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# Safety

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## 1.1 Labels

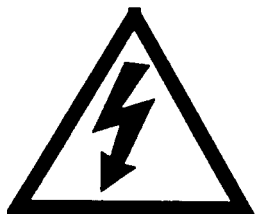
Labels are provided to alert operating and service personnel to conditions that may cause personal injury or damage to the equipment from misuse or abuse. Please read the labels and understand their meaning.

### 1.1.1 Important Operating or Maintenance Instructions



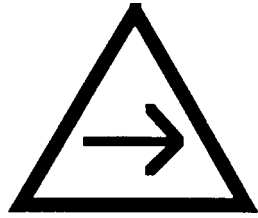
The exclamation point within a triangle is to alert the user or service personnel to the presence of important operating or maintenance instructions in the Operation and Service Manual.

### 1.1.2 Shock Hazard



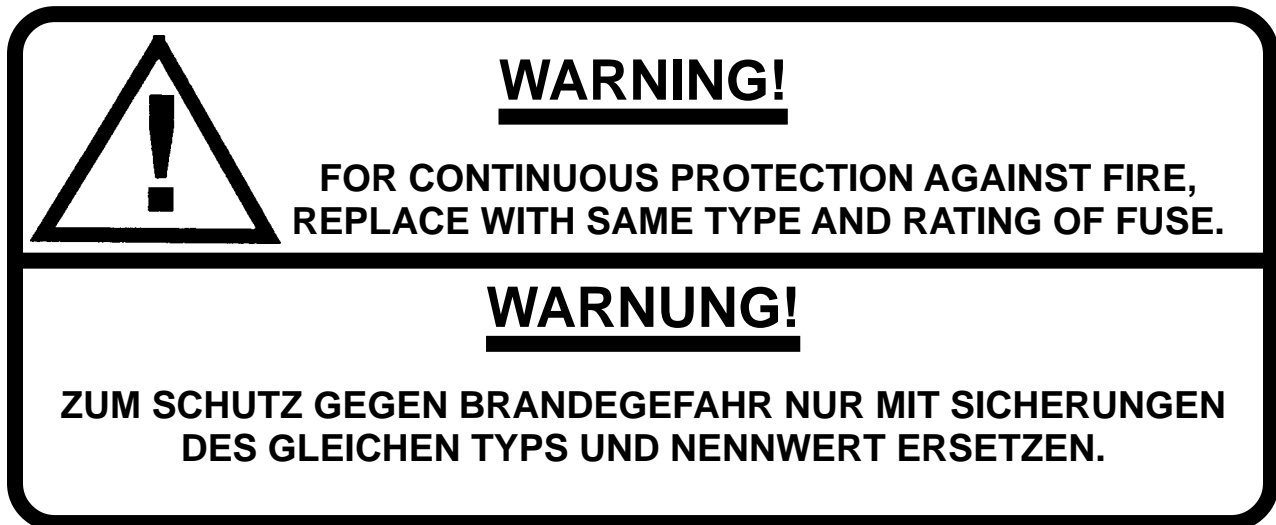
The lightning bolt within a triangle is to alert operating and service personnel to the presence of uninsulated voltage within the enclosure of sufficient magnitude to cause dangerous electric shock. Only authorized service personnel with a schematic diagram and knowledge of the voltages existing within the equipment shall remove covers or panels bearing this symbol.

### 1.1.3 Rotating Fan Blade



The arrow within a triangle is to alert the user or service personnel to the presence of rotating fan blades.

### 1.1.4 Fuse Warning



Replacement fuses must be same as those supplied. Spare fuses are provided with the equipment.

## 1.1.5 Service



### **WARNING!**

- SERVICE BY AUTHORIZED PERSONNEL ONLY
- REFER TO INSTALLATION AND OPERATING INSTRUCTIONS
- DISCONNECT POWER FOR ANY SERVICE WORK

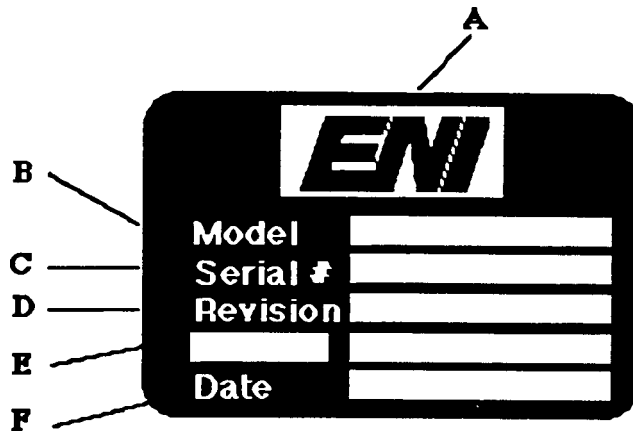
### **WARNUNG !**

- SERVICE NUR VON FACHPERSONAL
- INSTALLATIONS - GEBRAUCHSANWEISUNG BEACHTEN
- VOM NETZ TRENNEN BEI SERVICE ARBEITEN

ENI, Inc is responsible for safety, reliability, and performance of the equipment only if:

- Assembly operations, extensions, readjustments, modifications, or repairs are carried out by authorized personnel.
- The electrical installation is made in accordance with the installation instructions provided and the room in which the equipment is installed complies with the environmental requirements.
- The equipment is used in accordance with the instructions for use.

## 1.1.6 Name Plate



- A. **Manufacturer:**  
ENI, Inc.  
Rochester, NY USA
- B. **Model**  
The assembly number which uniquely identifies product configuration is contained on this line.
- C. **Serial #:**  
This line contains a number which is sequentially assigned as the product is manufactured.
- D. **Revision:**  
This line contains the revision letter which identifies the product configuration. The initial revision is A.
- E. This line is optional, but typically contains customer name and identification number.
- F. **Date:**  
This line contains the date of manufacture.
-

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# Introduction

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## 2.1 Introduction

The Model MRI-2000 is a broadband linear amplifier specifically designed for pulse mode operation. It is capable of 2000 watts of power output over a frequency range of 15 to 64 MHz.

Operating linear class AB, the MRI-2000 will amplify the output of the signal source by 63dB (+2,-0dB).

The use of field-effect power transistors and innovative transformer designs ensures ruggedness and enhances broadband high frequency performance. The modular construction provides easy servicing while the integral power supply and cooling system permits operation over a wide range of temperature and AC line conditions. For a list of specifications see Figure 1.

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# **System Installation & Maintenance**

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## **3.1 Initial Inspection**

### **3.1.1 Mechanical Check**

If damage to the shipping carton is evident, request the carrier's agent be present when the instrument is unpacked. Check the equipment for damage and inspect the cabinet and panel surfaces for dents and scratches.

