 3D Mid series click **[Prepare to Scan]** and **[Auto Prescan]**.
3. Highlight 3D Top series click **[Prepare to Scan]** and **[Auto Prescan]**.

## Scan with SmartStep

### Scan the Prescribed Series

### In Brief: Scan with SmartStep - Scan the Prescribed Series

1. Select **[Autostep]**, choose either Arterial, Mask and/or Venous acquisitions you which to acquire, click **[Accept]**.
2. Select 3D Top series (1st Mask meta-series), click **[Prepare to Scan]**.
3. Prepare for patient injection of contrast. Click **[Clear]** to clear message log. Click **[Close]**, then right-click on **[AutoStep]**.
4. Select **[End Exam]** when all images have reconstructed

#### Something to Think About...

- Make sure table is free of all sheets, blankets, pillows, IV tubing, headphones or anything that could obstruct table movement.

1. After 3D Top series has finished prescanning, *Left-click* the **[AutoStep]** button. The AutoStep menu appears, here you may choose to acquire a Mask Acquisition and/or Venous Acquisition. Arterial Acquisition is the system default and is always selected. Click **[Accept]**.

**NOTE:** The Rx Manager now reflects the Meta-Series chosen in the AutoStep menu. If both Mask and Venous Acquisitions are selected, the Rx manager indicates "M" for Mask, "A" for arterial, and "V" for Venous. All series indicate "PSCD" as the state, which means prescanned, therefore they do not have to be prescanned again.

2. Highlight 3D Top series click **[Prepare to Scan]**.
  - **If Mask acquisition was selected, the first series is annotated in the RX Manager by M 3D Top 1/3. Instruct patient to hold his/her breath. Right-click the [AutoStep] button. The system automatically deactivates SmartPrep if selected and start**

**scanning. After the 3D Top series has scanning patient can resume normal breathing. The table automatically moves to next station and starts the next scan. System stops after last station.**

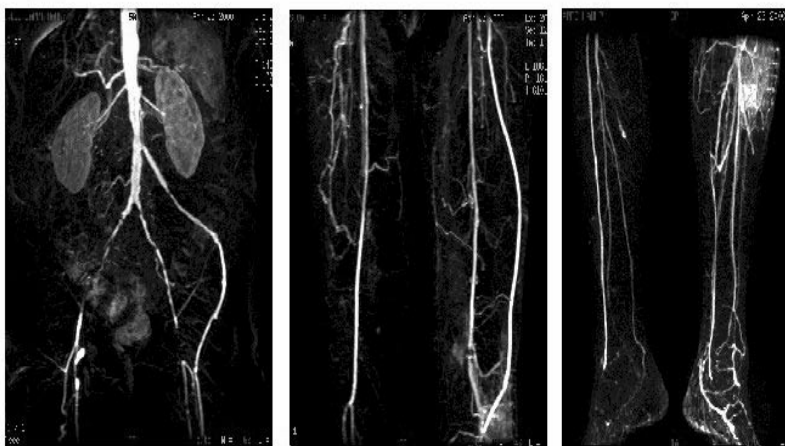
**NOTE:** It is recommended that a Mask run is acquired whenever performing this type of scan. This insures correct volume placement and helps to improve image quality when subtraction post-processing techniques are used.

3. Prepare for patient injection of contrast. Clear the message log. You can do this by simply left-clicking on on the message window and click **[Clear]** then **[Close]**. *Right-click* the **[AutoStep]** button.
  - SmartPrep starts as usual. The system prompts you in the message window when to begin giving contrast. Once contrast is detected instruct patient on breath holding technique. Once first station is done scanning, the patient can resume breathing.
  - System automatically continues scanning through the next 2 series and if Venous acquisition was selected it automatically moves to the first station again and starts scanning. This time, the system will not pause for you to give breathing instructions, therefore when you see the table moving to the first station give breathing instructions again.

3D Top Series

3D Mid Series

3D Bot Series



4. Click **[End Exam]** when images have all reconstructed.

## Chapter 5

# Imaging Real Time with iDrive

Where Am I?



## Introduction

This chapter explains how to image real time with iDrive™. This chapter provides key concepts regarding factors that affect frame-rate, home and bookmark images, cursor-control, cut plane tools, image buffer, and application tips on where to use interactive imaging. It contains the step-by-step instructions to help you learn how to:

- Prescribe a Real Time Sequence
- Drive Through the Image Volume
- \*Adjust Image Contrast (iDrive Pro)
- Define Cut Planes
- Prescribe Scan Locations for a Series
- \*Time a Bolus (iDrive Pro)
- Review and Manage the Image Buffer
- \*Save Images (iDrive Pro)
- Use iDrive to Scan Complex Anatomy

NOTE: \*Additional (purchasable) iDrive Pro options are annotated. When a feature is unavailable, the corresponding button is disabled.

In addition, this chapter answers the following questions:

1. What factors affect frame rate?
2. What is the difference between home and bookmark images?
3. What is the cursor control?
4. When do you use the cut plane tools?
5. What is the image buffer?
6. What applications do you use interactive imaging for?

NOTE: \*Additional (purchasable) iDrive Pro options are annotated. When a feature is unavailable, the corresponding button is disabled.

# About... Imaging Real Time with iDrive

This section presents the concepts necessary to successfully complete imaging real time with the iDrive process. Specifically, you need to understand:

- iDrive
- Factors that Affect Frame Rate
- Home and Bookmark Images
- Cursor Control
- Cut Plane Tools
- Image Contrast Buttons
- Orientation Buttons
- Other Controls
- Image Buffer
- Applications

## iDrive

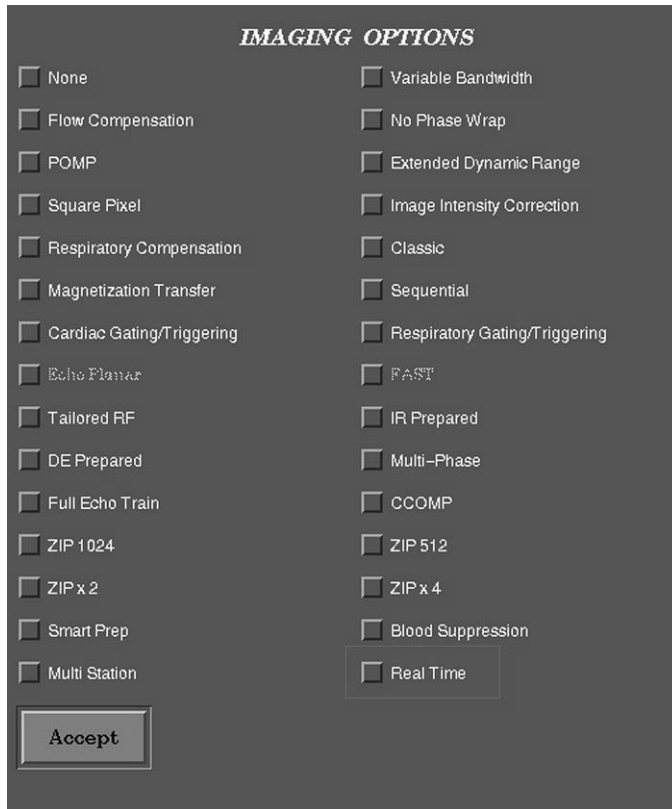
The standard iDrive feature is a Real Time Interactive Acquisition (RTIA) that can be used for navigating through the patient anatomy for rapid visualization, and monitoring temporal physiological events including patient breathing, kinematic studies, and bolus activity. Real Time Interactive images can also be used for directly prescribing scan planes of other series in the exam.

**NOTE:** iDrive Pro is an optional feature that enables the use of the orientation, contrast, FOV, tools, and timer. It also includes the ability to define, save, and view a range of images acquired with real time imaging.

iDrive is based on a Fast GRE (FGRE) sequence that has been specially modified to provide minimal TR times, interactive contrast, and geometry control. iDrive Pro is contained within a series, which can be prescribed directly from the Scan Rx area, or retrieved as a saved protocol. As a series, it can also be saved as a stand-alone protocol or as part of a larger protocol with an existing batch series. It can be cut, copied or pasted using the RX Manager tools. It can be used in a protocol that is being Auto Scanned. Once the series has been prescanned, starting the series with the **[Scan]** button brings up a new user interface, with unique controls for using the iDrive feature. After scanning using the iDrive feature, click the **[Close]** button to return you to the original user interface and the Scan Rx area.

While the images are being acquired, the imaging plane can be tilted and/or rotated. This allows for instantaneous visualization of anatomy in orthogonal, off axis, or double oblique planes. To manipulate the scan plane, click and/or drag the cursor. The shape, configuration, and function of the cursor changes, depending on the area of the window in which the cursor is located, allowing for different functions. Real Time Interactive imaging also allows the tissue contrast of the acquired images to be modified. This is achieved with selectable pulse sequences and imaging options.

To initiate the iDrive scan, select FGRE, go to imaging options, and select Real Time. Real Time is compatible with FC, NPW, and SqP.

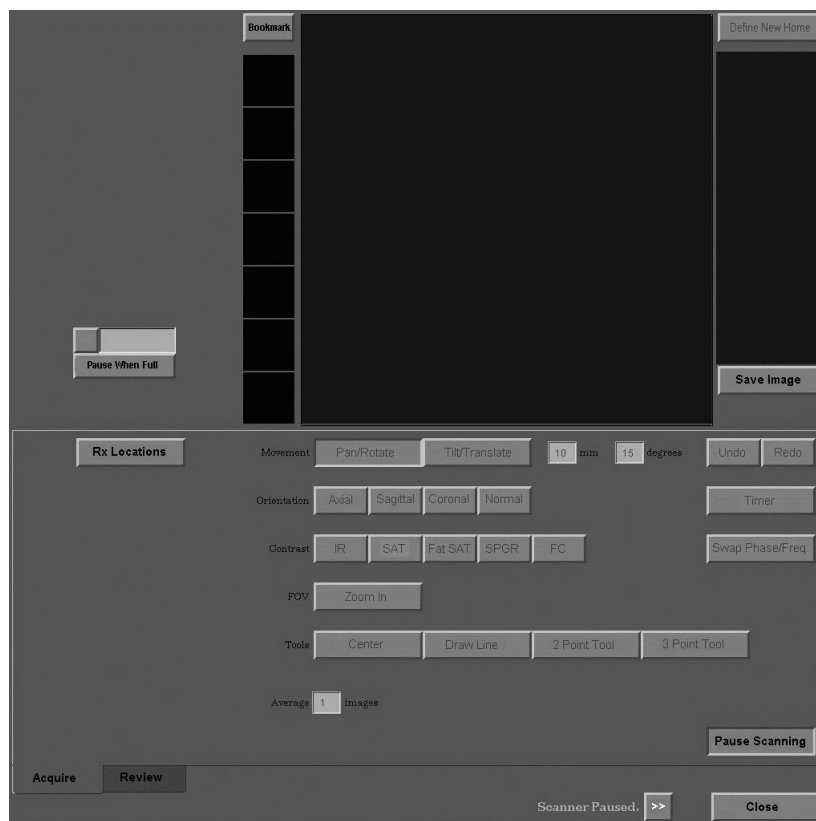


NOTE: See Prescribing a Real Time sample protocol in Scanning with iDrive.

When the iDrive Pro Real Time Interactive feature is initiated, the Acquire Tab Card window is displayed. The tools and functions available on the Acquire Tab Card window help you manipulate the scan plane and contrast of the images. These actions are a combination of button selections and cursor manipulations on the image screen itself.

NOTE: When the iDrive Real Time Interactive Imaging application is launched, Archive, Network and Filming operations are automatically paused by the system. However, there is **no** notification of the pause status. These processes automatically resume when iDrive is closed.

NOTE: The start-up of Real Time Interactive imaging is not instantaneous. There is a pause of less than six seconds before the system is ready to display the image.



---

## Factors that Affect Frame Rate

The gradient platform and array processor configuration are the hardware components that affect the maximum number of images or frames per second that can be generated.

- Scan parameters also affect the frame rate:
  - TR
  - NEX
  - Frequency matrix
  - Phase matrix
  - Phase FOV
  - Bandwidth
  - FOV
  - Slice Thickness
  - Fractional vs. full TE
  - Coil Selection (Body coil gives more fps than a multicoil configuration)

### TR

- The TR affects the frame rate because it affects the scan time per image. As TR increases, scan time increases and frame rate decreases.
- Minimum TR is the only option.
- The minimum TR displayed represents the smallest TR possible for the selected imaging parameters. Only “minimum” is available in the TR shortcut menu because, in most cases, you want to scan as fast as possible. The PSD has to calculate and predict for all possible user desired parameters ahead of time (for example: Fat SAT, Flow Comp, IR prep, and spatial SAT) which could potentially be selected simultaneously and interactively during RTIA.

### NEX

- Nex affects the frame rate because it affects the scan time per image.
- NEX affects the number of times each phase encoding step is collected. A NEX of 2 collects each phase encoding step twice.
- As NEX increases, scan time increases and frame rate decreases.
- Keep NEX at a minimum.

### Frequency Matrix

- The frequency matrix affects the echo readout time. As the frequency matrix increases, the system must read more samples during the echo, thereby increasing the minimum TR.
- Balance spatial resolution needs with temporal resolution needs.
- The lower the Frequency matrix, the faster the acquisition.

### Phase Matrix / Phase FOV

- The phase matrix and the phase FOV determine the total number of phase encoding steps that must be acquired. A phase matrix of 256 and a phase FOV of 0.8 require 206 phase encoding steps to be acquired.
- The system “plays out” the pulse sequence once for each phase encoding step. Therefore, as the phase matrix and phase FOV increase, the scan time also increases.
- Balance spatial resolution needs with temporal resolution needs.
- The lower the Phase matrix, the faster the acquisition.

### Bandwidth

- Bandwidth affects the echo readout time. As bandwidth decreases, the system samples slower during the echo; this, in turn, increases the minimum TR.
- Balance signal-to-noise needs with temporal resolution needs.

### FOV and Slice Thickness

- The FOV and slice thickness affect the workload of the gradients. Thicker slices result in both higher SNR and faster frame rates.
- A small FOV and/or a thin slice require a steep gradient magnetic field across a small area.
- The system reduces the maximum frame rate to compensate.
- Balance spatial resolution needs with temporal resolution needs.

- Larger FOVs generally decrease the minimum TR and thus increase the imaging frame rate. Smaller FOVs may require smaller Bw.

The following chart is a guide to help you understand frame rate:

<b><i>If INCREASED</i></b>	<b><i>Then frame rate is</i></b>
<b>TR</b>	<b>Decreased</b>
<b>NEX</b>	<b>Decreased</b>
<b>Frequency Matrix</b>	<b>Decreased</b>
<b>Phase Matrix</b>	<b>Decreased</b>
<b>Phase FOV</b>	<b>Decreased</b>
<b>Bandwidth</b>	<b>Increased</b>
<b>FOV</b>	<b>Increased</b>
<b>Slice Thickness</b>	<b>Increased</b>

## Home and Bookmark Images

### Home Images

The system acquires and displays three orthogonal images on the acquisition window at the start of an iDrive series. These are the home images.

iDrive Home Images are displayed in the following order:

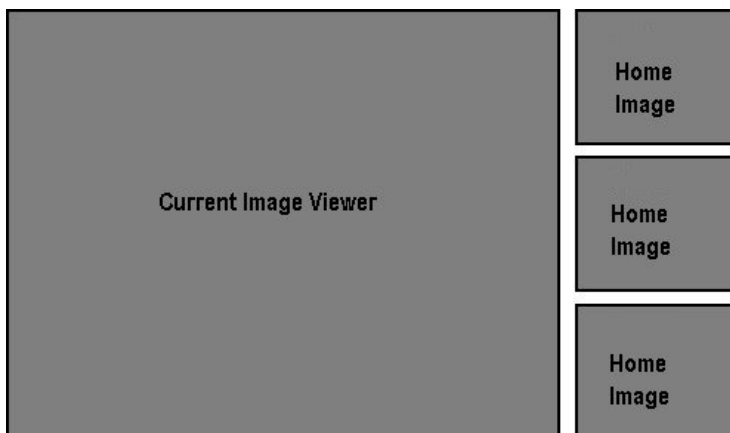
- The top-most Home Image is the same imaging plane as prescribed in the scan parameters during protocol prescription.
- The prescribed Image Plane and selected Frequency Direction determine the ordering of the orthogonal home image planes. The following table shows the order of the orthogonal image planes.

**NOTE:** All images are presented in a “most normal” orientation.

<u>Prescribed Image Plane</u>	<u>Frequency Direction (SPF or No SPF)</u>	<u>Home Image Order (top to bottom) (prescribed plane, phase, frequency)</u>
Axial	No SPF	Axial, Sagittal, Coronal
Sagittal	No SPF	Sagittal, Coronal, Axial
Coronal	No SPF	Coronal, Sagittal, Axial
Axial	SPF	Axial, Coronal, Sagittal
Sagittal	SPF	Sagittal, Axial, Coronal
Coronal	SPF	Coronal, Axial, Sagittal

Home images are created axial, sagittal, and coronal at the location prescribed in the scanning range. They are automatically saved to the database.

The reference lines on the home images indicate the location of the current image in the viewer in relation to the home images.



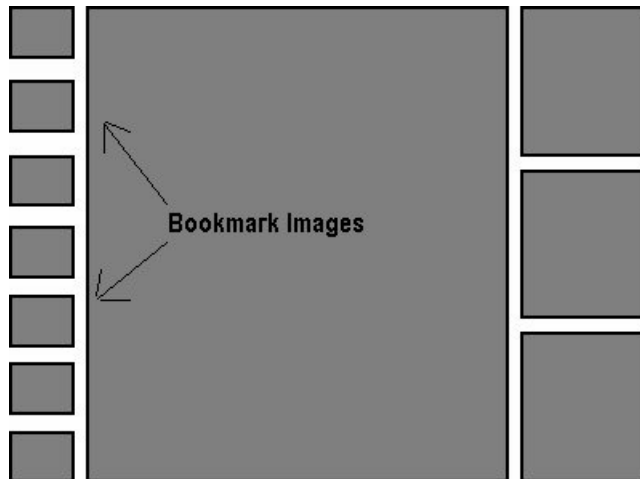
- The home images are essentially a three-plane localizer.
- Use your home images to reset your current scan plane.
- You can replace your home images with new ones by clicking the **[Define New Home]** button, which is located on the Acquire Tab window in the upper right hand corner above your bookmark images.



## Bookmark Images

The current image in the viewer can be saved as a bookmark.

- A bookmark saves the location as well as the contrast setting. Left-click the **[Bookmark]** button to save the displayed image as a bookmark. If all the slots are full a message is displayed.
- Bookmark is allowed in both Acquire and Review mode.
- You can use the bookmark images to reset the current scan plane and location to that of the selected bookmark image.
- To recall a bookmarked image, left-click on the bookmarked image to move the real-time image to the anatomical location and contrast settings of the bookmarked image.
- You can replace your bookmark images with new ones. Right-click on one of the occupied bookmark images to replace it with the current real-time image.
- Bookmark images are not automatically saved to the database.



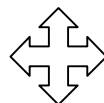
## Cursor Control



### Pan Cursor

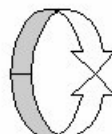
- The pan cursor changes the centering of the image within the viewer, but does not change the scan location or plane.

- The pan cursor is active in the center of the image when the pan rotate key is selected.



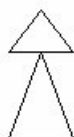
### Rotate Cursor

- The rotate cursor turns the image within the viewer, but does not change the scan location or plane.
- The rotate cursor is active on the periphery of the image.



### Translate Cursor

- The translate cursor changes the scan location in millimeter increments but does not change the scan plane. The millimeter increment can be adjusted.
- The translate cursor is active in the center of the image.



**RAS**



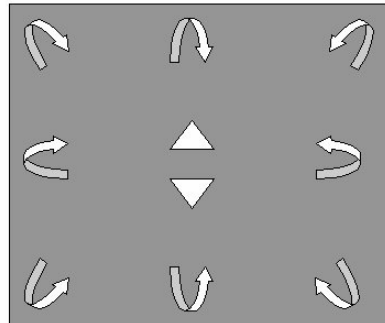
**LIP**

NOTE: Rotate and Translate cursor have a degree and increment indicator located in the lower right corner of the scan window, which defaults to 10mm and 15 degrees. This is especially helpful for prescribing thin slices.

### Tilt Cursor

- The tilt cursor changes the scan plane by tilting it in degree increments. The degree increment can be adjusted.
- The tilt cursor is active on the periphery of the image and provides single oblique motion at the top, right, bottom, and

left positions. The tilt cursor provides double oblique motion at the corner positions.



## Cut Plane Tools



Real time imaging enables special tools that allow you to graphically prescribe cut planes through the imaging volume.

### Draw Line

- Draw line allows you to prescribe a cut plane by drawing a line on the image in the viewer.
- The image plane becomes the plane defined by the line.



**This line defines a scan plane that runs along the optic nerve.**

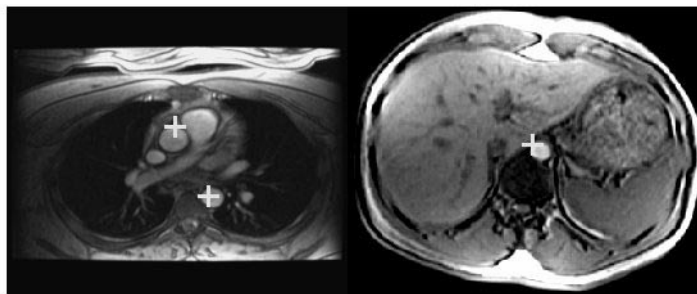
- **2-Point** mode allows you to prescribe a cut plane by depositing two points. The two points can be placed on the same or different image locations.

- The scan plane becomes the plane orthogonal to (perpendicular to) an imaginary line connecting the two points.



**These 2 points define a scan plane perpendicular to the optic nerve. The nerve will be viewed on end in the resulting image.**

- **3-Point** mode allows you to prescribe a cut plane using three points. The three points can be placed on the same image or different image locations.
- The scan plane becomes the plane defined by the three points.
- 3-Point mode is typically used with complex anatomy that requires you to work with multiple images during prescription.



**These 3 points define a scan plane along the thoracic aorta.**

### Image Contrast Buttons



The contrast buttons apply tissue-sensitive parameters to the real time image. For instance, these include tissue-specific techniques, such as fat suppression. Pre-saturation pulses or flow compensation can be applied. The contrast tools are

selected by either a push button or a toggle button as indicated below.

### Push Buttons

- IR
  - Single-shot Inversion Recovery pulse. Unique to Real Time Interactive imaging.

### Toggle Buttons

- SAT
  - Spatial Saturation. Uses two sat bands parallel to slice which track the RTIA (Real Time Interactive Acquisition) imaging plane.
  - Selecting Spatial SAT in an iDrive series results in unique SAT behavior. If the series is prescribed with a SAT pulse pair (e.g., S and I, R and L, A and P), toggling SAT off and on at the Acquire Tab window, after iDrive has been initiated, turns both the SAT pulses off and on. Likewise, if no SAT pulses are prescribed during series prescription, selecting SAT during Real Time Interactive imaging turns on a SAT pulse pair. You do not have the option of selecting a single spatial SAT pulse from the RTIA Acquire Tab window.
  - However, when a single SAT pulse is selected during series prescription and then turned off during iDrive, toggling SAT on again at the Acquire window turns on only the single, original SAT pulse prescribed. You do not have the option of turning on a SAT pulse pair once Real Time Interactive imaging is started.
  - Note that the displayed SAR values differ when a single SAT pulse versus a SAT pulse pair is prescribed. As you would expect, during series prescription you will see the SAR for a single SAT pulse is less than that for a SAT pulse pair. When no SAT pulses are selected during series prescription, the SAR displayed assumes a “worst case scenario.” Because you are able to interactively select SAT during an iDrive session, the SAR value is based on a worst case scenario of parameter selections. This scenario assumes a SAT pulse pair is selected during iDrive imaging.
  - Concatenated SAT is automatically used in iDrive acquisitions in both orthogonal and oblique scan planes. It is not necessary to click the **[Concat SAT]** button at the SAT window to invoke Concatenated SAT pulses.

NOTE: Disregard the error message that occurs when selecting Concatenated SAT in an oblique iDrive scan prescription: “Concat SAT not allowed for obliques.” iDrive sequences automatically use Concatenated SAT.

- Fat Sat
  - Chemical (fat) Saturation.
- SPGR
  - RF Spoiling.
- FC
  - Flow Compensation. Used for gradient moment nulling.

### Orientation Buttons



The positioning tools of the **[Axial]**, **[Sagittal]**, **[Coronal]**, and **[Normal]** buttons move the real time image to the specified orthogonal orientation. For example, when the **[Axial]** button is selected, the real time imaging plane moves to the axial plane at the current image center point. Click the **[Normal]** button to move the real time image to a normal viewing orientation at the current image center point.

### Other Controls

These controls are features that may be helpful in acquiring the Real Time Interactive images. Selecting specific controls improves the image quality of the Real Time Interactive imaging. Select controls to define, save, and recall the range of “images” for acquisition.

### Message Area



The message area is a single text line at the bottom of the Real Time Interactive window. It is used to convey warning and error messages. The message area is visible regardless of which tab is selected. Error and warning messages that are displayed are cleared when any action is performed with the user interface.

To the right of the message line is a double arrow **[>>]** button, when selected, displays a dialog box with a scrollable list of the previous messages that have been displayed.

Click the **[Dismiss]** button to close the dialog box. Note that the current error or warning message is not cleared when this dialog box is closed.

### Single Image Save

Clicking the **[Save Image]** button allows the currently displayed Real Time Interactive image to be saved to the image database. This functionality is available in both Acquire and Review.

The saved image is listed in the Browser and may be viewed in the Viewer or Mini Viewer.

NOTE: The Home Images are saved when iDrive Pro is started, regardless of using Save Image.

### Closing Real Time Interactive Imaging

Clicking the **[Close]** button loses the Real Time Interactive imaging session. Once you close real time, you cannot access images that have not been saved.

Closing Real Time Interactive imaging functionality is available in both Acquire and Review. Closing the session hides the real time user interface and returns control to the Scan Rx Desktop.

### Toggle Buttons

- **Undo**
  - The **[Undo]** button reverts the real time image to its state before the last geometry or contrast change, and has the ability to go back several steps.
- **Redo**
  - The **[Redo]** button returns the real time image to the state before the last undo was performed.

NOTE: When it is not possible to undo and/or redo, the corresponding buttons are disabled.

- **Timer**
  - The **[Timer]** button turns the timer on and off. The timer is reset to zero and the on-image timer readout is displayed. The timer readout updates with each new image acquired and displayed. When the **[Timer]** button is deselected, the timer readout is removed from the image.

- **Pause Scanning**
  - Selecting the **[Pause Scanning]** button stops Real Time Interactive imaging. Selecting the **[Pause Scanning]** button again changes to the deselected state and causes Real Time Interactive imaging to resume.
- **Zoom In**
  - Selecting FOV the **[Zoom In]** button decreases the displayed FOV of the real time image by 25%. Selecting the **[Zoom In]** button again changes to the deselected state and reverts back to the original FOV.
- **Swap Phase/Freq.**
  - Selecting the **[Swap Phase/Freq.]** button swaps the phase and frequency-encoding axes, and the **[Swap Phase/Freq.]** button stays selected. Selecting again reverts to the prior setting.

### Type-in Text Boxes

**Averages** is a type-in text box to specify the number of images to be averaged to create the real time image. This improves signal to noise as well as motion averaging. The number in this text box specifies the number of reconstructed images to be automatically averaged. Averaging occurs as long as the real time image location and contrast setting are not changed. A value of 1 effectively means no averaging. The maximum allowable value is 8.

### Rx Locations

Clicking the **[Rx Locations]** button reveals the IGRx tool. Clicking again hides the IGRx tool.

The IGRx tool is used to:

- Prescribe the start and end locations of a Real Time Interactive imaging series (2D or 3D) and apply these locations to a series in the RX Manager.
- Retrieve the start and end locations of a batch mode series (2D or 3D), if previously prescribed.
- Prescribe the initial scanning location of another Real Time Interactive imaging series.
- Retrieve the initial scanning location of a Real Time Interactive imaging series.

NOTE: The series you wish to prescribe must be downloaded in the Rx Manager and highlighted prior to starting Real Time Interactive.

## **IGRx Buttons**

### **Set Start and Set End**

The **[Set Start]** and **[Set End]** buttons set the current position and angle of the real time image as a start or end location. When defined, the RAS coordinates of the image center point are displayed. These locations may be applied to a series in the RX Manager by clicking the **[Apply Locations]** button.

If either the **[Set Start]** or **[Set End]** buttons is clicked again, the location is redefined. If a location is defined (or redefined) and the other location is already defined, one of two things happens:

1. The new location is defined if the plane of the new location is parallel to the other location.
2. Or, if the plane of the new location is not parallel with the other location, the new location is defined and the other location is cleared. A notification message is displayed.

### **Acquire Start and Acquire End**

The **[Acquire Start]** and **[Acquire End]** buttons allow images to be acquired from either the start or end locations. The center point and orientation of the image acquisition corresponds to the button selected (start or end). If there is no defined center point, then the corresponding button is disabled.

### **Retrieve Locations**

The **[Retrieve Locations]** button is used to retrieve previously prescribed start and end locations from a series currently in the RX MANAGER. If the currently selected series has no prescribed start and end locations, the locations become (or remain) undefined.

### **Apply Locations**

The **[Apply Locations]** button applies the currently defined start and end locations to the selected series prescription in the RX MANAGER. Any existing prescribed locations for the series are overwritten.

### Scan Plane Restrictions

Use of the Apply Locations feature (found on the Acquire Tab window) is restricted by the plane of the RTIA locations and the scan plane of the series selected in the Rx Manager. Apply Locations can only be used for the following situations:

<u><i>RTIA Scan Plane (location to be applied)</i></u>	<u><i>Plane of the Selected Series in the Rx Manager</i></u>
<b>Axial</b>	<b>Axial</b>
<b>Coronal</b>	<b>Coronal</b>
<b>Sagittal</b>	<b>Sagittal</b>
<b>Oblique</b>	<b>Oblique</b>
<b>Axial, Coronal or Sagittal</b>	<b>Oblique</b>

### Slice Location Limits

If the number of slice locations being applied (when using Apply Locations) exceeds the maximum number of acquisitions for the selected series in the RX Manager, an error message results stating, “Scn: Incompatible Scan Range. Apply Ignored.”

### Start and End Location Display

When a location is undefined, no numeric information is displayed.

## Image Buffer

- The image buffer holds approximately 240 images. This is equivalent to 60 seconds of scanning at four frames per second.
- Newer images replace/overwrite older images on a first-in-first-out (FIFO) basis. FIFO buffer images are not automatically saved.
- You can review images in the image buffer and save individual images or an entire range of images.
- You can select an image from the buffer and resume scanning at that location.
- The system allows you to automatically pause scanning once the image buffer fills.
- Think of the image buffer as fluoroscopy. Nothing is saved unless you “spot film”.

The **[Pause When Full]** toggle button indicates that no images acquired from this point forward are to be discarded. When the number of images acquired equals the capacity of the image buffer, scanning is paused. At any time before this point, the **[Reset]** button may be selected to reset the point that images cannot be discarded to the current image.

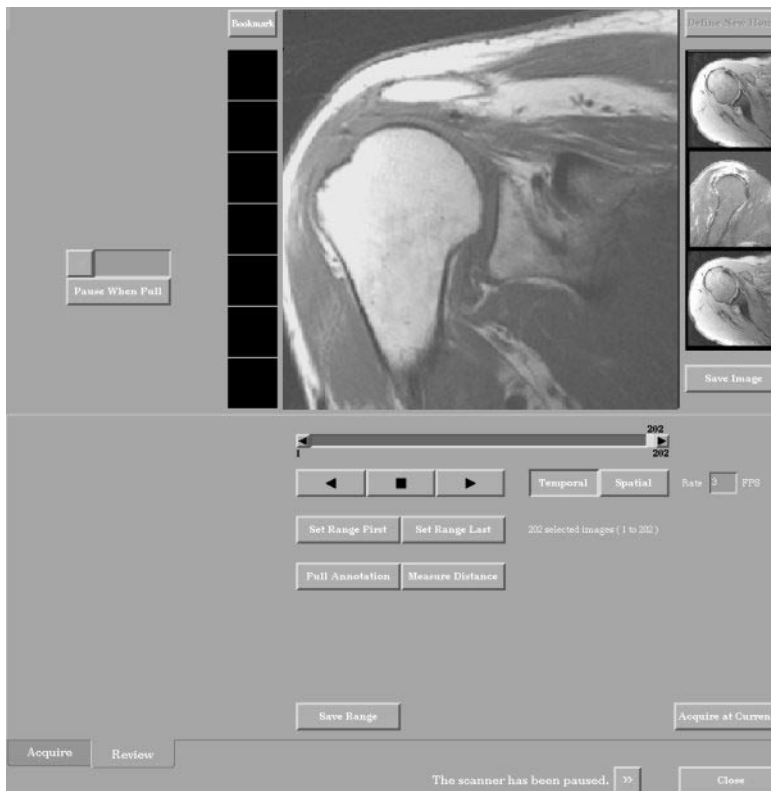
When the **[Pause When Full]** button is selected, a progress bar begins updating. The bar graphically indicates progress toward the point at which real time scanning is paused. When the **[Reset]** button is selected, the progress bar indicator is cleared, indicating that the buffer has been reset. When the **[Pause When Full]** button is deselected, **[<]** is disabled and the progress bar is cleared.