### **3.1.2 Claim for Damage**

If the amplifier is mechanically damaged or fails to meet specification upon receipt, notify ENI or our representative immediately. Retain the shipping carton and packing material for the carriers inspection as well as for subsequent use in returning the unit if necessary.

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## 3.2 Preparation for use

### 3.2.1 Power requirements

The driver amplifier requires less than 6A from a 50-60 Hz single phase power source. Line voltages of 190, 208, 220, and 240 can be selected by changing the main transformer tap. A terminal block, inside the unit has been provided to allow easy selection. See Figure 2 for line voltage selection and Figure 1 for tolerances.

### 3.2.2 Power Cable (not supplied)



#### **International Installation**

The AC Mains Power Cord shall be an IEC compliant national power cord. Three 1.0 mm<sup>2</sup> conductors are required.

#### **North American Installation**

A UL listed cord set with a 250V, 10A minimum rating is required. NEMA L6-20P attachment plug is required. Contact ENI, Rochester for additional information.

### 3.2.3 Cooling



When the amplifier is enclosed by an external cabinet, provisions must be made to insure an adequate flow of cooling air to the unit. Ambient temperature of the air must not exceed 50° C.

### 3.2.4 Performance Check

The electrical performance should be verified as soon as possible after receipt. The following is a performance check that is suitable for incoming inspection.

- a. Turn the unit on using the Remote Control connector located on the rear panel. Check to see if the fans are operating normally and if the AC line (power on) light is illuminated on the front panel. See Chapter 3 for a complete description of unit control and interfacing.
  - b. Perform RF Output Power Test, Section 3.8.
-

## 3.3 Rack Mounting

Rack mounting brackets are supplied for installation in any standard nineteen inch relay rack cabinet. To attach the brackets, remove the #8-32 screws on each side of the cover nearest the front and rear panel and reinsert them through the corresponding holes in the brackets. Tighten securely.

---

## 3.4 Packaging for Reshipment

Whenever possible, the original shipping carton and packing material should be used for reshipment. If the original packing material is not available, wrap the instrument in heavy paper or plastic. Use a strong shipping container. If a cardboard carton is used, it should be at least 200 lbs. test material. Use shock absorbing material around all sides of the instrument to provide a firm cushion and to prevent movement inside the container. A minimum of two inches should be between the instrument and the container wall on each side. Protect the front panel by means of cardboard spacers inserted between the front panel and the shipping carton. Make sure that the instrument cannot move in the container during shipment. Seal the carton with a good grade of shipping tape and mark the container: **FRAGILE ELECTRONIC INSTRUMENT**.

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## 3.5 Operating Procedure

Before operating, become familiar with the front and rear panel switches, indicators, and connectors described in Chapter 3. Determine that the line voltage is properly set, then proceed as follows:

- a. Connect the output via a  $50\Omega$  coaxial lead to the load.
  - b. Connect the input signal via a  $50\Omega$  coaxial lead to the input connector.
  - c. Connect the bias gating signal to the BNC connector on the rear panel.  
+5V=ON, 0 V=OFF.
  - d. Insure input RF voltage from the signal source is not excessive. This should be no more than 0 dBm for 2000 watts peak power output.
-

## 3.6 Precautions

- a. The input and output should not be connected together. This will cause oscillation and may damage the input preamplifier.
  - b. When the voltage of the signal source is unknown, insert an attenuator between it and the amplifier input. Adjust this attenuator until the proper drive level is obtained.
- 

## 3.7 Linearity Test

(See figure 3)

Connect the output to a suitable  $50\Omega$  load and power meter. An acceptable alternative is to connect the RF output sample to a spectrum analyzer with resolution of 1dB/cm. Connect the bias gating input to a pulse generator capable of providing a 5V signal with 0V pulses at a 5% duty cycle (typically 100 Hz at 0.5 millisecond pulse width). Connect the RF input to an RF signal generator operating at the desired frequency between 15 MHz and 64 MHz, set the generator output to -5 dBm. Turn on the amplifier and set the RF output to 100W average or 2000W peak depending upon the type of power meter used. Now, establish a reference on the spectrum analyzer and decrease the RF input by 10dB while increasing the gain of the analyzer by 10dB. Read the difference in dB's between the reference level and the actual level. Continue the 10dB reduction in input power and note the difference from the original reference level when the analyzers gain is increased in equal 10dB steps. The maximum deviation should be less than 1dB and should be typically 0.2 to 0.6dB across a 60dB dynamic range. If either are any problems, check transistor biasing as described in the Troubleshooting chapter.

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## 3.8 Adjustments

### a. Pulse Width

This adjustment is located inside the access door on the front panel. Connect the unit output to a suitable signal generator operating at between 15 MHz and 64 MHz with an output of -10 to -5 dBm. Provide a gating pulse at 10% duty cycle having a pulse width equal to that desired for the fault trip point. Loosen the locknut and rotate the adjustment slowly counter-clockwise until the pulse width fault light is on. Tighten the locknut after adjustment.

### b. Duty Cycle

This adjustment is also located inside the access door on the MRI-2000 front panel. Set up the MRI-2000 as for the Pulse width adjustment. Provide a gating pulse width of more than 50 and less than that needed for a pulse width fault. Set duty cycle equal to that desired for the fault trip point. Loosen the locknut and rotate the adjustment fully clockwise. Turn on the MRI-2000 and rotate the adjustment slowly counter clockwise until the duty cycle fault light is on. Tighten the locknut. This completes the adjustment.

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## 3.9 Maintenance

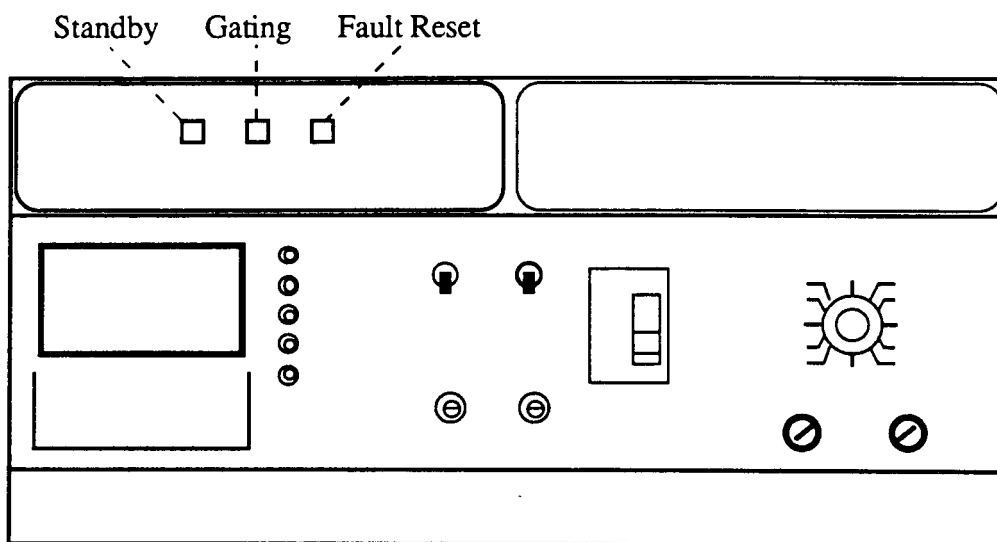
Periodic maintenance is not required. Occasionally, as dust accumulates, it should be vacuumed from the fan housings and vent holes in the amplifier cover.

Painted surfaces may be cleaned with a mild solution of dishwashing detergent and water, and then dried with a soft cloth or towel.

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# Driver Amplifier Front Panel Devices

## External Switches



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# Control & Interface

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## 4.1 Front Panel Devices

The following Front Panel devices and indicators are provided:

### 4.1.1 External Switches/Indicators

- Standby**      The Standby switch turns on the AC power when depressed. The internal led indicates that power is on.
- Gating**        The Gating switch enables bias. The indicator lights whenever bias is on.
- Fault Reset**    Pressing this switch resets pulse width and duty cycle faults. The indicator led lights for any fault condition. All other faults are self resetting except the overvoltage fault.

## 4.1.2 Internal Adjustment & Diagnostics

The following are located behind the lower front panel and are useful for troubleshooting and for verifying proper operation:

<b>Circuit Breaker</b>	Removes all power from the MRI-2000 and must be manually reset. This is a single-phase, 2-pole, 15A circuit breaker suitable for operation to 240VAC. Resetting the circuit breaker also resets the over voltage fault circuit.
<b>Fault Defeat</b>	Defeats the pulse width and duty cycle fault protection. This switch also lights the fault indicator lamp and sends a fault signal to external control via the rear panel connector.
<b>Power Meter FWD/REFL.</b>	Selects either forward or reflected peak power metering when the Meter Select switch (below) is set to read Peak Power. Full scale reading is 3000W peak. The metering circuit uses a track-and-hold technique that responds to pulses as narrow as 10 $\mu$ s. Reset occurs automatically 1-2 seconds after the last pulse has ended.
<b>Meter Select</b>	<p>This switch allows monitoring of the following parameters:</p> <ol style="list-style-type: none"><li>1) Current, PA 1 thru PA4 measures the average DC current into each P.A. module. The meter reading is 7.5A full scale.</li><li>2) Peak Power measures the peak forward and peak reflected output power when used in conjunction with the Fwd/Refl switch (above). The meter reading is 3000W full scale.</li><li>3) Voltage measurements allow monitoring of internal power supply voltages. The meter readings are 75V full scale.</li><li>4) Bias measures the DC voltage of the gate bias to the FET RF power transistors.</li></ol>
<b>Pulse Width Adjust</b>	Used to set the pulse width fault trip point. This fault detector is independent of pulse duty cycle. It is reset using the Fault Reset switch. It can be defeated with the Fault Defeat switch.

### Duty Cycle Adjust

Used to set the duty cycle fault trip point. This fault detector is independent of pulse width. It is reset using the Fault Reset switch and may be defeated with the Fault Defeat switch.

### Fuse F1 and F2

Used to protect the +15V power supply, the +5V power supply, and the cooling fan.

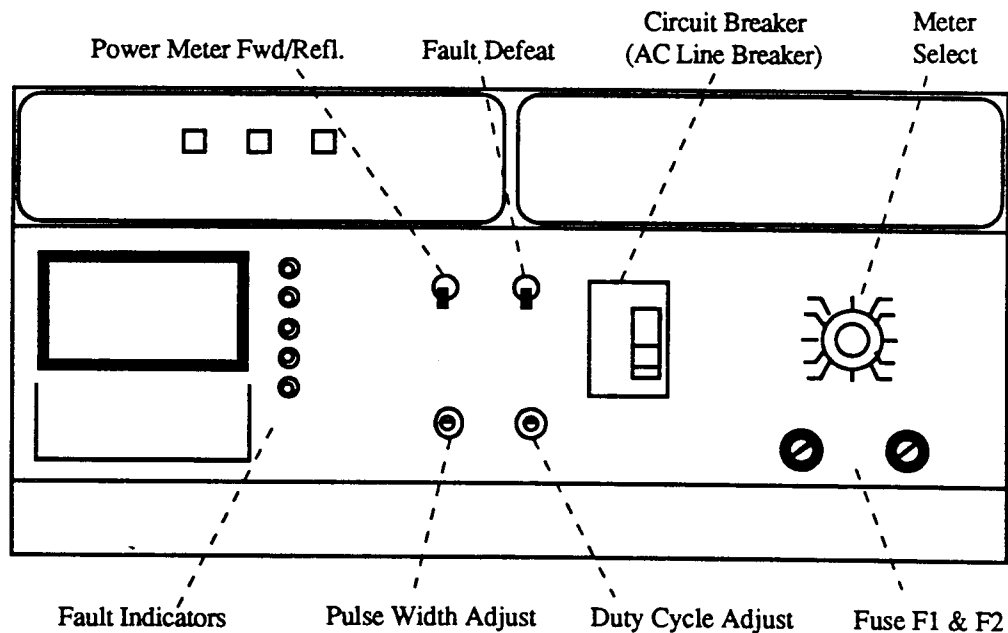
### Fuse Indicators

- 1) Pulse width indicates excessive pulse width and is reset with the Fault Reset switch.
- 2) Duty cycle indicates excessive pulse duty cycle and is reset with the Fault Reset switch.
- 3) Overheat indicates excessive amplifier heatsink temperature and is self-resetting.
- 4) Overvoltage indicates a failure in the +60V power supply. It must be reset by turning the circuit breaker OFF then ON. Do not reset this fault unless the +60V supply has been checked.
- 5) P.A. Current indicates excessive power amplifier current. This fault is self-resetting.