Something to Think About...

- When the scanner is paused, most of the controls on the Acquire card are disabled. This includes the interactive graphic prescription tool (IGRx) and acquire at the start and end location buttons. The exceptions to this are the **[Pause Scanning]** toggle button and the remaining IGRx buttons.
- When pressing **Pause** on the keyboard, the **[Pause Scanning]** button is automatically selected to indicate this state. Scanning is resumed by pressing **Pause**, and the **[Pause Scanning]** button is automatically deselected to indicate this state.

### Viewing Images That Are In The Image Buffer

The Review Tab Card is used to view the images that are stored in the image buffer. The real time acquisition pauses when entering the Review Tab Card.



The images are played cine-style. The defined image range determines the images available to be played.

### Image Play Buttons

**Play Forward**


Click the **Play Forward** toggle to display the images in ascending image number order, starting at the first image in the defined range. The Image Selection slider updates to reflect the image that is currently being viewed.

**Play Backward**

Click the **Play Backward** toggle to display the images in descending image number order, starting at the last image number defined in the image range. Play continues according to the temporal or spatial play mode selected.

NOTE: If play is in progress and the you click the other play button, the play direction reverses.

Playing may be stopped in one of two ways:

1. Press the **Stop** button. 
2. Press the selected toggle that started play.

### Temporal and Spatial Image Play Modes

The temporal and spatial play modes determine the action when image play reaches the end of the defined range.

- Temporal  
Temporal displays images in a continuous loop from first image to last. For example, an image set consisting of four images appears in the following order: 1, 2, 3, 4, 1, 2, 3, 4, etc.
- Spatial  
Spatial displays images sequentially in a repeating loop from first image to last, then last image to first. For example, an image consisting of four images appears in the following order: 1, 2, 3, 4, 3, 2, 1, etc.

### Frames per Second

The frames per second (FPS) type-in text box indicates the rate at which images are displayed during the Play Forward or Play Backward operation.

The range is 0-60 FPS. If you enter a value higher than the system allows, the maximum allowed value of 60 is displayed.

### Image Range

The image range is used for saving or playing and can be defined or redefined.

The default image range includes all images in the image buffer.

### Image Range Buttons

Click the **[Set First]** button to set the currently viewed image to be the first image in the defined range.

Click the **[Set Last]** button to set the currently viewed image to be the last image in the defined range.

### Save Image Range Buttons

Click the **[Save Image Range]** button to save all the images in the defined image range to the image data base. A dialog box

indicates the total number of images that are being saved and the number of images that were previously saved.

Clicking the **[Cancel]** button, in the dialog box, allows the save to be canceled.

**Full Annotation Buttons**

Click the **[Full Annotation]** button to display the full SIGNA image annotation.

Click the **[Full Annotation]** button again to return to partial image annotation.

**Acquire at Current Button**

Click the **[Acquire at Current]** button to resume real time scanning at the orientation and contrast parameters of the image currently being viewed.

**Measure Distance Button**

Click the **[Measure Distance]** button to deposit the measure tool on the image.

1. Select the **Review** tab card.
2. Select the desired image in the buffer.
3. Click the **[Measure Distance]** button, the Measure tool appears.
4. Position the line to measure the desired region.
5. Click and drag either end box to adjust the line distance. Click and drag the center line to move the line without changing the distance. The distance is annotated in the right lower corner of the image viewer.
6. Click the **[Save Image]** button to save the image with the measure annotation.

Something to Think About...

- If an attempt is made to set the first image in the range to a value greater than the currently defined last image in the range, the first and last images are swapped.
- The Image Selection slider is set to the number of the last real time image acquired before pausing. The image displayed on the image viewer is the same image.
- Note that within Review, the operations of playing and saving images are applied to a single defined range of images within the image buffer.

## Applications

- iDrive provides instantaneous visualization of anatomy and allows interactive contrast adjustments and scan plane prescription. Scan planes defined in iDrive can be copied to a scan series.
- iDrive works well to monitor temporal physiological events, including patient breathing and bolus or perfusion activity.
- Use iDrive to:
  - navigate through patient anatomy for orientation--to “scope out the lay of the land.”
  - define the boundaries of an imaging volume.
  - localize complex anatomy or anatomical anomalies that lie in double oblique planes.
  - monitor temporal events such as the passage of a contrast timing bolus.
  - image dynamic joint studies.
  - know what the scan looks like before investing the scan time.

# How to Image Real Time with iDrive

This section provides the step-by-step instructions for scanning with iDrive. Specifically, it describes how to:

- Prescribe a Real Time Sequence
- Drive Through the Image Volume
- Adjust Image Contrast (iDrive Pro)
- Define Cut Planes
- Prescribe Scan Locations for a Series
- Time a Bolus (iDrive Pro)
- Review and Manage the Image Buffer
- Save Images (iDrive Pro)
- Use iDrive to Scan Complex Anatomy
  - IAC's
  - Temporal Lobe
  - Orbits
  - TMJ's
  - Spine
  - Knee
  - Shoulder
  - Brachial Plexus
  - Abdomen
  - Female Pelvis
  - Heart and 3D Aortogram
  - Use iDrive as 3 plane localizer

**NOTE: The start-up of Real Time Interactive imaging is not instantaneous. There is a pause of less than six seconds before the system is ready to display the image.**

## Prescribe a Real Time Sequence

Real Time Interactive Acquisition (RTIA) can be used for navigating through the patient anatomy for rapid visualization, and monitoring temporal physiological events including patient breathing, kinematic studies, and bolus activity. Real time Interactive images can also be used for directly prescribing scan planes of other series in the exam.

There are important considerations and parameter choices to make when setting up a real time sequence. The following explains how to prescribe a real time sequence.

1. Click **[New Series]** from Rx Manager.
  2. Select **Patient Position** and **Entry**.
    - Real Time Interactive is compatible with any patient position or entry.
  3. Select the appropriate **Coil**.
    - Real Time Interactive imaging is compatible with all coils.
  4. Enter the appropriate **Series Description**.
  5. Select **Axial** scan plane from the Imaging Parameters.
    - Real Time Interactive imaging can be initiated in any orthogonal plane. Oblique planes may be prescribed using explicit coordinate entry or from localizer images using Graphic Rx tools.
  6. Select **2D Mode**. (2D is the only valid mode.)
  7. Select either **FGRE** or **FSPGR** pulse sequence.
- NOTE: Only iDrive Pro allows the ability to choose **FSPGR**.
8. Select **Real Time** for imaging option.
    - Real time must be selected to enter the feature. Other options that are compatible are FC, NPW, and SqP.
  9. Enter the following scan parameters.
    - **1 echo** from scan timing. Only one echo is allowed.
    - **Minimum Full TE**.
      - Permits use of 1 NEX.
    - **Minimum TR**.
      - TR controls contrast.

### In Brief: Prescribe a Real Time Sequence

1. Click **[New Series]**.
2. Select **Patient Position** and **Entry**.
3. Select the appropriate **Coil**.
4. Enter the appropriate **Series Description**.
5. Select **Axial** or other orthogonal scan plane.
6. Select **2D Mode**.
7. Select either **FGRE** or **FSPGR**.
8. Select **Real Time**.
9. Enter the scan parameters: **1 echo, Minimum Full TE, Minimum TR, FA 30, 62.5 Bw, FOV, Slice Thickness, 1 NEX, Freq. Matrix 128, Phase Matrix 96, Phase FOV 1, Freq. Dir. R/L, Auto Center Freq. Water, Autoshim**.
10. Prescribe slice locations, usually 0,0,0.
11. Click the following in this order: **[Save], [Prepare to Scan]**, and then **[Auto Prescan]**.
12. Click **[Scan]**.

- **Flip Angle 30 degrees** for desired contrast.
    - Flip angle controls contrast.
  - **Bandwidth 62.50 Bw.**
    - Allows fastest scanning with limited signal to noise. Lowering the Bw allows for smaller FOVs and improves SNR, but may slow frame rates.
  - The appropriate **FOV**.
  - The desired **Slice Thickness**. (Spacing is not an option)
  - **1 NEX**.
  - **Freq. Matrix 128**.
  - **Phase Matrix 96**.
  - **Phase FOV of 1**.
    - 0.5 or 0.75 may increase phase wrap artifacts.
  - **Freq. Direction R/L**.
  - **Auto Center Frequency to Water**.
    - Centering on fat is not allowed for Real Time Interactive imaging.
  - Select **Autoshim**.
10. Prescribe one slice and enter the location coordinates explicitly or graphically - usually 0, 0, 0.
- It is possible to graphically prescribe a single slice iDrive slice location during scan prescription. The Graphic Rx icon appears once the FOV and Slice Thickness are entered. Enter the Graphic Rx window and deposit the slice as usual. Note that it is possible to drop more than one slice location. However, you are not be allowed to click **[Accept]** and close the Graphic Rx window with more than one slice location dropped.
11. Click the following in this order:
- a) **[Save]**,
  - b) **[Prepare to Scan]**, and then
  - c) **[Auto Prescan]**.
12. Click **[Scan]** to initiate the real time acquisition.
- This initiates the Real Time Interactive Acquire Tab Card window.

NOTE: SAR values normally change as TR is modified. When a Minimum TR is selected parameters such as flow compensation, Bandwidth and the Frequency matrix affect the minimum TR and, so too, affect SAR. Other factors affecting SAR include parameters which increase the RF used in a scan. For example, SAT pulses, suppression pulses, and changes in flip angle all affect the RF used during data acquisition.

- Because you can interactively select (or change) RF-producing parameters during an iDrive session, the SAR value displayed during prescription is based on a worst case scenario of parameter selections.
- The SAR value changes if the minimum TR is selected and changes are made to Bandwidth, Frequency matrix and parameters which affect the minimum TR. However, you will not see SAR values change when RF-producing options/parameters are selected during a RTIA session, including chemical saturation pulses and Spatial SAT pulses.

NOTE: Remember, frames per second is based on your system configuration. Before the beginning of the scan, notification of the FPS rate appears toward the bottom of the page.

## Drive Through the Image Volume

### In Brief: Drive Through the Image Volume

1. Adjust the image orientation by using **[Pan/Rotate]**.
2. Move through the anatomy using **[Translate]**.
3. Oblique the scan plane using **[Tilt]**.
4. Click **[Center]**.
5. Click **[Scan Plane]**.
6. Click **[Normal]**.
7. If necessary do any of the following:
  - Click **[Zoom In]**, **[Swap Phase/Freq]**, or **Average images**.
  - Click **[Bookmark]** to save images for future recall.
  - Click the appropriate **Bookmark** icon to recall a bookmark.
  - Right-click **Bookmarked** icon to replace with current real-time image.
  - Click **[Redefine New Home]**.
  - Click **[Undo]**.

You can page through the real time images while you are scanning with iDrive. These steps explain how to manipulate your way around the anatomy you are scanning.

NOTE: To regain orientation to the anatomy, select one of the home images to reset the viewer image.

1. Adjust the image orientation by using **[Pan/Rotate]**.
2. Move through the anatomy using **[Translate]**. Adjust the millimeter increment, if necessary.
3. Oblique the scan plane using **[Tilt]**. Adjust the degree increment if necessary.
4. Click **[Center]** to select a specific point in the current image to become the center point in the viewer:
  - Position and deposit the cursor.
5. Click **[Axial]**, **[Sagittal]**, or **[Coronal]** to prescribe an axial, sagittal, or coronal image at the current image center point.
6. Click **[Normal]** to adjust the current image to a normal viewing orientation. The scan location does not change.
7. If necessary do any of the following:
  - Click **[Zoom In]** to magnify the image.
  - Click **[Swap Phase/Freq]** to reduce wrap-around artifact.
  - Enter a value for **Average images** to improve the SNR.



- Click **[Bookmark]** to save the current real-time image for future recall. Bookmarks are not saved to the image database.
- Click the appropriate **Bookmark** icon to recall a bookmark image.
- Right-click an occupied **Bookmark** icon to replace it with the current real-time image.
- Click **[Redefine New Home]** to redefine the home images.
- Click **[Undo]** if you made an unwanted change.

## Adjust Image Contrast (iDrive Pro)

You may need to adjust the real time image contrast to better visualize the anatomy. These steps explain how to manipulate image contrast by using different pulse sequences and imaging options.

1. Click **[GRE/SPGR]** toggle to switch between FGRE and FSPGR\*.
  - FGRE accentuates T2/T2\* contrast.
  - FSPGR\* accentuates T1 contrast.

NOTE: A window with no message occurs when you Copy/Paste a Real Time Interactive Acquisition (RTIA) prescription and change the PSD from FGRE to FSPGR. Click **[OK]** and you can proceed with the Rx.

2. Do any of the following as needed:
  - Click **[FatSAT]** toggle to suppress the signal from fat.
  - Click **[SAT]** toggle to reduce flow artifact and turn flow black. This gives two sat bands parallel to slice.
  - Click **[FC]** toggle to reduce flow artifacts and turn flow bright. Flow Compensation and Spatial Saturation can be used together:
    - Flow that receives a SAT pulse before entering the image volume remains black because it has no signal to rephase.
    - Flow that does not receive a SAT pulse before entering the imaging volume is bright due to gradient re-phasing.
  - Click **[IR]** to apply a single shot inversion pulse. The system applies one 180°RF pulse.

NOTE: FatSAT, SAT and FC slow down image acquisition. As you increase number of options, you decrease frame rate.

NOTE: \*Additional iDrive Pro options are annotated. When a feature is unavailable, the corresponding button is disabled.

### In Brief: Adjust Image Contrast (iDrive Pro)

1. Click the **[GRE/SPGR]** toggle.
2. Do any of the following as needed:
  - Click **[FatSAT]** toggle.
  - Click **[SAT]** toggle.
  - Click **[FC]** toggle.
  - Click **[IR]**, to apply a single shot inversion pulse.

## In Brief: Define Cut Planes

### Draw Line

1. Click **[Draw Line]**.
2. Drag the cursor and deposit at first location.
3. Drag the line and deposit at second location.

### 2-Point Tool

1. Click **[2-Point Tool]**.
2. Click **[Point 1]**, drag and deposit at first location.
3. Click **[Point 2]**, drag and deposit at second location.

### 3-Point Tool

1. Click **[3-Point Tool]**.
2. Click **[Point 1]**, drag and deposit at first location.
3. Click **[Point 2]**, drag and deposit at second location.
4. Click **[Point 3]**, drag and deposit at third location.

## Define Cut Planes

Real time imaging enables special tools that allows you to graphically prescribe specific cut planes through the imaging volume. These cut planes can help visualize complex anatomy.

These steps explain how to use the cut plane tools for visualizing complex anatomy.

### Draw Line

Use the draw line tool to define a cut plane when the desired plane can be defined from the current image location.

1. Click **[Draw Line]**.
2. Drag the cursor to the first location and left mouse click to deposit.
3. Drag the line to the second location and left mouse click to deposit.



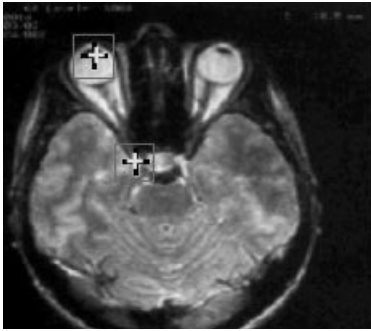
**This line defines a scan plane that runs along the optic nerve.**

### 2-Point Tool

Use the 2-point tool to define a cut plane when you need to use two different image locations and you want a cut plane **perpendicular** to the line connecting the two points.

1. Click **[2-Point Tool]**.
2. Click **[Point 1]**, drag the cursor to the first location, and left mouse click to deposit.
  - Move the image location if needed.

- Click **[Point 2]**, drag the point cursor to the second location, and deposit.

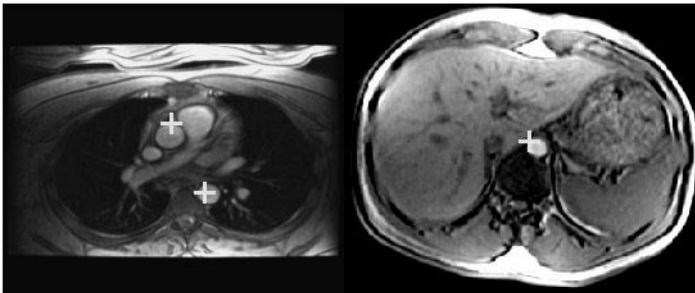


**These 2 points define a scan plane perpendicular to the optic nerve. The nerve will be viewed on end in the resulting image.**

### 3 Point Tool

Use the 3-point tool to define a cut plane when you need to use more than one image location and you want a cut plane along the plane defined by the points.

- Click **[3-Point Tool]**.
- Click **[Point 1]**, drag the point cursor to the first location, and deposit.
  - Move the image location if needed.
- Click **[Point 2]**, drag the point cursor to the second location, and deposit.