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## Front Panel Devices

### Internal Adjustment and Diagnostics



## 4.2 Rear Panel Devices

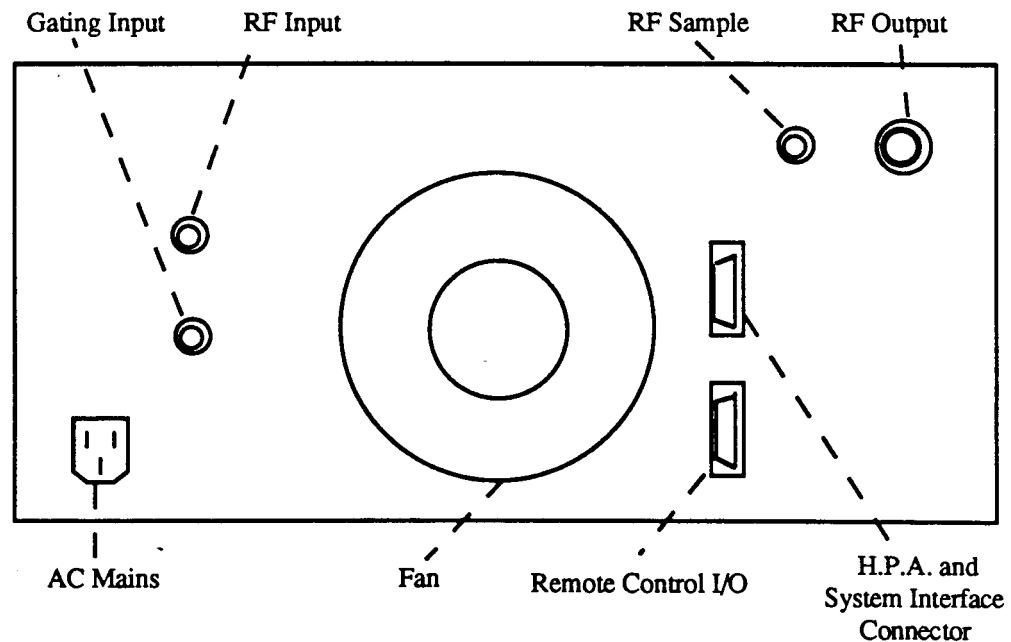
### 4.2.1 RF Output Connector

Amplifier output is delivered through this type “N” connector.

### 4.2.2 BNC Connectors

- 1) RF Sample Connector provides a low-level sample output of the RF output.
- 2) RF Input connector accepts drive from signal source or exciter at 0dBm maximum for 2KW output.
- 3) Gating input connector accepts external bias gating.  
>3.5V = P.A. bias ON  
<0.7V = bias OFF.  
Inverted control logic optional.

## Driver Amplifier Rear Panel



## 4.2.3 Remote Control I/O

Pin 1	AC ON	A logic 1 turns on the MRI-2000 ( $1 \geq 3.5V$ , $0 \leq 1.0V$ )
Pin 2	Fault Reset	A logic 1 resets the pulse width and duty cycle faults.
Pin 3	Fault	This output is at logic 1 for any fault condition and also for a Fault Defeat condition.
Pin 4	Duty Cycle Fault	This output is at logic 1 for a Duty Cycle fault.
Pin 5	Pulse Width Fault	This output is at logic 1 for a Pulse Width fault.
Pin 6	Overheat Fault	This output is at logic 1 for an Overheat Fault.
Pin 7	Bias On Readback	This output is at logic 0 when FET RF power transistor gate bias is on.
Pin 8	Power Supply Shutdown	A logic 1 will shutdown the main DC power to the output and driver stages of the amplifier.
Pin 9	External Bias Gating	A logic 1 = P.A. bias on.
Pin 10	Ext. Bias Gating (Invert)	A logic 0 = P.A. Bias on.
Pin 11	Forward Power	This is the squared output of the VSWR Bridge forward power detector. This output is linear with RF Power.
Pin 12	Reflected Power.	This is the squared output of the VSWR Bridge reflected power detector. This output is linear with RF Power.
Pin 13	AC On Readback	This output is at logic 1 when unit is ON. ( $1 \geq 2V$ , $0 \leq 0.8V$ )
Pin 14	Signal Ground	Chassis and signal ground are available at this point.
Pin 15	No Connection	

## 4.2.4 HPA and System Interface Connector

Pin 1	AC ON	Turns on High Power Amplifier with logic 1 on this pin.
Pin 2	Fault Reset	Used to reset fault condition in HPA.
Pin 4	Bias Enable	To turn on gating bias in HPA.
Pin 5	Power Supply Shutdown	Turns off power supply to output stages of HPA.
Pin 6	Fault Input	Disables MRI-2000 in event of fault in HPA.
Pin 7	Signal Ground	Chassis and signal ground are available at this point.

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# Operation

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## 5.0 Major Circuit Blocks

The MRI-2000 Consists of 4 major Circuit blocks (see figure 4):

- 1) The Power Supply
  - 2) The RF Amplifier Assembly
  - 3) The Control Board Assembly
  - 4) Diagnostic and Metering Circuits
-

## 5.1 The Power Supply (See Figure 5 and 6)

The power supply provides regulated DC at +60 Volts to the power amplifier and driver modules. The circuit consists of a bridge rectifier, followed by a capacitor of 64,000  $\mu\text{F}$  for energy storage. This voltage is then supplied to a series-pass transistor assembly controlled by the voltage regulator located on the regulator assembly.

The power supply also provides +33 Volts to the output stage of the pre-amplifier. This circuit consists of a bridge rectifier, capacitor, and series-pass transistor. A separate voltage regulator located on the regulator assembly controls the +33 Volts. The output of this regulator is used to provide an input to the +25 Volt regulator for the pre-amplifier, and to the bias supply regulator for the RF power transistors.

A separate power supply transformer and regulator provides +15 Volts and +5 Volts to the control board circuitry. A second output winding on this transformer supplies a +15V voltage regulator referenced to the +60 Volt supply to operate the power amplifier current sensing circuits.

The bias supply for the RF power transistors consists of a three-terminal regulator driven by a gating buffer amplifier. The output voltage of the regulator is controlled by a temperature compensation circuit located on the power amplifier heatsink assembly. The temperature compensation is calibrated at 2.98V at a temperature of 20 °C and has an output directly proportional to temperature at 10mV/°C. This voltage is applied to the inverting input of the temperature compensation amplifier and compared with the reference voltage set on the non-inverting input.

The gain of this amplifier has been calculated to compensate the gate bias voltage on the MOSFET power transistors in the MRI-2000 to maintain a constant class AB bias current regardless of heatsink temperature. The amplifier output voltage sets the output of the bias regulator which provides the power needed for rapid pulse gating to all the power amplifier and driver transistors. The gating buffer amplifier performs the actual switching of the regulator control voltage in response to the gating enable signal from the fault logic on the control board. See figure 8 and 12. The gating signal from the front panel or external pulse gating is interrupted during any fault condition in the MRI-2000. driven by a gating buffer amplifier. The output voltage of the regulator is controlled by a temperature compensation circuit located on the power amplifier heatsink assembly. The temperature compensation is calibrated at 2.98V at a temperature of 20 °C and has an output directly proportional to temperature at 10mV/°C. This voltage is applied to the inverting input of the temperature compensation amplifier and compared with the reference voltage set on the non-inverting input.

The gain of this amplifier has been calculated to compensate the gate bias voltage on the MOSFET power transistors in the MRI-2000 to maintain a constant class AB bias current regardless of heatsink temperature. The amplifier output voltage sets the output of the bias regulator which provides the power needed for rapid pulse gating to all the power amplifier and driver transistors. The gating buffer amplifier performs the actual switching of the regulator control voltage in response to the gating enable signal from the fault logic on the control board. The gating signal from the front panel or external pulse gating is interrupted during any fault condition in the MRI-2000.

## 5.2 The RF Amplifier Assembly

(See Figure 7)

The RF Amplifier assembly consists of a preamplifier assembly, four output power amplifiers, a four-way splitter, a four-way output combiner, and a VSWR bridge assembly.

The pre-amplifier amplifies the RF input to about 20 watts to drive the driver module. This is a class A linear amplifier with the first four bipolar stages operating from the regulated +25 volt supply. The FET output stage operates from the regulated +33 volt supply with the gate bias derived from the bias supply to the driver and output amplifiers.

The driver module is identical to the output power amplifiers but operates at a much lower output level. It amplifies the output of the preamplifier to about 200 watts which, when split 4 ways, provides 50 watts to each power amplifier module. Driver operation is Class AB push-pull with a FET drain supply of regulated +60 volts and a regulated, temperature compensated gate voltage.

The power amplifiers each operate in push-pull Class AB and are feedback stabilized for operation into high VSWR loads without spurious oscillations. Output from each module is in excess of 500 watts peak power at a maximum 10% duty cycle. Resistors used for current sensing are located on each power amplifier.

The 4-way splitter and the 4-way output combiner are used at the input and the output of the power amplifiers to combine the power of the four modules. All ports are 50 ohms nominal for the frequency range of the MRI-2000.

The VSWR Bridge Assembly, located on the power amplifier heatsink, senses the forward and reflected power simultaneously and provides DC outputs to the control board for monitoring functions.

These DC levels are applied to a voltage squaring circuit so that the outputs are linear and directly proportional to the RF power output. The VSWR Bridge has a residual null reading of less than 10 watts at full output into a 50 $\Omega$  load.

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## 5.3 The Control Board Assembly

The Control Board contains the following functions:

- 1) Pulse width detector circuit
- 2) Duty cycle detector circuit
- 3) Current sensing circuits
- 4) Bias control and readback circuits
- 5) Fault detector interfacing and reset circuits
- 6) Forward and Reflected power peak detector circuits
- 7) AC line on/off control circuit

### 5.3.1 Pulse Width Detector

The pulse width detector is comprised of an integrating amplifier driven by an amplifier/limiter. The output ramp of the integrator is linear and its amplitude is directly proportional to the pulse width. Transistors Q1 and Q2 discharge the integrating capacitor CS whenever the output of the limiter is below .7 volts. Potentiometer R64 on the Control board introduces an offset which optimizes the usable adjustment range. This adjustment is made by the 10K potentiometer located on the lower front panel. The integrator output is connected to the threshold detector and then to IC8 flip-flop. IC8 provides separate Outputs for remote fault sensing and for the LED indicator. It is automatically reset at turn-on by IC15 and may be either manually or remotely reset during operation. See Figure 8.

### 5.3.2 Duty Cycle Detector

This detector, like the pulse width detector, operates from the output of the amplifier/limiter. It is basically a capacitor coupled inverting negative peak detector having an output pulse amplitude directly proportional to the duty cycle. This pulse output is integrated by the RC time constant of C4 and the 50K adjustment potentiometer. As the duty cycle increases, it causes the charge on C4 to increase and trigger the threshold detector. The threshold detector out is connected to the other half of IC8 flip-flop. IC8 provides separate outputs for remote fault sensing and for the LED indicator. It is automatically reset at turn-on by IC15 and may be either manually or remotely reset during operation. See Figure 8.

### **5.3.3 Current Sensing and Averaging**

The current sensing and protection operates from the voltage drop across the current sense resistors located on each power amplifier module. The power supply side (high side) of the resistor is connected to the inverting input of an op-amp through a voltage divider. The power amplifier (low side) of the resistor is connected to the non-inverting input. When the current through the sense resistor is less than 15 amps, the output of the op-amp will be high and allow Q3 to remain off. When 15 amps is exceeded, the voltage to the non-inverting input will be less than that to the inverting input and the op-amp will be driven low, thus turning on Q3 and lighting D26 LED on the control board. The output of 1C12 pulses the current fault LED and also pulse modulates the fault logic to interrupt the bias enable line and light the front panel fault LED. This fault mode results in a pulsed RF output and is self restoring as the RF input is reduced or P.A. load impedance is corrected. See Figure 9.

### **5.3.4 Bias Control and Readback**

The transistor bias gating is normally pulsed via the accessories connector on the rear panel. Input circuitry is designed to allow for gating with either a TTL '1' or a '0' on separate lines. These are connected with diode 'or' logic with the front panel switch to the local and remote fault logic. Any fault will disable the bias gating to the bias regulator on the voltage regulator board assembly. The output of the bias regulator is buffered and connected to the rear panel accessories connector and to the bias LED on the front panel. See Figure 10.

## 5.3.5 Fault Interfacing and Reset

The fault reset function may be operated either from the front panel switch or from the external command via the accessories connector. Both inputs are capacitor coupled to prevent a continuous reset command from defeating the protection circuits. The following faults are detected (See Figure 8 and 10):

- 1) Pulse width - see § 5.3.1. The output of this circuit is coupled through various 'or' logic to the bias control line. This fault may be defeated by interrupting the output with the fault defeat switch. Operating this switch will light the front panel 'Fault' LED.
- 2) Duty Cycle - see § 5.3.2. As in the case of the pulse width detector above, this circuit is coupled through 'or' logic to the bias control line. The fault defeat switch will interrupt the output of this circuit and light the 'Fault' LED.
- 3) Current Sense - see § 5.3.3. This circuit is connected through 'or' logic to the bias control line and the 'Fault' LED. It is self-resetting and cannot be defeated.
- 4) Overheat - The thermostat is located on the power amplifier assembly and operates at a heatsink temperature of 200 Degrees. It is connected through 'or' logic to the bias control line and the 'Fault' LED. It is self-resetting and cannot be defeated.
- 5) Overvoltage - Responds to a threshold detector located on the voltage regulator board which monitors the +60V supply to the RF power transistors. This fault does not disable the bias control line but instead turns off the MRI-2000 and lights the 'Fault' LED. It cannot be defeated and must be reset by turning off the main circuit breaker. Do not turn this circuit breaker on after this fault without monitoring the +60V supply. Damage to the RF power transistor may result.