**These 3 points define a scan plane along the thoracic aorta.**

- Move the image location if needed.
- Click **[Point 3]**, drag the point cursor to the third location, and deposit.

## Prescribe Scan Locations for a Series

### In Brief: Prescribe Scan Locations for a Series

1. Click **[Rx Locations]**.
2. Move to start location and click **[Set Start]**.
3. Move to end location and click **[Set End]**.
4. Select the desired series from the Rx Manager.
5. Click **[Apply Locations]** and **[Save Series]**.

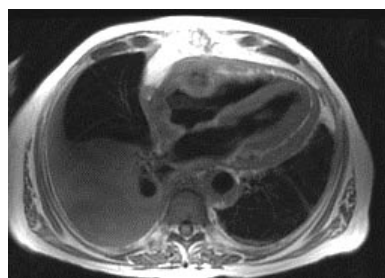
### Prescribing Series Locations into Real Time Imaging

1. Click **[Rx Locations]**.
2. Select the desired series from the Rx Manager.
3. Click **[Acquire at Start]** to view first location.
4. Click **[Acquire at End]** to view last location.

You may want to use the exact same locations from the real time images for non-real time imaging. The following are the steps to prescribe the real time start and end locations for a series.

NOTE: The series needs to be in the Rx manager before the real time series is started.

1. Click **[Rx Locations]**.
2. Use the cursor control options such as pan, rotate, and tilt to move through the image set. Move the real time image location to the desired start location and click **[Set Start]**.




3. Move the real time image to the desired end location and click **[Set End]**.



4. Select the desired series from the Rx Manager. You can load orthogonal or oblique scan locations into an oblique series, but you cannot load oblique scan locations into an orthogonal series.

State #	Series Description
ACT 1	Real-time
INRX 2	Oblique PD/T2



5. Click **[Apply Locations]** and **[Save Series]**.

NOTE: The protocol to which we are linking (series) should be oblique. If you do not see **[Applied Locations]**, check to see that you have an oblique.

- The number of slice locations and acquisitions is posted on the real time window.

### Prescribing Series Locations into Real Time Imaging

1. Click **[Rx Locations]** to retrieve start and end locations from a series into real time.
2. Select the desired series from the Rx Manager.
3. Click **[Acquire at Start]** to view first location.
4. Click **[Acquire at End]** to view last location.

**In Brief: Time a Bolus (iDrive Pro)**

1. Define the appropriate real time location.
2. Click **[Pause When Full]**.
3. Click **[SAT]**.
4. Inject the bolus. At the same time, click **[Timer]**.
5. Click **[Pause Scanning]** after the bolus has passed.
6. Review the images.

## Time a Bolus (iDrive Pro)

Real time imaging can be used to monitor temporal events such as the passage of a contrast timing bolus. These steps explain how to use real time to accurately time when the bolus arrives.

NOTE: Timer is only available with iDrive Pro.

1. Define the appropriate real time location.
2. Click **[Pause When Full]**.
3. Click **[SAT]** to suppress bright flow signal.
4. Inject the bolus as prescribed by the physician. At the same time, click **[Timer]**.
5. Click **[Pause Scanning]** after the bolus has passed.
6. Review the images. Images are time-stamped.



NOTE:

Something to Think About...

- Do not allow Real Time Interactive Acquisition (RTIA) to pause scanning for more than 15 minutes. If you think this will happen (e.g., you are reviewing and saving images from the Review window), Apply Locations to a series in the Rx Manager to ensure that the slice locations are saved.
- During a RTIA session, if scanning is paused for more than 15 minutes, the gradients and RF amplifier go into a standby mode and scanning cannot be resumed. The RTIA slice locations can be lost when the system is in standby and you are in the Review Tab window or you enter the Review Tab while the system is in standby.

## Review and Manage the Image Buffer

The image buffer is a temporary holding area for real time images and can hold approximately 240 images. The image buffer allows you to review the images. These steps explain how to review images in the image buffer.

1. Click **[Review]**. Real time image acquisition pauses.
2. Select a specific image, click and drag the slider to the desired image number.
3. Click **[Temporal]** or **[Spatial]** to review all images in the buffer.
  - Temporal pages through the images from beginning to end and then restart at the beginning.
  - Spatial pages through the images from beginning to end and then end at the beginning.
  - a) Enter a value for FPS, to set playback speed.
  - b) Click **[Play Forward]**.  , to begin review.
  - c) Click **[Stop]**.  , to stop review.
4. To define a range of images in the buffer for review:
  - a) Click and drag the slider to the first image number.
  - b) Click **[Set Range First]**.
  - c) Click and drag the slider to the last image number.
  - d) Click **[Set Range Last]**.
5. To prevent the images in the buffer from being overwritten or replaced before you have a chance to review them, click **[Pause When Full]** on the acquisition window.
6. To return to real time imaging at the same location and scan plane as the image displayed, click **[Acquire at Current]**.

### In Brief: Review and Manage the Image Buffer

1. Click **[Review]**.
2. Click and drag the slider to the desired image number.
3. To review all images in the buffer, click **[Temporal]** or **[Spatial]**.
  - a) Enter a value for FPS.
  - b) Click **[Play Forward]**.
  - c) Click **[Stop]**.
4. Define a range of images.
  - a) Click and drag the slider to the first image number.
  - b) Click **[Set Range First]**.
  - c) Click and drag the slider to the last image number.
  - d) Click **[Set Range Last]**.
5. Click **[Pause When Full]**.
6. Click **[Acquire at Current]**.

## Save Images (iDrive Pro)

### In Brief: Save Images (iDrive Pro)

1. Choose one of the following methods to save real time images.
  - Click **[Save Image]**.
  - Click **[Pause When Full]**.
  - Display the image and click **[Save Image]**.
  - Define the range of images and click **[Save Range]**.

The image buffer is a temporary holding area for real time images and can hold approximately 240 images. None of the images in the image buffer are saved unless you specifically select to save them. These steps explain how to save images during real time imaging.

1. There are a number of ways to save real time images, choose one of the following methods.
  - Click **[Save Image]** to save images during real time imaging.
  - Click **[Pause When Full]** to pause acquisition automatically when the buffer becomes full and before any images are overwritten.
  - Display the image and click **[Save Image]** to save an image during the review mode.
  - To save a range of images during review mode, define the range of images by setting the start and end. Then click **[Save Range]**.

**NOTE:** Do not save more than 999 real time images. **System performance is not guaranteed when more than 999 Real-Time images are saved.**

- When more than 999 real time images are saved to the Signa® image database, the Browser and viewer performance are affected. The system performance may dramatically slowdown. In addition, image transfer problems are likely to occur when sending images to systems on the Genesis (non-LX or MR/i) platform.

## Use iDrive to Scan Complex Anatomy

### IAC Application

This application acquires direct axial and coronal planes to symmetrically image bilateral IAC's. The series to use are: oblique axial T1, oblique axial 3D FSE, and oblique coronal T1.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

NOTE: If you open the Graphic Rx window, all locations are lost.

1. Start the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior to the level of the IAC.
3. Click **[Draw Line]** and draw a line parallel to the IAC from right to left. The new image is a direct coronal plane. **[Bookmark]** this image.
4. Click **[Tilt/Translate]** and drive posterior 20mm.
5. Open Rx Locations and click **[Set Start]**. Drive anterior 40mm and click **[Set End]**.
6. Select the oblique coronal T1 series from Rx Manager and click **[Apply Locations]**.
7. Retrieve the Bookmarked coronal image of the IAC.
8. Click **[Draw Line]** and draw a line parallel through the IAC from right to left. The new image is a direct axial plane. **[Bookmark]** this image.
9. Drive inferior 20mm and click **[Set Start]**. Drive superior 40mm and click **[Set End]**.
10. Select the oblique axial T1 series from the Rx Manager, click **[Apply Locations]** and **[Save Series]**.
11. Retrieve the axial Bookmarked image.

#### In Brief: IAC Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior.
3. Click **[Draw Line]**, draw a line parallel to the IAC and **[Bookmark]**.
4. Click **[Tilt/Translate]** and drive posterior.
5. Click **[Set Start]**, drive anterior, and click **[Set End]**.
6. Select the T1 oblique coronal series and click **[Apply Locations]**.
7. Retrieve the Bookmarked coronal image.
8. Click **[Draw Line]**, draw a line parallel through the IAC, and **[Bookmark]**.
9. Drive inferior, click **[Set Start]**, drive superior, and click **[Set End]**.
10. Select T1 oblique axial series, click **[Apply Locations]**, and **[Save Series]**.
11. Retrieve the axial Bookmarked image.

### In Brief: IAC Application

12. Select the oblique 3D FSE series.
  13. Change the Translate increment.
  14. To drive inferior, click once and click **[Set Start]**. To drive superior, click twice, click **[Set End]**, and then click **[Apply Locations]**, and **[Save Series]**.
  15. Click **[Close]**.
12. Select the oblique 3D FSE series from the Rx Manager.
  13. Change the Translate increment to 15mm.
  14. To drive inferior, click once and then click **[Set Start]**. To drive superior, click twice, click **[Set End]**, and then click **[Apply Locations]** and **[Save Series]**.
  15. Click **[Close]** to stop the real time session, review each series, and begin scanning.

## Use iDrive to Scan Complex Anatomy

### Temporal Lobe Application

This application acquires an oblique coronal plane to image the temporal lobes and hippocampus. Use the oblique coronal FSEIR series to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior to the level of the mid-brain.
3. Click **[Draw Line]** and draw a line parallel to the falx cerebri to achieve a true sagittal plane. **[Bookmark]** this image.
4. Click **[Tilt/Translate]** and drive lateral to visualize the hippocampus.
5. Click **[Draw Line]** and draw a line that intersects a 90-degree angle to the body of the hippocampus. This can be viewed on the reference images.
6. Click **[Center tool]** to re-Center (fallback) the image, and place it on the brain stem. **[Bookmark]** this image.
7. Open Rx Locations.
8. Drive posterior to the limit of the tail of the hippocampus and click **[Set Start]**.
9. Drive anterior to the head of the hippocampus/anterior temporal lobes and click **[Set End]**.
10. Select the oblique coronal FSEIR series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
11. Click **[Close]** to stop the real time session. Then review the series, and begin scanning.

#### In Brief: Temporal Lobe Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior.
3. Click **[Draw Line]** and draw a line parallel to the falx and **[Bookmark]**.
4. Click **[Tilt/Translate]** and drive lateral.
5. Click **[Draw Line]** and draw a line perpendicular to hippocampus.
6. Click **[Center tool]** and **[Bookmark]**.
7. Open Rx Locations.
8. Drive posterior to tail of the hippocampus and click **[Set Start]**.
9. Drive anterior and click **[Set End]**.
10. Select the oblique coronal series, click **[Apply Locations]** and **[Save Series]**.
11. Click **[Close]**.

### In Brief: Orbit Application

1. Start real time in sagittal plane.
2. Click **[Tilt/Translate]** and drive left or right and **[Bookmark]**.
3. Click **[Draw Line]** and draw a line parallel on the optic nerve and **[Bookmark]**.
4. Click **[Center tool]** and place on optic chiasm and **[Bookmark]**.
5. Click **[Apply Locations]**.
6. Change Translate to 5 mm.
7. Click **[Tilt/Translate]**, drive inferior and click **[Set Start]**.
8. Drive superior and click **[Set End]**.
9. Select the oblique axial series, click **[Apply Locations]** and **[Save Series]**.
10. Click **[Close]**.

## Use iDrive to Scan Complex Anatomy Orbit Application

This application acquires an oblique axial plane to image the optic nerves. Use an oblique axial FSEIR series to obtain the images.

**NOTE:** It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, Func Tool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in a sagittal plane.
2. Click **[Tilt/Translate]** and drive left or right to visualize the optic nerve. **[Bookmark]** this image.
3. Click **[Draw Line]** and draw a line parallel on the optic nerve. This is an oblique axial image. **[Bookmark]** this image.
4. Click **[Center tool]** to re-center (fallback) the image, and place it on the optic chiasm. **[Bookmark]** this image.
5. Click **[Apply Locations]**.
6. Change the Translate value to 5 mm.
7. Click **[Tilt/Translate]** and drive inferior to the lower orbital rim, and click **[Set Start]**.
8. Drive superior to the upper orbital rim and click **[Set End]**.
9. Select the oblique axial FSEIR series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
10. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

## Use iDrive to Scan Complex Anatomy

### TMJ Application

This application acquires oblique, coronal, and sagittal planes to image the TM Joint for T1 and Kinematic acquisitions. Use oblique coronal T1, oblique sagittal FSE PD, and FGRE to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Select the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior to visualize the mandibular condyle. **[Bookmark]** this image.
3. Click **[Draw Line]** and draw a line parallel on the mandibular condyles. This is an oblique coronal image. **[Bookmark]** this image.
4. Open Rx Locations.
5. Change the Translate value to 5 mm.
6. Click **[Tilt/Translate]** and drive to the posterior limit of the TM joint and click **[Set Start]**.
7. Drive anterior to the limit of the TM joint and click **[Set End]**.
8. Select the oblique coronal T1 series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
9. Retrieve the axial Bookmarked image.
10. Click **[Draw Line]** and draw a parallel line on the mandibular body. **[Bookmark]** this image.
11. Change the Translate value to 3 mm.
12. Click **[Tilt/Translate]**, drive lateral, and click **[Set Start]**.
13. Drive medial and click **[Set End]**.
14. Select the oblique sagittal FSE PD series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.

#### In Brief: TMJ Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior, and then **[Bookmark]**.
3. Click **[Draw Line]**, draw a line parallel on the condyles, and **[Bookmark]**.
4. Open Rx Locations.
5. Change Translate to 5mm.
6. Click **[Tilt/Translate]**, drive posterior, and click **[Set Start]**.
7. Drive anterior and click **[Set End]**.
8. Select the T1 oblique coronal series, click **[Apply Locations]** and **[Save Series]**.
9. Retrieve the axial Bookmarked image.
10. Click **[Draw Line]**, draw a parallel line on the mandibular body, and **[Bookmark]**.
11. Change Translate to 3 mm.
12. Click **[Tilt/Translate]**, drive lateral, and click **[Set Start]**.

**In Brief: TMJ Application**

- 13. Drive medial and click **[Set End]**.
- 14. Select the oblique sagittal FSE PD series, click **[Apply Locations]** and **[Save Series]**.
- 15. Retrieve the sagittal Bookmarked image.
- 16. Drive medial or lateral, click **[Set Start]** and **[Set End]**.
- 17. Select the kinematic GRE oblique sagittal series and click **[Apply Locations]**.
- 18. Click **[Close]**.

- 15. Retrieve the sagittal Bookmarked image.
- 16. Drive medial or lateral, whichever is best to view the TM joint. Click **[Set Start]** and then **[Set End]**.
- 17. Select the oblique sagittal kinematic GRE series from the Rx Manager and click **[Apply Locations]**.
- 18. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

## Use iDrive to Scan Complex Anatomy

### Spine Application

This application acquires an oblique sagittal plane to demonstrate the intervertebral foramen for T2 weighted FSE. Use the oblique sagittal FSE series to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior to visualize the mid C4-5 vertebral bodies. **[Bookmark]** this image.
3. Click **[Draw Line]** and draw a line at a 45-degree angle from coronal through the vertebral foramen/lateral mass. **[Bookmark]** this image.
4. Open Rx Locations.
5. Change the Translate value to 4 mm.
6. Click **[Tilt/Translate]** and drive posterior to the limit of the spinal canal and click **[Set Start]**.
7. Drive anterior to the opposite limit and click **[Set End]**.
8. Select the oblique sagittal FSE series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
9. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

#### In Brief: Spine Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior, and then **[Bookmark]**.
3. Click **[Draw Line]**, draw a line at a 45-degree angle from coronal through the vertebral foramen/lateral mass and **[Bookmark]**.
4. Open Rx Locations.
5. Change Translate to 4 mm.
6. Click **[Tilt/Translate]**, drive posterior, and click **[Set Start]**.
7. Drive anterior and click **[Set End]**.
8. Select FSE oblique sagittal series, click **[Apply Locations]** and **[Save Series]**.
9. Click **[Close]**.

### In Brief: Knee Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior, and then **[Bookmark]**.
3. Click **[Draw Line]**, draw a line bisecting the inter-condylar fossa and parallel to the lateral femoral condyle, and **[Bookmark]**.
4. Change the tilt box to three degrees.
5. Click **[Tilt/Translate]** and change the obliquity until the ACL is seen and **[Bookmark]**.
6. Drive medial to the limit of the medial condyle.
7. Open Rx Locations and click **[Set Start]**.
8. Drive lateral to the lateral condyle, and click **[Set End]**.
9. Select the T2 oblique sagittal series, click **[Apply Locations]** and **[Save Series]**.
10. Click **[Close]**.