## 5.3.6 Forward and Reflected Power Peak Detectors

(See figure 11)

The forward and reflected power sensing circuits are identical and are connected to the forward and reflected output ports of the VSWR bridge. The signal is first applied to a four-quadrant analog multiplier connected as a squaring circuit to linearize voltage with respect to power. The output of the squaring circuit is buffered and used to charge the hold capacitor of a track-and-hold amplifier which drives the power meter and also provides an output to the Remote I/O connector at 1.0 volt/kilowatt. The track-and-hold amplifier is reset by the reset timer circuit approximately 2 seconds after the RF output power has stopped. Calibration is accomplished by first adjusting R3 or R4 for the output at 1.0v/kw and then by adjusting R17 or R18 for the correct panel meter reading. .

## 5.3.7 AC Line Control

AC Line Control is via the front panel or by a logic '1' (+5 V) present at the accessories connector on the rear panel. Either control input will operate a solid state relay through the 'or' gate and also will send a logic '1' command to an external High Power Amplifier or other instruments. (See figure 12).

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# 5.4 Diagnostics and Metering

The built-in-test circuitry consists of the meter and selector switch. Normally the selector switch will be set to the Peak Power position for monitoring peak forward or reflected power. See section 5.3.6 for a description of the power metering circuit.

This same meter may be used to monitor current and voltage levels to facilitate troubleshooting or monitor power amplifier performance. Four of the switch positions monitor power amplifier current measured across a 0.02 ohm resistor connected in series with each amplifier module. The remaining switch positions connect the meter to various power supply voltages and the bias supply voltage.

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# Troubleshooting

---

## 6.0 General

The first step in isolating a malfunction is to review the conditions under which the symptoms were observed. Determine that the problems were not due to external cabling or abnormal line voltages. If the amplifier is being operated by remote control, verify that proper commands are being received. After the problem has been definitely attributed to the driver, refer to the Troubleshooting Guide in Figure 14. Much of the unit can be checked without the application of RF power. When the problem has been isolated to a particular circuit, refer to the Theory of Operation section for an explanation of the circuit and a simplified schematic diagram.

---

## 6.1 RF Section

The RF section consists of the following:

- 1) Pre-amplifier
- 2) Driver
- 3) 4-way Splitter
- 4) Power Amplifiers
- 5) 4-way Combiner
- 6) VSWR Bridge

Problems on the circuits can be isolated with a systematic test procedure. The test equipment described in Figure 15 will be needed for a thorough check-out of the unit.

## 6.1.1 Pre-Amplifier

The Pre-amplifier consists of five amplifier stages, the first four use bipolar devices and are biased more like class A continuously (not gated).

### *Bias Voltages for transistors Q1-Q5 in Volts*

Transistor	Emitter	Base	Collector
Q1	1.35	2.05	18
Q2	3.9	4.6	20
Q3	1.5	2.2	20
Q4	2.5	3.2	25
MOS FET	Source	Gate	Drain
Q5	Gnd	See Text	33

The last stage power MOSFET is also biased class A, but is gated with the driver and PA stages temperature compensated bias supply. To check Q5's bias, gate the unit continuously and measure 50mV across the 20m $\Omega$  resistor. This corresponds to 2.5A drain current and can be adjusted by the potentiometer.

To verify proper operation, disconnect the output cable from the pre-amp, connect the pre-amp output to a suitable power meter and 50 $\Omega$  load/attenuator. Gating the preamplifier continuously, set the input to 0dBm The output should be about 20W at 21MHz.

## 6.1.2 Driver Amplifier Board

The driver amplifier board operates class AB push-pull at a quiescent current of 1.6 to 2.6 A. Gain is nominally 10 db. To verify proper operation, disconnect the output cable from the driver module. Connect the driver output to the power meter and power attenuator. Before applying RF drive, check the bias current on an external meter. Measure the voltage drop across the 0.02 $\Omega$  resistor (R17) while continuously gating the transistors. Multiply the voltage measured by 0.02 to obtain the bias current. If the reading is normal, check the current balance in each of the driver transistors by shorting the gate to ground at the R3 - C4 or R5 - C6 junction. Each transistor should be operating at 0.8 to 0.13 Amps and the currents must be within 5% of each other. Adjustment is made with R20 and R21 on the driver module (CW lowers the bias current).

The bias current of the driver module may also be adjusted over a limited range by using the driver bias adjustment located on the regulator board.

**Caution-never perform bias adjustments without monitoring the current to the module, and under no condition exceed 1.5 amps per device or 3.0 amps per module. (60mV across R17)**

Now apply 0dBm at 21MHz via the rear panel RF connector and operate the unit at a 10% duty cycle. Output power should be about 200W peak.

## 6.1.3 4-way Splitter

Each splitter output should be 6dB below the input power level. If a fault is suspected at any port, check the associated transformers, resistors and interconnecting cables.

## 6.1.4 Power Amplifiers

The four power amplifiers operate class AB push-pull at a quiescent current of 2.0A. Gain is nominally 10db.

To isolate a faulty module, proceed as follows:

- a) Set up the amplifiers to operate at 21 MHz, 10 % duty cycle, and 500W output into a 50 $\Omega$  attenuator and a power meter.
- b) With an output of 500W, disconnect the input cable to one P.A. module and note the reduction in output power. The power will drop for a properly functioning power amplifier. Reconnect the input cable to that module and repeat this test for the remaining three modules, one at a time.
- c) If the power output drops by an equal amount (within 2%) as each cable is removed, the fault is not in the amplifiers. The output combiner or the driver/preamplifier circuitry should be checked. If the output does not drop, or drops less than normal, as each of the cables is removed, the fault is in the power amplifier associated with that cable.
- d) It is also possible, in most cases, to isolate a faulty module by observing the individual module currents on the diagnostic meter. The current to all power amplifiers should be the same (within 10%). If it is determined that transistors need replacement, refer to para. 6.4.6. After replacing the MOSFET devices, turn the bias adjustment potentiometers fully CCW. Monitor the P.A. current. Turn on the unit and adjust the current in one transistor to 1.0 amps, adjust the current in the other transistor until a total of 2.0 A is indicated on the front panel meter. The bias current of the P.A. module may be adjusted over a limited range by using the P.A. bias adjustment located on the regulator board.

**CAUTION: never perform bias adjustments without monitoring the current to the module, and under no condition exceed 1.5A per device or 3.0A per module.**

## 6.1.5 4-way Combiner

The output power of the 4 P.A. modules is combined to produce the 2000 watt output. A combiner is best tested by measuring the total output power and then the individual power of each P.A. module. The sum of the individual P.A. module outputs should be within 5% of the total output power. Set up the amplifier to operate at 30 mHz, 10% duty cycle, and 500W output into a 50Ω load.

Turn off the amplifier and connect the output of one P.A. module to a 50Ω attenuator coupled to the power meter. Turn on the amplifier and note the P.A. module output power. Turn off the amplifier and reconnect that module. Measure the output power of the other P.A. modules in the same way. Individual P.A. outputs should be within 10% of each other with the total output power equal to 500W. If the output is significantly less than this, the combiner is defective. Inspect the combiner transformers and associated capacitors and resistors.

## 6.2.2 + 33 Volt Adjustment

Monitor the +33 volt power supply on the front panel meter. If it is not 33 volts, adjust R14. If unsuccessful, check the power supply regulator voltages. Also check the overheat fault line from the thermostat, a ground on this line will disable this power supply. Check voltages on Q11 and Q12 on the regulator heatsink. Replace 1C3 or Q11 or Q12, if necessary.

### *Integrated Circuit 1C3 pin voltages :*

Pin #	2	3	4	5	6	7	10	11	12	13
Voltage	33.2	33	18.1	18.1	18.1	11	36	40	40	37.2 Volts

### *Bias Voltages for transistors Q1-Q13*

Transistor	Emitter	Base	Collector
Q11	33.2	33.8	40

## 6.2.3 + 25 Volt Supply

This power supply may be monitored on the front panel meter, it's input is the regulated 33 volt supply discussed above. Troubleshooting of the +25 volt supply should therefore begin with a verification that the 33 volt supply is nominal. IC1 mounted on the regulator heatsink assembly provides the 25 volts to the first four stages of the pre-amplifier. Resistors R35 and R36 on the regulator heatsink assembly set the output voltage.

IC1	Pin #	Voltage
	Input	33
	Output	25
	Adjust	23.8

## 6.2.4 Bias Supply

The bias supply voltage may be monitored on the front panel meter and should read nominally 5V when the bias is continuously gated on. The reading will be less during pulse gated operation.

It is recommended that the unit be externally pulse gated at a nominal 10% duty cycle when troubleshooting the bias supply. The unit may be continuously gated with proper attention being paid to heatsink cooling with covers removed and the cooling air-flow disrupted. For a circuit description and simplified schematic diagrams, refer to section 5-1.

The input voltage to the bias regulator is taken from the 33V supply, refer to section 6.2.2 if the input is suspected. Verify that the enable signal from the fault logic is present at the gating buffer amplifier. Also check the output voltage of the temperature compensation circuit using the following table:

<b>Temperature (°C)</b>	20	25	30	35	40	45
<b>Voltage (V)</b>	2.982	2.987	2.992	2.997	3.002	3.007

Note that before adjusting either the temperature compensation or the reference voltage of the temperature compensation amplifier, it is recommended that the bias adjust controls on the regulator board be turned CCW to reduce the bias voltage to the P.A. and Driver modules. Also reduce the bias voltage to the output stage of the pre-amplifier. This precaution will prevent an increase in bias voltage from damaging the MOSFET with excessive drain current. Typical voltages for the integrated circuit used for biasing is:

### *Integrated Circuit IC2 pin voltages :*

<b>Pin #</b>	1	2	3	4	5	6	7	
<b>Voltage</b>	-12.5	5.5	5.5	15.5	5.3	5.3	8.9	Volts
<b>Pin #</b>	8	9	10	11	12	13	14	
<b>Voltage</b>	6.7	3.3	3.3	-15.6	1.5	1.4	14.8	Volts

## 6.2.5 5 Volt and 15 Volt Supplies

Each of these power supplies has its own three-terminal regulator. They operate from a common center-tapped transformer and bridge rectifier. There are no adjustments provided, the output voltage is set with a voltage divider. These regulators are located on the voltage regulator assembly.

There is another 5V supply located on the regulator assembly. It is used for the local and remote AC ON circuit that activates the solid-state-relay to turn on the amplifier. This supply consists of a transformer, rectifier, and zener diode and is on whenever the circuit breaker on the front panel is on. There is no adjustment provided for this supply. The other +15V supply is referenced to the +6 volt supply. It provides +4V and +7V to the P.A. current sense circuits. The voltages are developed from a center-tapped transformer, bridge rectifier, and an integrated circuit. As in the case of the other control power supplies, no adjustments are provided.

---

## 6.3 Control Board

The Control Board contains all the logic, fault and power metering circuits. Refer to section 5.3 for detailed explanations and simplified schematic diagrams of the basic circuit function. Many of the functions can be checked using routine troubleshooting procedures. Be certain that necessary power supply voltages are present and proper inputs are applied. The digital logic consists mostly of NAND and OR gates (CMOS operating at TTL compatible levels). These circuits may be checked using steady-state (not pulsed) inputs. The following circuits, however are directly related to the pulsed operation of the amplifier and should be checked using a pulse generator capable of providing a variable pulse width and duty cycle. Measurements should be made using an oscilloscope.

## 6.3.1 Pulse and Width Detector

See para. 5.3.1 for a description of the circuits. Troubleshooting is best done by introducing a pulse to the input of the limiter at J3. Use a signal of approximately 0.1 volts positive at 100Hz and 1 ms pulse width. The output of the limiter should be at +5 volts. Check the output of the integrator circuit. The voltage ramp corresponding to the input pulse should reset to zero between pulses. If not, check Q1 and Q2 around the integrator. Verify that this ramp voltage is present through the front panel adjustment potentiometer to the input of the threshold detector.

The threshold voltage should be approximately 0.56 volts and the ramp should reach this voltage to trigger the detector at 10-30 ms pulse width depending upon the front panel setting. The detector output is diode clamped to +5 volts at the set input of the flip-flop. The set input is normally logic 1 (+5 volts), a logic 0 here will cause the flip-flop outputs to light the fault LED, disable the gating bias and send a fault signal to the rear panel connector. A logic 0 on the reset input will reset the flip-flop.

## 6.3.2 Duty Cycle Detector

See also para. 5.3.2 for an explanation of the circuit operation. As in the case of the pulse width detector above, introduce a 100 Hz pulse for 10% duty cycle and 0.1 volts amplitude at J3 on the control board. The limiter output should be +5 volts. As the duty cycle is increased toward 20%, the waveform into the peak detector should become more negative with respect to a ground reference. The positive output of the peak detector should be directly proportional to the amplitude of that portion of the waveform that is below the ground reference. The peak detector output level is adjusted with the front panel potentiometer and compared with the 0.56 volt reference at the threshold detector. The set input to the flip-flop is normally at a logic 1 level, a logic 0 here will cause the flip-flop outputs to light the fault LED, disable the gating bias, and send a fault signal to the rear panel connector.