## Use iDrive to Scan Complex Anatomy Knee Application

This application acquires an oblique sagittal plane to optimize the ACL. Use the oblique sagittal T2 series to obtain the images.

**NOTE:** It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior to visualize the inter-condylar fossa. **[Bookmark]** this image.
3. Click **[Draw Line]** and draw a line bisecting the inter-condylar fossa and parallel to the lateral femoral condyle. The resulting image is an oblique sagittal. **[Bookmark]** this image.
4. Change the tilt box to three degrees.
5. Click **[Tilt/Translate]** and use the Tilt function to change the obliquity until the ACL is optimally seen. **[Bookmark]** this image.
6. Drive medial to the limit of the medial condyle.
7. Open Rx Locations and click **[Set Start]**.
8. Drive lateral to the limit of the lateral condyle and click **[Set End]**.
9. Select the oblique sagittal T2 series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
10. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

## Use iDrive to Scan Complex Anatomy

### Shoulder Application

This application acquires an oblique coronal and oblique sagittal plane to optimize the rotator cuff. Use the oblique coronal FSE T1 and oblique sagittal FSE series to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior to visualize the glenoid. **[Bookmark]** this image.
3. Click **[Draw Line]** and draw a line perpendicular to the glenoid fossa. The resulting image is an oblique coronal. **[Bookmark]** this image.
4. Change the Tilt box to three degrees.
5. Click **[Tilt/Translate]** and use the Tilt function to best visualize the rotator cuff. Drive posterior to the limit of the humeral head.
6. Open Rx Locations and click **[Set Start]**.
7. Drive anterior to the limit of the humeral head and click **[Set End]**.
8. Select the oblique coronal FSE series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
9. Select the oblique coronal T1 series from the Rx Manager, then click **[Apply Locations]**.
10. Retrieve the Bookmarked axial image.
11. Click **[Draw Line]** and draw a line parallel to the glenoid fossa. This is now an oblique sagittal. **[Bookmark]** this image.
12. Drive medial to the mid-glenoid level and click **[Set Start]**.
13. Drive lateral to the limit of the humeral head and click **[Set End]**.

#### In Brief: Shoulder Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive inferior or superior, and then **[Bookmark]**.
3. Click **[Draw Line]**, draw line perpendicular to the glenoid fossa, and **[Bookmark]**.
4. Change Tilt box to 3°.
5. Click **[Tilt/Translate]** and change the obliquity to best visualize the rotator cuff and drive posterior.
6. Open Rx Locations and click **[Set Start]**.
7. Drive anterior and click **[Set End]**.
8. Select FSE oblique coronal series, click **[Apply Locations]** and **[Save Series]**.
9. Select T1 oblique coronal series and click **[Apply Locations]**.
10. Retrieve the Bookmarked axial image.
11. Click **[Draw Line]**, draw a line parallel to glenoid and **[Bookmark]**.
12. Drive medial and click **[Set Start]**.

### In Brief: Shoulder Application

- 13. Drive lateral and click **[Set End]**.
- 14. Select FSE oblique sagittal series, click **[Apply Locations]** and **[Save Series]**.
- 15. Click **[Close]**.

- 14. Select the oblique sagittal FSE series from the Rx Manager, then click **[Apply Locations]** and **[Save Series]**.
- 15. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

## Use iDrive to Scan Complex Anatomy

### Brachial Plexus Application

This application acquires an oblique coronal plane for optimal viewing of the brachial plexus. Use the oblique coronal T1 and T2 series to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in a sagittal plane.
2. Click **[Tilt/Translate]** and move medial or lateral to visualize the spinal column.
3. Click **[Draw Line]** and draw a parallel line to the posterior vertebral bodies. The resulting image is an oblique coronal. **[Bookmark]** this image.
4. Change the Translate box to 5 mm.
5. Drive posterior to the limits of the posterior spinal elements.
6. Open Rx Locations and click **[Set Start]**.
7. Drive anterior to the limit of the anterior vertebral bodies and click **[Set End]**.
8. Select the oblique coronal T2 series from the Rx Manager and **[Apply Locations]**.
9. Repeat for the T1 series.
10. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

#### In Brief: Brachial Plexus Application

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and move medial or lateral.
3. Click **[Draw Line]**, draw a parallel line to the posterior vertebral bodies and **[Bookmark]**.
4. Change Translate to 5 mm.
5. Drive posterior to the limits of the posterior spinal elements.
6. Open Rx Locations and click **[Set Start]**.
7. Drive to the anterior vertebral bodies and click **[Set End]**.
8. Select T2 oblique coronal series and **[Apply Locations]**.
9. Repeat for the T1 series.
10. Click **[Close]**.

### In Brief: Abdomen Application

1. Start real time in axial plane.
2. Click **[FC]**.
3. Click **[Tilt/Translate]** and drive inferior or superior and click **[Sagittal]**.
4. Change Translate to 5 mm.
5. Drive left or right to see the aorta.
6. Click **[Draw Line]**, draw a line parallel and through the aorta, and **[Bookmark]**.
7. Open Rx Locations, drive posterior so that the most posterior elements of the kidneys are seen and click **[Set Start]**.
8. Drive to the anterior limit of the aorta and click **[Set End]**.
9. Select FGRE coronal 3D series, click **[Apply Locations]** and **[Save Series]**.
10. Click **[Close]**.
11. Set up a real time in sagittal plane.
12. Drive medial or lateral to see the aorta. Click **[Pause When Full]**.

## Use iDrive to Scan Complex Anatomy Abdomen Application

This application acquires a coronal plane for optimal imaging of the aorta, for a dynamic injection 3D abdominal aortogram and renal arteries, and for a single slice, multi-phase acquisition to monitor test bolus contrast injections. Use the oblique coronal 3D FSPGR and axial FSPGR series to obtain the images.

**NOTE:** It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in an axial plane.
2. Click **[FC]** (Flow Comp) Imaging Option to better visualize blood flow in the aorta.
3. Click **[Tilt/Translate]** and drive inferior or superior to reach the level of the renal arteries. Click **[Sagittal]**.
4. Change the Translate box to 5 mm.
5. Drive left or right for optimal visualization of the aorta.
6. Click **[Draw Line]** and draw a line parallel and through the aorta. This image is an oblique coronal. **[Bookmark]** this image.
7. Open Rx Locations and drive posterior so that the most posterior elements of the kidneys are seen and click **[Set Start]**.
8. Drive anterior to the anterior limit of the aorta and click **[Set End]**.
9. Select the coronal 3D FGRE series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
10. Click **[Close]** to end the real time session. Then review the series, and begin scanning.
11. Set up a real time series in the sagittal plane.
12. Drive medial or lateral which ever is best to see the aorta. Click **[Pause When Full]**.

13. Inject a test bolus of contrast (amount should be prescribed by a physician) and click **[Timer]** at the same time. The scan continues while monitoring the images for contrast uptake.
14. When the contrast has 'washed out,' select the **Review** tab. Review the images time stamp to determine the scan delay time for a dynamic bolus injection series based on the images and time when the contrast is seen entering the image.
15. Click **[Set First]** and **[Set Last]** for the range of images to save to the database.
16. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

### In Brief: Abdomen Application

13. Inject a test bolus of contrast and click **[Timer]** at the same time.
14. When the contrast has 'washed out,' select the **Review** tab.
15. Click **[Set First]** and **[Set Last]** for the range of images.
16. Click **[Close]**.

### In Brief: Female Pelvis Application

1. Start real time in sagittal plane.
2. Click **[Tilt/Translate]** and drive to lateral aspect of pelvic basin.
3. Open Rx Locations and click **[Set Start]**.
4. Drive right to the opposite most lateral location and click **[Set End]**.
5. Select FSE sagittal series and click **[Apply Locations]** and **[Save Series]**.
6. Retrieve the sagittal home image.
7. Click **[Draw Line]**, draw line bisecting parallel to the uterine fundus, and **[Bookmark]**.
8. Change Translate to 5 mm.
9. Drive inferior and click **[Set Start]**.
10. Drive superior and click **[Set End]**.
11. Select the oblique axial FSE series from Rx Manager and click **[Apply Locations]** and **[Save Series]**.

## Use iDrive to Scan Complex Anatomy Female Pelvis Application

This application acquires a sagittal, oblique coronal & axial planes for optimal viewing of the uterus. Use the sagittal FSE, oblique coronal FSE, and axial FSE series to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in a sagittal plane.
2. Click **[Tilt/Translate]** and drive left to the most lateral aspect of the pelvic basin.
3. Open Rx Locations and click **[Set Start]**.
4. Drive right to the opposite most lateral location and click **[Set End]**.
5. Select the sagittal FSE series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
6. Retrieve the sagittal home image.
7. Click **[Draw Line]** and draw a bisecting parallel line to the uterine fundus. The resulting image is an oblique axial (assuming the uterus is in a normal “ante flexed” position). **[Bookmark]** this image.
8. Change the Translate box to 5 mm.
9. Drive inferior to the lower limits of the uterus and click **[Set Start]**.
10. Drive superior to the upper limit of the uterus and click **[Set End]**.
11. Select the oblique axial FSE series from Rx Manager and click **[Apply Locations]** and **[Save Series]**.
12. Retrieve the sagittal home image.
13. Click **[Draw Line]** and draw a line perpendicular to the cervix (90 degrees opposed to the last line drawn through the fundus). This image is an oblique coronal, (again assuming normal anatomic positioning).

14. Drive posterior to the limit of the cervix and click **[Set Start]**.
15. Drive anterior to the mid-uterine cavity and click **[Set End]**.
16. Select the oblique axial FSE series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
17. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

### In Brief: Female Pelvis Application

12. Retrieve the sagittal home image.
13. Click **[Draw Line]**, draw a line perpendicular to the cervix.
14. Drive to posterior cervix and click **[Set Start]**.
15. Drive anterior to the mid-uterine cavity and click **[Set End]**.
16. Select FSE oblique axial series, click **[Apply Locations]** and **[Save Series]**.
17. Click **[Close]**.

### In Brief: Heart and 3 D Aortagram

1. Start real time in sagittal plane.
2. Click **[FC]**.
3. Click **[Tilt/Translate]** and drive inferior or superior to visualize the heart.
4. Click **[Draw Line]**, draw line that bisects the heart from superior to inferior, and **[Bookmark]**.
5. Open Rx Locations, click **[Set Start]** and **[Set End]**.
6. Select the Long Axis Fast Card series, click **[Apply Locations]** and **[Save Series]**.
7. Click **[Tilt/Translate]**, drive to posterior heart and click **[Set Start]**.
8. Drive anterior and click **[Set End]**.
9. Select the Long Axis Gated T1 series, click **[Apply Locations]** and **[Save Series]**.
10. Retrieve the Bookmarked image.
11. Click **[Draw Line]**, draw line perpendicular to the inter-ventricular septum at the level of the mitral valve, and **[Bookmark]**.

## Use iDrive to Scan Complex Anatomy Heart and 3D Aortagram Application

This application acquires a double oblique long and short axis to demonstrate the complex cardiac planes and oblique sagittal plane for a dynamic injected 3D FGRE aortagram. Use the Long Axis Fast Card, Long Axis T1, Short Axis Fast Card, and Sagittal 3D Aortagram to obtain the images.

NOTE: It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, FuncTool, and ClariView. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in a sagittal plane.
2. Click **[FC]** (Flacons) Imaging Option to better visualize blood flow.
3. Click **[Tilt/Translate]** and drive inferior or superior to visualize the heart.
4. Click **[Draw Line]** and draw a line that bisects the heart from superior to inferior at an angle through the apex and mitral valve plane. **[Bookmark]** this image.
5. Open Rx Locations and click **[Set Start]** and **[Set End]**.
6. Select the Long Axis Fast Card series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
7. Click **[Tilt/Translate]** and drive to the posterior limit of the heart and click **[Set Start]**.
8. Drive anterior and click **[Set End]**.
9. Select the Long Axis Gated T1 series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
10. Retrieve the Bookmarked image.
11. Click **[Draw Line]** and draw a line perpendicular to the inter-ventricular septum at the level of the mitral valve. This is now a short axis image. **[Bookmark]** this image.
12. Drive superior to the upper level of the mitral valve and click **[Set Start]**.
13. Drive inferior to the apex and click **[Set End]**.

14. Select the Short Axis Fast Card series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
15. Click the axial home image and drive to the level of the aortic root.
16. Click **[3-Point Tool]** and deposit point 1 on the aortic root.
17. Select point 2 and deposit it on the thoracic aorta.
18. Drive inferior 70 mm and select point 3. Deposit it on the aorta. This is now the “arch” view. **[Bookmark]** this image.
19. Drive lateral to the extent of the thoracic aorta and click **[Set Start]**.
20. Drive medial to the extent of the ascending aorta and click **[Set End]**.
21. Select the 3D aortogram series from the Rx Manager and click **[Apply Locations]** and **[Save Series]**.
22. Click **[Close]** to end the real time session. Then review the series, and begin scanning.

### In Brief: Heart and 3D Aortogram

12. Drive superior to the upper level of the mitral valve and click **[Set Start]**.
13. Drive inferior to the apex and click **[Set End]**.
14. Select Short Axis Fast Card series, click **[Apply Locations]** and **[Save Series]**.
15. Click axial home image and drive to the aortic root.
16. Click **[3-Point Tool]** and deposit point 1 on the aortic root.
17. Select point 2 and deposit it on the thoracic aorta.
18. Drive inferior 70 mm select point 3, deposit it on aorta, and **[Bookmark]**.
19. Drive to lateral aspect of thoracic aorta and click **[Set Start]**.
20. Drive to medial aspect of ascending aorta and click **[Set End]**.
21. Select the 3D aortogram series, click **[Apply Locations]** and **[Save Series]**.
22. Click **[Close]**.

**In Brief: Use iDrive as 3 Plane Localizer**

1. Start real time in axial plane.
2. Click **[Tilt/Translate]** and drive to the level of the anatomy of interest.
3. Click **[Save]** to save each image and click **[Close]**.
4. Use the iDrive localizer images for prescribing regular Graphic Rx.

## Use iDrive to Scan Complex Anatomy Use iDrive as 3 Plane Localizer

In addition to selecting **3-Plane Loc** from the **Scan Rx Desktop**, iDrive can be a quick method to obtain a three plane localizer.

**NOTE:** It is recommended that all other applications be closed before starting iDrive. Applications which should be closed include: Viewer and Mini Viewers, Reformat, 3D, Edit Patient, Add/Sub, MIROI, IVI, Func Tool, and Clari View. Allowing these applications to remain open could significantly affect iDrive performance.

1. Start the real time series in an axial plane.
2. Click **[Tilt/Translate]** and drive to the level of the anatomy of interest. Acquire three optimized double or single oblique localizer images.
3. Click **[Save]** to save each image, and then click **[Close]** to exit iDrive.
4. Use the iDrive localizer images for prescribing regular Graphic Rx.

## Symbols

# of Phases to Reconstruct V2, 13-18

## Numerics

2D Mode V1, 3-16

2D PC Oblique Imaging V2, 8-7

2D Phase Contrast (2D PC) V2, 8-6

2D Time of Flight GRE and SPGR V2, 6-3

2D TOFX V2, 6-6

2-Point Tool V3, 5-13, V3, 5-32

3 Plane Localizer V2, 1-1, V2, 1-6

3D Analysis V4, 7-1, V4, 7-2

3D CSI Viewport Layout V4, 8-18

3D Focal CSI V2, 12-32

3D Focal CSI Display Tool Command Window V4, 8-40

3D Mode V1, 3-17

3D MultiSlab V1, 3-19

3D Phase Contrast (3D PC) V2, 8-23

3D TOF GRE/SPGR V2, 6-15

3D Volume Prescription V1, 3-19

3-Point Tool V3, 5-14, V3, 5-32, V3, 5-33

## A

A.I. V1, 6-10

A.I. Code V1, 6-30

A.I. Mappings Browser V1, 6-10

Abbreviated Patient Information V1, 3-8

Abdomen Application V3, 5-50

Abort Scan V1, 2-6

About IVI... V4, 5-6

abs N..M V4, 8-45

Accelerator Bar V1, 9-70

Accelerator Command List V1, 9-71

Accelerator Commands V1, 9-18, V1, 9-70

Accept Negative Pixels V4, 3-10

Acoustic Hazards V1, 1-26

Acquire at Current V3, 5-37

Acquire at End V3, 5-34, V3, 5-35

Acquire at Start V3, 5-34, V3, 5-35

Acquire End V3, 5-19

Acquire Start V3, 5-19

Acquire Tab Card Screen V3, 5-6

Acquisition Matrix V1, 3-58

Acquisition Timing V1, 3-58

Active Spectrum V4, 8-32

Adaptive Phased Array V1, 4-8

Add a Host V1, 11-35

Add One or Two Sets of Images V4, 3-12

Add Protocol V4, 5-30

Adding one or two sets of images V4, 3-12

Additional Imaging Options V3, 1-45

Additional Parameters V1, 3-39

Adjust the Receiver Gain to Achieve Optimum Signal V1,

8-17

Adjust the Transmit Gain to Achieve Optimum Flip Angle V1, 8-12

Adjusting the Composite Overlay V4, 8-59

Advanced Processing V4, 5-7

Advisory Panel V1, 3-84

AE Title V1, 2-19

Algorithms V4, 8-10

Along trace V4, 5-18

Analog Gain R1 V1, 8-17

Analyzing Images V1, 9-36

Angle V4, 5-8

Angle Between Views V4, 5-30

Angle between views V4, 5-33

Annotate V1, 9-48

Annotation V1, 9-16

annotation V1, 9-10

Annotation (system) V1, 9-59

Annotation of an Edited Exam V4, 2-6

Anonymous Patient V1, 11-4

Apply Cut V4, 5-18

Apply Locations V3, 5-19, V3, 5-34, V3, 5-35

Applying Mattes to Images V1, 9-51

Archive Image Data V1, 11-18

Archive Media V1, 11-5

Archive Node V1, 6-35

Archive Queue V1, 11-9

Area V4, 5-8

Arrhythmia Rejection V2, 10-5

Arrhythmia Rejection Window V2, 13-18, V3, 2-40

Arrhythmia Rejection Window (ARW) V3, 2-42

Assign Image Storage V1, 6-34

Audio Trigger Volume V3, 2-34

Auto Archive V1, 3-73

Auto Center Frequency V1, 3-65

Auto Clear V1, 10-15

Auto Clear Page V1, 10-7

Auto Prescan V1, 3-89, V1, 8-4

Auto Printing V1, 10-6, V1, 10-15

Auto Scan V1, 3-83, V1, 7-12

Auto Transfer by Exam V1, 3-74

Auto Transfer by Series V1, 3-74

Auto Window/Level V1, 3-26

Automatically Prescanning V1, 8-9

Autoshim V1, 3-68

AutoStep V1, 3-84, V1, 7-13, V3, 4-6, V3, 4-9

Autoview V1, 3-24

autoview screen V1, 2-2

AutoView Window V1, 3-24

Available Imaging Time (AIT) V3, 2-47, V3, 2-55

Average V4, 8-16

Averages V3, 5-18

**B**

Bandwidth V1, 3-38  
 Basic Problem Resolutions V1, 2-18  
 Batch Command Window V4, 6-26  
 Batch Filming/Movies V4, 5-6  
 Batch Projection V4, 5-28  
 Bind Images V4, 3-20  
 Binding Images V4, 3-7  
 Binding images V4, 3-20  
 Biomagnetic Hazards V1, 1-23  
 Birthdate V1, 6-5  
 Blood Oxygen Level Dependent V4, 8-11  
 Blood Suppression V3, 1-44  
 Body Coil V1, 4-7, V1, 4-16  
 body coil V1, 4-16  
 BOLD V4, 8-11  
 Bolus Chasing V3, 4-1  
 Bookmark V3, 5-39  
 Bookmark - Recall V3, 5-30  
 Bookmark - Replace V3, 5-30  
 Bookmark Images V3, 5-9  
 Bookmark images V3, 5-11  
 Bore heating V1, 1-17  
 Brachial Plexus Application V3, 5-49  
 Brain Spectrum V2, 12-6  
 Browser V1, 9-6  
 Building a Protocol V1, 5-9  
 Burn Hazards V1, 1-16  
 Burst Scan Time V3, 3-3  
 B-Value V2, 11-34

**C**

Cable Connection Ports V3, 2-17  
 Cable/Connector Warnings V1, 1-18  
 Cancel Identify V4, 5-24  
 Cardiac Array coil V1, 4-24  
 Cardiac Compensation V3, 1-32  
 Cardiac Gating V3, 2-6  
 Cardiac Gating and Triggering V3, 1-33  
 Cardiac Gating and Triggering Parameters V3, 2-37  
 Cardiac Gating/Triggering V3, 2-74  
 Cardiac Phases V3, 2-47  
 Cardiac Phases to Reconstruct V2, 9-6  
 Cardiac Pulse Sequences V2, 13-1  
 Cardiac Sweep Rate V3, 2-29  
 Cardiac Trigger Level V3, 2-31  
 Cardiac Trigger Level Annotation V3, 2-33  
 Cardiac Triggering V3, 2-7  
 Cardiac Waveform V3, 2-24  
 Cardiac/Peripheral Display V1, 2-5  
 CEMRA V3, 3-2  
 Centric K-space Filling V3, 3-6

Change window width and level V1, 9-27  
 Check the Archive Queues V1, 11-30  
 Check the Cryogen Levels V1, 1-46  
 Chemical Saturation V1, 7-37, V1, 8-7, V3, 1-39  
 Chemical Shift Imaging (CSI) V2, 12-4  
 ChemSAT Tune V1, 8-7  
 Choline V4, 8-43  
 Choline (Cho) V2, 12-6  
 Choline/creatine V4, 8-43  
 Choline/N-acetyl V4, 8-43  
 CINE V3, 2-5  
 CINE Acquisitions V3, 2-9  
 Cine GRE V2, 9-3  
 Cine Mode V1, 3-21  
 Cine Paging V1, 9-7, V1, 9-31  
 Cine PC V2, 9-19  
 Cine Pulse Sequences V2, 9-1  
 Cine Screen V1, 3-48  
 Cine SPGR V2, 9-17  
 ClariView V4, 1-1, V4, 1-3, V4, 1-10  
 ClariView and PPS V1, 6-26  
 ClariView filters and PPS V1, 6-26, V4, 1-4  
 ClariView Screen V4, 1-6  
 Classic V3, 1-20  
 Classic and Improved Fat Saturation V1, 7-39  
 Clear Trace V4, 5-18  
 Clinical Hazards V1, 1-23  
 Closing Real Time Interactive Imaging V3, 5-17  
 Coil Sensitivity Range V1, 4-8  
 Coil Type V1, 3-11  
 Color / Light / Window V4, 5-6  
 Combined Cardiac and Respiratory Gating/Triggering V3, 2-56  
 Combined Cardiac and Respiratory Gating/Triggering Guide V3, 2-58  
 Combined Cardiac and Respiratory Gating/Triggering Screen V3, 2-35  
 Combining Images V4, 3-1  
 COMP V1, 6-25  
 compare V1, 9-34  
 Complete V1, 6-10, V1, 6-25  
 Complex Difference V2, 8-6  
 Composite V4, 8-43  
 composite overlay V4, 8-10  
 Composition of Archiving Option V1, 11-6  
 Computer room V1, 2-14  
 Concatenated SAT V1, 7-34  
 concatenated spatial saturation V1, 7-73  
 Configure V1, 10-22  
 Configure a Remote Host V1, 11-35  
 Configuring a Remote Host V1, 11-38  
 Configuring mobile sites V1, 2-22

Connect Pro V1, 6-23  
 ConnectPro V1, 6-7  
 ConnectPro Plus V1, 6-7, V1, 6-12  
 Console Room V1, 2-9  
 Contraindications for Use V1, 1-6  
 Contrast V1, 3-70  
 Contrast Mechanism V3, 3-3, V3, 4-4  
 Contrast resolution V1, 7-15  
 contrast-enhanced MR angiography V3, 3-1  
 Control panel V1, 5-4  
 control room V1, 2-9  
 Conventional SAT V1, 7-32  
 copy an entire protocol V1, 5-14  
 Copy Rx V1, 7-26  
 Copying a Protocol V1, 5-14  
 Copying a series in a Protocol V1, 5-22  
 Correlation Coefficient V4, 8-10, V4, 8-52  
 Create an Anonymous Patient V1, 11-16  
 Creatine V4, 8-43  
 Creatine/phosphocreatine (Cr/PCr) V2, 12-6  
 Creating a Custom 3D Focal CSI Protocol V4, 8-63  
 Creating Vascular Projections V4, 5-1  
 Cross-Reference V1, 9-56  
 Cross-Reference a Series V1, 9-56  
 Cryogenics V1, 1-11  
 CTL Array coil V1, 4-21  
 Cube V4, 5-26  
 Cursor Location Spectrum V4, 8-33  
 Cursor Lock V4, 5-6  
 Curved reformat V4, 6-68  
 Custom annotation V1, 9-60  
 Cut Plane Tools V3, 5-13

**D**

Data Available for Edit V4, 2-3  
 dB/dt Level V1, 3-87  
 Defer V1, 6-10, V1, 6-25  
 Define Cut Planes V3, 5-32  
 Define Saturation Bands V1, 7-72  
 Defining a Region of Interest with MIROI V4, 4-1  
 Defining a Scanning Range V1, 7-22, V1, 7-62  
 Defining Saturation Bands V1, 7-32, V1, 7-72  
 deg V4, 5-7, V4, 5-26  
 Degrees V4, 5-26  
 Delay After Acquisition V1, 3-50  
 Delete protocol V4, 5-35  
 Deleting a Host V1, 11-38  
 Deleting a Protocol V1, 5-19, V1, 5-20  
 Deleting a Registered Patient V1, 6-6, V1, 6-22  
 Deleting an IVI protocol V4, 5-35  
 Deleting Site Protocols from MOD V1, 5-31  
 Desktop Organization V1, 2-16  
 Detach Storage Media V1, 11-32

dev N..M V4, 8-46  
 Diastole V3, 2-12  
 Difference Function V4, 8-16, V4, 8-56  
 Diffusion Coefficient V4, 8-16, V4, 8-54  
 Diffusion EPI V2, 11-32  
 Digital Gain R2 V1, 8-17  
 Discontinue V1, 6-11, V1, 6-25  
 Display Desktop V1, 2-16  
 Display Modes V4, 5-6  
 Display modes V4, 5-32  
 Display Normal V1, 9-44  
 Display/Actions Defaults V4, 5-6, V4, 5-17  
 Displaying 3D Focal CSI Images V4, 8-60  
 Displaying Images in Viewer V1, 9-25  
 Displaying the Graphs V4, 8-51  
 Displaying Valid Image Sets V4, 8-50  
 Distance V4, 5-8  
 Double-IR V2, 13-4  
 Drag and Drop V1, 10-15  
 Draw Line V3, 5-13, V3, 5-32  
 Driven Equilibrium Preparation V3, 1-24  
 DWI Screen V1, 3-50

**E**

E,S,I V1, 10-15  
 ECG Gating Warnings V1, 1-20  
 ECG Gating/Triggering V3, 2-5  
 ECG Histogram V3, 2-25  
 ECG Inversion V3, 2-30  
 ECG Lead Placement V3, 2-18  
 ECG Lead Selection V3, 2-29  
 ECG Leads V3, 2-13  
 ECG Noise Filter V3, 2-28  
 ECG Waveform V3, 2-9  
 Echo Planar Imaging (EPI) V2, 11-4  
 Echo Planar Pulse Sequence V2, 11-1  
 Echo Time V1, 3-30  
 Echo Train Length V1, 3-36  
 Edit Applications screen V4, 2-10  
 Edit Log V4, 2-8  
 Edit Patient Data V4, 2-12  
 Edit Patient Data Screen V4, 2-7  
 Edit Patient Data screen V4, 2-12  
 Editing a Protocol V1, 5-16, V1, 9-54  
 Editing a protocol V1, 5-16  
 Editing Patient Data V4, 2-10  
 Eliminate Ferromagnetic Items From The Security Zone V1, 1-36  
 Eliminate Magnet Hazards V1, 1-36  
 Ellipse ROI V4, 8-46  
 elliptical matte V1, 9-51  
 Elliptical ROI V4, 8-51  
 elliptic-centric k-space filling V3, 4-2

Emergency Magnet Run-Down V1, 1-28  
 Emergency Off V1, 1-27  
 emergency off V1, 1-27  
 Emergency Stop V1, 1-26, V1, 2-4  
 emergency stop V1, 1-26  
 End Exam V1, 3-78, V1, 7-10  
 End Exams with ConnectPro V1, 6-10  
 End PPS V1, 6-25  
 Enhancing Images V1, 9-54  
 Enhancing with Smoothing V4, 1-9  
 Equipment Hazards V1, 1-26  
 Erase All V1, 9-42  
 Erasing an Image From the Film V1, 10-19  
 Exam Description V1, 6-6  
 Exam Text Page V1, 10-18  
 Exclusion Zone V1, 1-10  
 Explicit V4, 5-25  
 Explicit Prescription V1, 7-22  
 Explicit prescription V1, 7-62  
 Explicitly V1, 7-62, V4, 5-26  
 Exponential Diffusion Coefficient V4, 8-17, V4, 8-57  
 Expose Order V1, 10-7  
 Extended Dynamic Range V3, 1-48  
 Extract Minimum or Maximum Pixel Values V4, 3-16  
     One Set of Images V4, 3-16  
     Two Sets of Images V4, 3-18  
 Extract the minimum or maximum pixels V4, 3-16  
 Extremity coil V1, 4-22

**F**

F Keys V1, 10-8  
 F1 V1, 10-8, V1, 10-16  
 F1-F11 V1, 10-8  
 F1-F4 keys V1, 10-8, V1, 10-16  
 F2 V1, 10-9, V1, 10-16  
 F3 V1, 10-9, V1, 10-16  
 F4 V1, 10-9, V1, 10-17  
 Factors that Affect Contrast V1, 7-15  
 Factors that Affect Scan Time V1, 7-17  
 Factors that Affect SNR V1, 7-18  
 Factors that Affect Spatial Resolution V1, 7-16  
 Fallback V1, 7-27  
 Fan V1, 2-6  
 Fast 2D Phase Contrast V2, 8-15  
 Fast 2D Time of Flight GRE/SPGR V2, 7-4  
 Fast 2DPC V2, 8-15  
 Fast 3D TOF GRE/SPGR V2, 7-17  
 Fast Gradient Echo (FGRE) V2, 5-3  
 Fast Recovery Fast Spin Echo (FRFSE) V2, 3-21  
 Fast Spin Echo (FSE) V2, 3-3  
 Fast Spin Echo Pulse Sequences V2, 3-1  
 Fast Spin Echo-Inversion Recovery (FSE-IR) V2, 3-30  
 Fast Spoiled Gradient Echo (FSPGR) V2, 5-3

Fast Time of Flight Pulse Sequences V2, 7-1  
 FastCard V2, 10-3  
 FastCard Non-sequential V2, 10-5  
 FastCard Pulse Sequence V2, 10-1  
 FastCard Sequential V2, 10-4  
 FastCine V2, 13-15  
 FastCine PC V2, 13-15  
 Feature Status Area V1, 11-4  
 Female Pelvis Application V3, 5-52  
 Field of View V1, 3-51  
 Film Composer V1, 10-4, V1, 10-13, V4, 5-6  
 Film Format V1, 10-5  
 Filming Queue V1, 10-23  
 Filming Setup V4, 5-6  
 filming the text page V1, 10-18  
 Filter and Save to Database V4, 1-7  
 Filter Description and Use V4, 1-4  
 Filter Floaters V4, 5-8  
 Filter J V4, 1-3  
 Filter Name V4, 1-4  
 Final View V4, 5-34  
 First View V4, 5-33  
 FLAIR V2, 3-38  
 Flair EPI V2, 11-26  
 Flip Angle V1, 3-35, V1, 8-6  
 flip or rotate V1, 9-47  
 Flow Analysis V2, 9-28  
 Flow Compensation V3, 1-26  
 Flow Compensation Direction V1, 3-67  
 Flow Encoding Axis V2, 9-34  
 Flow Recon Type modes V2, 8-6  
 FOV Center V1, 3-55  
 FPS V1, 9-32  
 Fractional Echo V1, 3-31  
 Frame Rate V3, 5-7  
 Frames per Second Notification V1, 3-86  
 free trace V4, 5-17  
 Frequency Direction V1, 3-64  
 Frequently Asked Cardiac Questions V3, 2-69  
 FRFSEOPT V2, 3-23  
 FSE-XL V2, 3-7  
 FSE-XL IR with Blood Suppression V2, 13-6  
 FSE-XL with Blood Suppression V2, 13-4  
 Full annotation V1, 9-60  
 Full Echo Train V3, 1-47  
 Function (F) keys F5-F10 V1, 9-68  
 Function Algorithms V4, 8-52  
 Function menu V4, 8-40  
 FuncTool V4, 8-1  
 FuncTool Layout V4, 8-5

**G**

Gated 2D TOF V2, 7-4

Gating V3, 2-6  
 Gating Contro V1, 3-75  
 Gating Control V3, 2-23  
 Gating Reset V3, 2-34  
 Gating/Triggering Icon V1, 3-47  
 Gating/Triggering Screen V1, 3-47  
 GE Library V1, 5-5, V1, 9-16  
 GE Protocol Library V1, 7-5  
 Get Protocol V4, 8-42  
 GI  
     HIS/RIS DICOM V1, 6-27  
     Mobile V1, 2-24, V1, 2-26  
 Glutamate (Glu) V2, 12-7  
 Glutamine (Gln) V2, 12-7  
 GPFlex V1, 4-25  
 Gradient and Shim Coil Function V1, 4-3  
 Gradient Coils V1, 4-3  
 Gradient Echo (GRE) V2, 4-3  
 Gradient Echo EPI V2, 11-11, V2, 11-19  
 Gradient Echo Pulse Sequences V2, 4-1  
 Gradient, Shim, and Imaging Coils V1, 4-1  
 Graphic Prescription V1, 7-23  
 Graphic Prescription Screen V1, 3-42  
 Graphic Rx Icon V1, 3-43  
 Graphic SAT Prescription V1, 7-41  
 Graphically V1, 7-65  
 Graphics V4, 5-8  
 Greyscale V1, 10-6  
 Grid V1, 9-41  
 Grid appearance V1, 9-63  
 Grid Preferences V1, 9-17, V1, 9-63  
 Grid spacing V1, 9-63  
 Guided Install V1, 2-23, V1, 2-26, V1, 6-13, V1, 6-30  
 Guided Install - HIS/RIS DICOM Mode V1, 6-33  
 Guided Install for HIS/RIS DICOM V1, 6-13  
 Guided Install for Mapping Protocols to Action Items V1, 6-13  
 Guided Install HIS/RIS DICOM Mode V1, 6-27  
 Guided Install window V1, 6-28

## H

Handle V4, 5-26  
 Handle Contact with Liquid Cryogenics V1, 1-48  
 Hazard Warnings V1, 1-13  
 Head Coil V1, 4-6  
 head coil V1, 4-13  
 Head Coil QA V1, 4-10  
 Heart Application V3, 5-54  
 Heart Rate/Update Rate V3, 2-50  
 Hide and Show V1, 9-43  
 High Risk Patients V1, 1-24  
 HIS/RIS V1, 6-7  
 HIS/RIS Action Item Code V1, 6-32

HIS/RIS DICOM mode V1, 6-13, V1, 6-27  
 HIS/RIS tab V1, 6-14  
 Histogram V4, 8-51  
 histogram V4, 8-10  
 Home V1, 2-6  
 Home Images V3, 5-9  
 Home images V3, 5-9  
 Hydrogen Proton Precessional Frequency V1, 4-5

## I

IAC Application V3, 5-39  
 Icon labels V1, 10-7  
 Identify mm./slices V4, 5-6  
 Identify W/L V4, 5-24  
 iDrive V3, 5-1, V3, 5-4  
 iDrive Pro V3, 5-4  
 IGRx V3, 5-18, V3, 5-19  
 ilinq Desktop V1, 2-17  
 Image V1, 10-15  
 Image Acquisition Delay V3, 3-3  
 Image Addition V4, 3-4  
 Image Analysis V4, 7-2  
 Image Annotation V1, 9-12  
 Image Buffer V3, 5-20  
 Image Combination V4, 3-4  
 Image Combination Menu V4, 3-7  
 Image Contrast Buttons V3, 5-14  
 Image Display V1, 3-25  
 Image Enhance V1, 9-54  
 Image Enhancement Purpose and Benefits V4, 1-3  
 Image Management Desktop V1, 2-16  
 Image Slide Bar V4, 1-6  
 Image Storage Annotation V1, 6-34  
 Image Subtraction V4, 3-5  
 Imaging Coil Function and Classification V1, 4-5  
 Imaging Mode V1, 3-16  
 Imaging Option Annotation V1, 9-13  
 Imaging Options V1, 3-22, V1, 7-14  
 Imaging Plane V1, 3-13  
 Implant and Prosthesis Hazards V1, 1-6  
 Indications for Use V1, 1-5  
 Individual Spectra V4, 8-33  
 Infusion Angiography V3, 3-3  
 inhomogeneities V1, 4-5  
 INPR V1, 6-25  
 Inside trace V4, 5-18  
 Interactive V4, 5-25  
 Interactive Vascular Imaging V4, 5-1  
 Interleaved V1, 3-49  
 Inter-Sequence Delay V3, 2-46  
 Inter-Sequence Delay (ISD) V3, 2-55  
 inverse video V1, 9-78  
 Inversion Recovery (IR) V2, 2-15

- Inversion Recovery Preparation V3, 1-23
- Inversion Time V1, 3-34
- IP address V1, 2-18, V1, 2-19, V1, 2-23
- Isometric voxels V4, 5-3
- IVI V4, 5-1, V4, 5-15
- IVI Command Window V4, 5-15, V4, 5-20
- IVI process V4, 5-1
- K**
- Keyboard & Mouse V1, 2-10
- Knee Application V3, 5-46
- K-space Filling V3, 4-4
- L**
- Label Storage Media V1, 11-20
- Labeling the Storage Media V1, 11-6
- Lactate (Lac) V2, 12-7
- Lactate lipid V4, 8-43
- Landmark V1, 2-6, V1, 3-8, V1, 5-10, V1, 6-6
- Landmarking V1, 7-50
- Laser Align Light V1, 2-5
- Laser Light Hazards V1, 1-13
- Lead Display V3, 2-29
- level V1, 9-6
- Light V1, 2-6
- Limit Access to the Exclusion Zone - Screen Patients and Personnel V1, 1-37
- Linking a Protocol to a Patient V1, 6-18
- Lipids (Lip) V2, 12-7
- Liquid Cryogen Concerns V1, 1-11
- List of Previously Entered Hospitals V1, 2-20
- Loading Text Pages V1, 10-18
- Loading the images V1, 10-8
- Loading with Drag and Drop V1, 10-15
- Loading With the Function Keys V1, 10-16
- Locations per Acquisition V3, 2-68
- Locations per Acquisitions V2, 9-5
- log N..M V4, 8-46
- Lower Left (LL) Viewport V4, 8-35
- Lower Right (LR) Viewport V4, 8-38
- LX Table V1, 2-8
- M**
- Magnet Emergencies V1, 1-41
- magnet enclosure V1, 2-4
- Magnet Hazards V1, 1-8
- magnet room V1, 2-4
- Magnetic Resonance Angiography (MRA) V4, 5-1
- Magnetic Resonance Suite V1, 2-3
- Magnetization Transfer V3, 1-42
- Magnify glass V1, 9-65
- Magnifying Glass V1, 9-39
- Magnifying Images V1, 9-37
- Manage Disk Space V1, 11-33
- Managing Disk Space V1, 11-10
- Managing Images V1, 11-1
- Managing Site Protocols V1, 5-7
- Manual Arrhythmia Monitoring V2, 13-18, V3, 2-43
- Manual Prescan V1, 3-89, V1, 8-4
- Manually Prescan V1, 8-10
- Manually Prescanning V1, 8-10
- Mapping Protocols V1, 6-30
- mask V3, 4-1
- masking V3, 4-2
- Match Coarse Center Frequency to the Patient V1, 8-10
- Match Fine Center Frequency to the Patient V1, 8-15
- Matrix Zerofill Interpolation Processing V3, 1-13
- Matte V1, 9-51
- max N..M V4, 8-46
- Maximize/Minimize V1, 3-27
- Maximum Difference Function V4, 8-15, V4, 8-56
- Maximum intensity pixel V4, 5-4
- Maximum Monitor Period V3, 3-3
- Maximum Pixel Extraction V4, 3-6
- Maximum Slope of Increase V4, 8-14, V4, 8-53
- Mean Time to Enhance V4, 8-13, V4, 8-53
- Measure V1, 9-53
- Merge ROI V4, 8-47
- Message area V3, 5-16
- Metabolite and Ratio Maps with Sharp Edges V4, 8-48
- Metal Heating Warnings V1, 1-21
- Meta-series V3, 4-3
- meta-series V3, 4-2
- Millimeters V4, 5-26
- min N..M V4, 8-46
- Minimum Pixel Extraction V4, 3-6
- MIP V4, 5-1, V4, 5-4
- MIROI Basics V4, 4-4
- MIROI Layout V4, 4-4
- mm V4, 5-26
- Mobile Site Configuration V1, 2-18, V1, 2-23
- Mobile Site Setup V1, 2-23, V1, 2-24
- Mobile Site Setup window V1, 2-24
- MOD V1, 2-10
- Mode V1, 3-73
- Modify Model V4, 5-7, V4, 5-16, V4, 5-21
- Modifying the Volume V4, 5-14
- Mouse basics V1, 2-13
- Move to Scan V1, 2-6
- Movement/Rotation Increment buttons V4, 6-25
- Movies screen V4, 5-28, V4, 5-29
- Movies window V4, 5-29
- MPVR V4, 7-1
- MR Angio V4, 7-1
- MR Compatibility V1, 1-31
- MR Spectroscopy Protocols V4, 8-17

MRA Algorithms V4, 1-9, V4, 1-13  
 MRA-MIP filter V4, 1-3  
 MRS Mode V1, 3-21  
 Multi Phase V3, 1-50  
 Multi Phase Icon V1, 3-49  
 Multi Phase Screen V1, 3-48  
 Multi-Plane Graphic Rx V1, 7-28  
 multiple stations V3, 4-1  
 Multi-Slab V2, 6-20  
 Multi-Station V3, 1-53  
 Myo-inositol (ml) V2, 12-7

## N

N-acetyl V4, 8-43  
 N-acetylaspartate (NAA) V2, 12-6  
 Navigate the Schedule Screen V1, 6-8  
 Navigate through screens and menus V1, 2-30  
 Negative Enhancement Integral V4, 8-12, V4, 8-53  
 Netmask V1, 2-19  
 Network DICOM Devices V1, 2-20  
 Network from the Scan Rx Desktop V1, 11-42  
 Network Images To & From Connected Stations V1, 11-42, V1, 11-45  
 Network Queues V1, 11-13  
 Networking Terms V1, 11-12  
 Networks V1, 11-12  
 Neurovascular coil V1, 4-23  
 New Save Series V4, 3-8  
 New Series V1, 3-77, V1, 7-9  
 NEX and SNR V1, 7-21  
 niobium-titanium V1, 4-5  
 No Phase Wrap V3, 1-9  
 No. of Copies V1, 10-7  
 Number of Acquisitions Before Pause V1, 3-63  
 Number of Acquisitions/Locations Before Pause V1, 3-63  
 Number of Cardiac Phases to Reconstruct V3, 2-48, V3, 2-68  
 Number of Echoes V1, 3-28  
 Number of Excitations (NEX) V1, 3-60  
 Number of Locations Before Pause V1, 3-63  
 Number of Repetitions Before Pause V1, 3-63  
 Number of Respiratory Intervals V3, 2-51  
 Number of R-R Interval V3, 2-39  
 Number of Shots V1, 3-29  
 Number of Slices/Slabs V1, 3-56  
 Number of views V4, 5-33

## O

Oblique Batch V4, 6-64  
 Oblique Mode Select V4, 5-7  
 on-screen trackball V4, 5-25, V4, 5-26  
 Optimize Chemical Saturation V1, 8-19  
 Optimizing Image Quality with Prescanning V1, 8-1

Options for Saturation Techniques V3, 1-36  
 Options that Control Artifacts V3, 1-4  
 Options that Enhance or Alter Contrast V3, 1-17  
 Options that Enhance Spatial Resolution V3, 1-12  
 Options that Minimize the Effects of Motion V3, 1-26  
 Options to Balance SNR V3, 1-45  
 Orbit Application V3, 5-42  
 Orientation Buttons V3, 5-16  
 Output mode V4, 5-30  
 Outside trace V4, 5-18

## P

PAC (Physiologic Acquisition Control) Unit V1, 2-7  
 Paging V1, 9-7, V1, 9-31  
 Pan Cursor V3, 5-11  
 Parameter Trade-offs V1, 7-15  
 Parametric images V4, 8-10  
 Partial annotation V1, 9-60  
 Partial Radial Spacing V1, 7-29  
 Patient Age V1, 6-5  
 patient alert device V1, 2-2  
 Patient Alert System V1, 1-30  
 Patient Comfort Module V1, 1-16  
 Patient Demographics V1, 6-4  
 Patient Emergencies V1, 1-31, V1, 1-40  
 Patient Entry V1, 3-11  
 Patient History V1, 6-6  
 Patient Information V1, 3-6  
 Patient Information Edit Log V4, 2-8  
 Patient Information Edit Log V4, 2-14  
 Patient Log V4, 2-14  
 Patient Position V1, 3-9  
 Patient Positioning Warnings V1, 1-16  
 Patient Preparation and Scan Start Up V3, 3-13  
 Patient Register V1, 6-21  
 Patient Screening Form V1, 1-38  
 Patient transport V1, 2-8  
 Patient Weight V1, 6-5  
 Pause Scan V1, 2-6  
 Pause Scanning V3, 5-18, V3, 5-36  
 Pause When Full V3, 5-38  
 Pause When Full V3, 5-36, V3, 5-37  
 PC V4, 5-3  
 PC Monitor V1, 2-10  
 Perform Arrhythmia Rejection and FastCard V3, 2-42  
 Performed Procedure Step V1, 6-12  
 Performing Coil QA V1, 4-10  
 Performing QA for Other Coils V1, 4-11  
 Peripheral (photo-pulse) Sensor V3, 2-15  
 Peripheral Gating Warnings V1, 1-20  
 Peripheral Gating/Triggering V3, 2-5  
 Peripheral Nerve Stimulation V1, 1-13  
 Peripheral nerve stimulation V1, 1-29

- Peripheral Vascular coil V1, 4-24
  - Phase Acquisition Order V1, 3-49
  - Phase Contrast V4, 5-3
  - Phase Contrast (PC) V2, 8-3
  - Phase Contrast Pulse Sequences V2, 8-1
  - Phase Correct V1, 3-69
  - Phase Difference V2, 8-6
  - Phase FOV V1, 3-61
  - Phase Offset Multi-Planar V3, 1-45
  - Phased Array Breast coil V1, 4-23
  - phased array coils V1, 4-18
  - Phases of SmartPrep V3, 3-5
  - Phases Per Location V1, 3-49
  - Picture This Library V1, 5-6, V1, 9-18
  - Picture This Protocol Library V1, 7-5
  - Place Bellows and Route the Tubing V3, 2-84
  - Place Electrodes and Route the Cable V3, 2-74
  - Play Backward V3, 5-22
  - Play Forward V3, 5-22, V3, 5-37
  - Port No. V1, 2-19
  - Position the Patient V1, 7-51
  - Positive Enhancement Integral V4, 8-11, V4, 8-57
  - Post Process Three Station Runoffs
    - Acquire Collapsed Images with IVI V4, 3-26
    - Bind Multiple Series into a Single Series V4, 3-28
    - Subtractions V4, 3-22
  - Post Processing Three Station Runoffs V4, 3-22
  - Power down under emergencies V1, 2-38
  - Powering down under Emergencies V1, 2-22
  - PPS V1, 6-12, V1, 6-23
  - P-R Interval V3, 2-11
  - Precessional and Transmit Frequency V1, 8-6
  - Pregnant or Infant Patients V1, 1-23
  - Prep Scan V1, 3-89
  - Prepare the Patient for the Exam V1, 7-46
  - Prepare to Scan V1, 3-82, V1, 7-11
  - pre-register a patient V1, 6-1
  - Pre-Registering a Patient V1, 6-16
  - Pre-Registering Patient V1, 6-4
  - Prerequisite Skills V1, About-1, V2, About-1
  - Prescan V1, 3-88
  - Prescanning V3, 4-6, V3, 4-11
  - Prescribe Scan Locations For A Series V3, 5-34
  - Preset buttons V4, 6-19
  - Preset window widths and window levels V1, 10-25
  - Presets V1, 9-18, V1, 9-68, V1, 10-25
  - PRESS V2, 12-10
  - Preview V4, 5-30
  - Previewing Command Window for Film Batch or Movie Loop V4, 6-37
  - primary viewport V1, 9-5
  - print options V1, 10-6
  - Print Queue V1, 10-11, V1, 10-23
  - Print Series V1, 10-10, V1, 10-17
  - Print Series window V1, 10-10, V1, 10-17
  - Printer V4, 5-30
  - Printing V1, 10-8, V1, 10-20
  - Printing Images V1, 10-20
  - Printing Protocols V1, 5-24
  - Printing Site Protocols V1, 5-24
  - PROBE/SV V2, 12-4
  - PROBE-P V2, 12-10
  - PROBE-S V2, 12-10
  - Protect the Patient from RF Burns V1, 1-43
  - Protect the Patient's Eyes and Ears V1, 1-45
  - Protocol V1, 3-23, V1, 7-4
  - Protocol Algorithms V4, 8-55
  - Protocol Building V1, 5-1, V1, 5-9
  - Protocol Desktop V1, 2-16
  - Protocol Libraries V1, 7-4
  - protocol Libraries V1, 5-14
  - protocol library V1, 5-14
  - Protocol Manager V1, 5-4
  - Pulse Sequence V1, 3-21
  - Pulse Sequence Annotation V1, 9-15
  - Pulse Sequence Database Name V1, 3-22
  - Pulse Sequences V1, 7-13
  - Purpose and Benefits V1, 8-4
  - P-Wave V3, 2-10
- Q**
- QA test V1, 2-15
  - QRS Complex V3, 2-11
  - Quality Assurance V1, 2-15
  - Quench V1, 1-11
  - Quench with Vent Failure V1, 1-42
  - Quick Step iDrive for 3 Plane Localizer V3, 5-56
- R**
- Radial Batch V4, 6-66
  - Radial Graphic Rx V1, 7-28
  - Radial Graphically V1, 7-70
  - Ramp Pulse V2, 6-16
  - Ratio (A-B)/(C-D) V4, 8-17, V4, 8-45, V4, 8-54
  - Ratio Slider V4, 3-9
  - Raw file manager V1, 2-36
  - Raw file manager V1, 2-37
  - Real Time V3, 5-5
  - Real Time Interactive Acquire Tab Card V3, 5-28
  - Real-Time V3, 1-53
  - Real-Time Sequence V3, 5-27
  - Reasons for Auto Prescan Failures V1, 8-5
  - reboot V4, 1-13
  - Rebooting During the ClariView Procedure V4, 1-13
  - Receive V1, 8-7

- Receive Gain V1, 8-7
- Receiver Bandwidth and SNR V1, 7-20
- Receiver Sensitivity V1, 8-7
- rectangular matte V1, 9-51
- Redo V3, 5-17
- Reference Image V1, 9-8, V1, 9-45
- reference image V4, 8-9
- Reference Scan V1, 3-90
- Reformat
  - Cursor / Annotations Command Window V4, 6-42
  - Display / Graphics Options Command Window V4, 6-42
  - Display / Graphics Options Command window V4, 6-44
  - File Menu V4, 6-7
  - Graphics Command Window V4, 6-10
  - Identify mm. / Slices Command Window V4, 6-39
  - Layout V4, 6-5
  - Oblique Mode Select Button V4, 6-18
  - On View Operations V4, 6-50
  - Plane Orientation Indicator V4, 6-6
  - Series/Image Selection V4, 6-5
  - Tilt/Rotate Mode Select Button V4, 6-17
  - Valid Image Set V4, 6-4
  - View Type Buttons V4, 6-20
- Reformat Layout V4, 6-5
- Reformation Color Window Command V4, 6-46
- Reformation Film Command Window V4, 6-48
- Refresh V1, 10-24
- Refresh List V1, 9-24
- Region of Interest V4, 8-46
- Region-of-Interest (ROI) V4, 8-19
- Regulate Contrast with Cardiac Gating V3, 2-80
- Regulate Contrast with Respiratory Gating V3, 2-88
- Relative SNR% V1, 3-85
- Remote Configure window V1, 10-22
- Remote Printer V1, 10-11, V1, 10-21
- Remove a Host V1, 11-38
- Remove Annotation V1, 9-50
- Remove Image Data V1, 11-33
- Removing Images from the System Disk V1, 11-11
- Repeat a Series V1, 5-22
- Repetition Time V1, 3-33
- Report Cursor V1, 3-25
- Reset Center V1, 7-27
- Reset the TPS V1, 2-35
- Reset TPS V1, 2-18
- Reset Values V1, 3-85
- Respiratory Bellows Placement V3, 2-21
- Respiratory Compensation V3, 1-28
- Respiratory Display V1, 2-4
- Respiratory Gating V3, 2-7, V3, 2-16
- Respiratory Gating and Triggering V3, 1-30, V3, 2-16
- Respiratory Gating and Triggering Parameters V3, 2-50
- Respiratory Gating with FastCine/FastCine PC V2, 13-19
- Respiratory Gating/Triggering V3, 2-5
- Respiratory Gating/Triggering V3, 2-84
- Respiratory Triggering V3, 2-8, V3, 2-17
- Respiratory Waveform V3, 2-25
- Respond to Emergencies V1, 1-40
- Restore Images from Local Archive Media V1, 11-26
- Restoring Images from Local Archive Media V1, 11-8
- Restoring Protocols from MOD V1, 5-31
- Restrictions for Restoring Images from Archive Media V1, 11-8
- Restrictions for Saving Images V1, 11-7
- Restrictions on Use V1, 1-5
- Retrieve Images from a Remote Host (Network Receive) V1, 11-48
- Retrieve Locations V3, 5-19
- Reversing the Video V1, 9-78
- Review Tab Card V3, 5-22
- Reviewing Protocol Parameters V1, 7-60
- RF Power V1, 1-22
- Right Mouse Button V1, 9-65
- Right Mouse button V1, 9-17
- Rotate Cursor V3, 5-12
- Rotate using first and last image V4, 5-32
- Rotating the MIP V4, 5-25
- Rotation V4, 5-29
- Rotation Increment V4, 5-7
- Rotation Movie Loop Command Window V4, 6-33
- R-R Interval V3, 2-12
- Rx Locations V3, 5-18
- Rx Manager V1, 3-71, V1, 7-6
- Rx Manager List V1, 3-79, V1, 7-7
- S**
- Safety Information V1, 1-5
- Safety Notices V1, About-7, V2, About-5
- Safety Review V1, 1-34
- SAR Level V1, 3-86
- SAR Limits V1, 1-24
- SAT Gap V2, 7-8
- SAT Icon V1, 3-40
- SAT in the FOV V1, 7-35
- SAT Prescription Screen V1, 3-40
- SAT pulse V2, 6-6
- Save V4, 5-30
- Save Image V3, 5-38
- Save Image button V3, 5-17
- Save Images V1, 11-23, V3, 5-38
- Save Range V3, 5-38
- Save raw data V1, 2-21
- Save Rx as Protocol V1, 3-82, V1, 5-19, V1, 7-11
- Save Series V1, 3-85

- Save State V1, 9-77
- Save Window/Level V1, 3-26
- Save/Restore/Print Protocol V1, 5-31
- Saveraw data V1, 2-36
- Saving a Protocol V1, 5-19, V1, 9-58
- Saving a Series V4, 3-8
- Saving and Filming Images V4, 8-48
- Saving Images V1, 11-7
- Saving Protocols to an MOD V1, 5-27
- Saving Site Protocols to MOD V1, 5-27
- SAVS/Paintbrush V4, 5-7
- Scale V4, 8-45
- Scalpel V4, 5-14, V4, 5-18
- scalpel V4, 5-9
- Scan V1, 3-89, V1, 7-75
- Scan Desktop V1, 2-16
- Scan Modes V1, 3-72
- Scan Operations V1, 3-87
- Scan Rx Desktop V1, 3-1
- Scan Rx Icon V1, 3-2
- Scan Timing V1, 3-27, V1, 7-15
- Scan TR V1, 8-17
- Scan with SmartStep V3, 4-7
- Scanning V1, 7-75
- Scanning Range V1, 3-51, V1, 7-22
- Scanning with a Protocol V1, 7-1
- Scanning with SmartPrep V3, 3-13
- Schedule V1, 6-6
- Schedule Screen V1, 6-7
- SCIC V1, 6-11, V1, 6-25
- SCIC and PPS V1, 6-11, V1, 6-25
- SCP V1, 6-27, V1, 6-29, V1, 6-31, V1, 6-32
- SCP tab V1, 6-29
- Screen Save V1, 9-58
- Scroll V1, 9-40
- Scrolling V1, 9-40, V1, 9-65
- Security Zone V1, 1-8
- segment trace V4, 5-17
- Select an Archive Device V1, 11-18
- Select Object V4, 5-6
- Selecting a Protocol V1, 7-58
- Selecting a Registered Patient V1, 6-20
- Selecting an Archive Device V1, 11-5
- Selecting the Image Set V4, 5-12
- Sequential V1, 3-49, V3, 1-49
- Series Binding V1, 9-17, V1, 9-66
- Series Control V1, 3-84
- Series Text Page V1, 10-18
- Service Tools Desktop V1, 2-17
- Set Batch/Movie Loop V4, 5-6, V4, 5-28
- Set End V3, 5-19
- Set Range First V3, 5-37
- Set Range Last V3, 5-37
- Set reference image V4, 8-40
- Set Start V3, 5-19
- Set up the Gating Control V3, 2-86
- Set up the Gating Control Parameters V3, 2-76
- Setting a Primary Viewport V1, 9-29
- Setting a Secondary Viewport V1, 9-30
- Setting the Trigger Point and Trigger Window V3, 2-53
- Setting Window and Level Presets V1, 10-25
- Sharpening V4, 1-3
- Sharpening Algorithms V4, 1-9, V4, 1-13
- sharpening algorithms V4, 1-9
- Shim Coils V1, 4-5
- Shoulder Application V3, 5-47
- Shoulder coil V1, 4-22
- Shutdown your Signa LX V1, 2-34
- Shutting down your Signa LX V1, 2-22
- Signa Gating Algorithms V3, 2-26
- Signal Enhancement Ratio V4, 8-14, V4, 8-55
- Single image save V3, 5-17
- Single Shot Fast Spin Echo (SSFSE) V2, 3-50
- Single Shot Fast Spin Echo-IR (SSFSE-IR) V2, 3-50
- Single-voxel Proton Brain Exam V2, 12-4
- Site Library V1, 5-6, V1, 9-5
- Site Protocol Library V1, 7-5
- Slice Location Limits V3, 5-20
- Slice Zerofill Interpolation Processing V3, 1-15
- Slide Format V1, 10-6
- Slider V1, 3-25
- SmartPrep V3, 1-52, V3, 3-1
- SmartStep V3, 4-1, V3, 4-2
- smoothing V4, 1-3
- Smoothing algorithms V4, 1-9
- SNR V1, 4-7
- Sorting Exams in Numerical Order V1, 9-21
- Sorting Images V1, 9-5
- Sorting the Patient Register V1, 6-21
- Spacing V1, 3-53
- Spatial mode V1, 9-7
- Spatial Resolution V1, 7-16
- Spatial Resolution Parameters and SNR V1, 7-19
- Spatial SAT V3, 1-37
- Spatial Saturation V1, 7-32
- spatial saturation V1, 7-72
- SPECIAL V3, 4-3, V3, 4-4
- Spectral Inversion at Lipids V3, 1-40
- Spectroscopy V2, 12-1
- Spectroscopy Single Voxel V2, 12-10
- Spectrum Average or Compression Techniques V4, 8-33
- Spectrum Colors V4, 8-19
- Spin Echo V2, 2-3
- Spin Echo EPI V2, 11-11

- Spin Echo Pulse Sequence V2, 2-1
- Spine Application V3, 5-45
- Split ROI V4, 8-47
- Split ROI and Merge ROI V4, 8-6
- Spoiled Gradient Echo (SPGR) V2, 4-20
- Square Pixel V3, 1-12
- Square ROI V4, 8-46, V4, 8-51
- Square Viewports V1, 9-17, V1, 9-67
- ST Segment V3, 2-11
- Standard CINE Screen V3, 2-66
- Start V1, 2-6
- Start a Scan Prescription V1, 7-48
- Start a stationary system V1, 2-28
- Start and End Location V1, 3-55
- Start your mobile system V1, 2-26
- Starting the Reformat Package V4, 6-5
- Starting your mobile system V1, 2-22
- Starting your stationary system V1, 2-22
- Startup V4, 8-43
- Status Area V1, 10-7
- STEAM V2, 12-10
- STL% V1, 3-87
- STL% or dB/dt V1, 3-22
- Subtract Two Images Within the Same Set or Two Sets of Images V4, 3-14
- Subtracting two images V4, 3-14
- Superimposed Spectra V4, 8-33
- surface V1, 4-5
- Surface and Phased Array Coils V1, 4-7
- surface and phased array coils V1, 4-21
- Surface Coil Intensity Correction V3, 1-17
- Surface Coil Warnings V1, 1-18
- surface coils V1, 4-18
- Swap Phase/Freq V3, 5-18
- System Cabinet Room (Computer Room) V1, 2-14
- System Disk Space V1, 11-10
- System supplied text V1, 9-10
- Systems with a Helium Level Meter V1, 1-46
- Systems with a Magnet Monitor Unit V1, 1-47
- Systole V3, 2-12
- T**
- T1 FLAIR V2, 3-38
- Table Transport Emergency Release V1, 1-29
- Tailored RF V3, 1-4
- Temporal and Spatial Image Play Modes V3, 5-23
- Temporal Lobe Application V3, 5-41
- Temporal mode V1, 9-7
- Tetramethylsilane (TMS) V2, 12-7
- Text Page V1, 10-18
- Text pages V1, 10-18
- The Chemical Shift or Upper Left (UL) Viewport V4, 8-25
- The Metabolite Image or Lower Left (LL) Viewport V4, 8-35
- The Reference or Lower Right (LR) Viewport V4, 8-38
- Thermal Stress V1, 1-22
- Threshold V3, 3-3, V4, 5-8, V4, 5-20, V4, 8-45
- Threshold /VOI V4, 5-16
- Threshold Range adjustment sliders V4, 5-23
- Threshold/VOI V4, 5-7
- Tick Marks V1, 9-17
- Ticks Marks V1, 9-62
- Tilt Cursor V3, 5-12
- Tilt/Rotate Mode Select V4, 5-6
- Time a Bolus V3, 5-36
- Time Display/Patient Position V1, 2-5
- Time of Flight V4, 5-3
- Time of Flight Pulse Sequences V2, 6-1
- time-intensity curves V4, 8-9
- Timer V3, 5-17, V3, 5-36
- time-varying magnetic fields V1, 4-3
- Tips for Adjusting the Gating Trigger Level in ECG Gating V3, 2-33
- Tissue heating V1, 1-22
- TMJ Application V3, 5-43
- TOF V4, 5-3
- Torso Array coil V1, 4-21
- Torso Pelvis Array coil V1, 4-24
- TPS Reset V1, 2-35
- tracker V3, 3-1
- Transfer the Patient to the System Table V1, 7-50
- Translate Cursor V3, 5-12
- Transmit Data to a Remote Host (Network Send) V1, 11-45
- Transmit Gain V1, 8-6
- Transmit Power V1, 8-6
- Trigger Delay V2, 7-6, V3, 2-44
- Trigger Delay (TD) V3, 2-44
- Trigger Point (TP) V3, 2-52
- Trigger Type V2, 9-4, V2, 13-17, V3, 2-38, V3, 2-67
- Trigger Window V3, 2-40
- Trigger Window (TW) V3, 2-53
- Triggering V3, 2-7
- Triple-IR V2, 13-6
- Tumble V4, 5-8
- Turbo Mode V3, 4-4
- Turbo mode V3, 4-2
- T-Wave V3, 2-11
- Two Prescan Programs V1, 8-4
- U**
- Undo V3, 5-17, V4, 5-8, V4, 5-18
- Undo Buttons V3, 5-17
- Update a Host V1, 11-40
- Update BPM V2, 9-5
- Update Images V1, 3-26

Update R-peak Amplitude V3, 2-34  
 Updating a Host V1, 11-40  
 Upper Left (UL) Viewport V4, 8-25  
 User Annot / Trace V4, 5-8  
 User Control Variables Screen V1, 3-46  
 User Preferences V1, 9-16  
 User Training V1, 1-7  
 Using Accelerator Commands V1, 9-70  
 Using Connect Pro V1, 6-23

**V**

Valid Image Set V4, 5-3  
 Variable Bandwidth V3, 1-6  
 Vascular Screen V1, 3-45  
 Velocities V2, 8-5  
 VENC V2, 8-5  
 Very Selective Spatial Saturation V2, 12-7  
 View buttons V4, 5-7  
 View Edit V1, 3-81, V1, 7-10  
 View Planes V4, 5-7  
 Viewer V1, 9-6  
 Viewing Patient List V1, 9-22  
 Viewing the Patient Log V4, 2-14  
 Viewport Control V1, 9-5  
 viewport layout V4, 5-5  
 Views per Segment V2, 13-18, V3, 2-48  
 Views Per Segment (VPS) V3, 2-48  
 volume controls V1, 2-2  
 volume of MRA images V4, 5-1  
 Voxel size V2, 6-8

**W**

Waveform Display V3, 2-24  
 window V1, 9-6  
 window width and level settings V1, 9-27  
 Window Widths and Window Levels V1, 9-68  
 Working Safely V1, 1-1  
 Worklis V1, 6-7  
 Worklist V1, 6-7, V1, 6-24  
 Workspace Cabinet V1, 2-10  
 Workstation components V1, 2-3  
 workstation components V1, 2-2  
 Workstation Monitor V1, 2-10  
 Wrist coil V1, 4-22

**X**

X-axis, Image Rank and the PPM Scale, and Spectrum  
 Zooming V4, 8-32

**Y**

Y-axis and Spectrum Scaling V4, 8-32

**Z**

Zoom V1, 9-37  
 Zoom In V3, 5-18