### 6.3.3 Peak Power Metering

Refer to para. 5.3.6 for a description of the circuits used. Troubleshooting is best done using the outputs from the VSWR bridge, however, an external pulse generator may be substituted if the problem is known to be in the metering circuits. The forward power detector on the VSWR bridge provides a peak voltage of 13 to 16 volts at 1.8 kw peak output. The reflected power sample should be approximately 0.7 volts or less when operating into a 50 ohm load. Before troubleshooting the squaring circuit or the track-and-hold circuit, be certain that the reset timer is functioning properly. The timer output voltage is at logic 1 as long as the pulse repetition rate is greater than 1 pulse per second. The timing capacitor will discharge sufficiently after 1 - 1 1/2 seconds to cause the output to drop to logic 0 and reset the track-and-hold circuit. The squaring circuit output satisfies the relationship:

$$V_{out} = (V_{in})^2 / 10.$$

With a nominal input level of 6 volts needed for 1V/kw output at the rear panel, the squaring circuit output should be 3.6 volts. The buffer amplifier that follows provides a small amount of gain (2) before driving the hold capacitor. The track-and-hold circuit operates at unity gain and is therefore transparent to the voltage on the hold capacitor.

Alignment is as follows:

- 1) With no RF input, adjust R6 for zero volts at the junction of R8 and R100.
  - 2) Drive the unit to exactly 1800W peak power at 20MHz. (Use a Thermometric Watt Meter and operate at 5% duty cycle. 90W average equals 1800W peak).
  - 3) Set the 1V/kW output at the rear panel (J7-11) to exactly 1.80V by adjusting R4 on the control board.
  - 4) Set the front panel meter to read 1800W by adjusting R18 on the control board.
  - 5) With 1800W output, adjust R5 for zero volts at the cathode of D1 (ICE-5).
  - 6) Reduce output power to approximately 300W. Turn off the RF and open circuit the RF output. Reflected power will now be equal to the forward power.
  - 7) Turn off the RF and adjust R3 so the reflected 1V/kW output at J7-12 is the same as the forward power.
  - 8) Adjust R17 to set the reflected power on the front panel meter to agree with the forward power.
  - 9) Turn off the RF and restore the output connection to the load.
-

## **6.4 Disassembly Procedure**

### **6.4.1 General**

The following disassembly procedures describe the recommended method of removing assemblies and printed circuit modules for the purpose of test, repair and/or replacement. Careful handling should be used to avoid damaging the boards. Generally, these procedures can be easily reversed for re-assembly.

### **6.4.2 Tools Required**

The model amplifier is assembled with standard hardware. Screw sizes range from #4-40 to #8-32 and are of the Phillips or slotted types. Transformer mounting bolts are 1/4 - 28. Standard tools required are screwdrivers, nut drivers (1/4" through 7/16"), and open end wrenches (1/4" through 5/8").

### **6.4.3 Removal of Cover**

The top cover may be removed by removing the (29) 6-32 screws. The internal covers used to control air flow and r-f shielding may be removed from the RF chassis by removing the associated #4-40 hardware. An interlock switch with a pull-to-defeat feature is located under the cover.

### **6.4.4 Removal of Pre-Amplifier Assembly**

Remove the RF input and RF output connectors and unsolder all wires after marking and noting the location of each. Remove the transistor mounting hardware. (#4-40 cap screws for flange mount devices and #8-32 nuts and washers for stud mount devices.) Remove the four (4) #4-40 screws at each corner of the board. Lift out the printed circuit board assembly. Note: To replace the power transistors and most other components, it is not necessary to remove the assembly. There is adequate access from the side of the unit.

## 6.4.5 Removal of Power Amplifier & Driver Assemblies

Remove the RF input and RF output connectors. Unsolder all wires to the P.A. P.C. board after carefully noting the location of each. Remove the four (4) #4-40 screws holding the five (5) #4-40 screws that hold the Power Amplifier assembly in place. Lift out the Power Amplifier assembly. Note: To replace the power transistors, it is not necessary to remove the printed circuit board. There is adequate access from the side.

## 6.4.6 RF Power Transistor Replacement

- 1) Remove the mounting hardware: 2 screws in the case of flange mount, #8-32 nut and washers in the case of stud mount.
  - 2) Carefully heat and remove as much solder as possible from each of the four (4) transistor leads. Use care not to damage the printed circuit board
  - 3) Apply heat to melt the remaining solder and lift the transistor leads one at a time with pliers or a pick. Use de-soldering braid to wick the remaining solder out from under the leads. Repeat this procedure until all leads are free of the circuit board.
  - 4) Lift out the transistor.
  - 5) Thoroughly clean the old thermal grease from the heatsink. There must be NO SIGN of old thermal grease, metal chips or residue of any kind on the mounting surface. A solvent and cotton swab is useful for this process. This cleaning is mandatory to provide the degree of thermal contact necessary.
  - 6) Clip the transistor leads to the same length as those on the defective transistor.
  - 7) Place a small amount of clean thermal grease uniformly on the transistor mounting flange.
  - 8) Place the transistor on the heatsink and secure with the hardware removed in step one (1). Stud mount transistors should be tightened to not more than 6.5 lbs. in order to avoid fracturing the copper stud. **DO NOT SOLDER THE TRANSISTOR BEFORE TIGHTENING THE MOUNTING HARDWARE.**
  - 9) Solder all four leads to the circuit board, soldering as close to the transistor case as possible. Use only heat necessary, do not overheat the transistor.
-

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## Chapter 7

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# MRI-2000 Specifications

<b>Frequency Coverage</b>	15-64 MHz
<b>Rated Power Output</b>	2,000 Watts pulse typical
<b>Gain</b>	63dB (+2dB -0dB)
<b>Gain Variation</b>	±0.15dB within 250kHz band width
<b>Maximum pulse width</b>	20 millisec
<b>Duty cycle</b>	10% maximum.
<b>Noise Figure</b>	<12dB
<b>Droop</b>	<0.5dB with 6 mSec, 2000W rectangular pulse
<b>RF Envelope rise or fall time</b>	<1µSec
<b>Unblank time</b>	< 15µSec
<b>Blank time</b>	< 4µSec
<b>Maximum Input VSWR</b>	<1.5:1 (50 ohms)
<b>Harmonics</b>	2nd -20dBc 3rd -12dBc
<b>Power Requirements</b>	180-252 VAC, 50-60 Hz single phase. Taps provided at 190, 208, 220, 240 VAC.
<b>Cooling</b>	Forced air
<b>Diagnostics</b>	Overtemperature, overcurrent
<b>Size</b>	8.7" x 17" x 18.5" (HxWxD) 22.1 cm x 43.2cm x 47cm Brackets for 19" Rack mount provided.
<b>Weight</b>	77 lbs; 34.9 kg.
<b>RF input Connector</b>	BNC
<b>RF output Connector</b>	Type N
<b>Control I/O Connector</b>	"D" sub-miniature, 15 pin

**Front Panel Indicators**

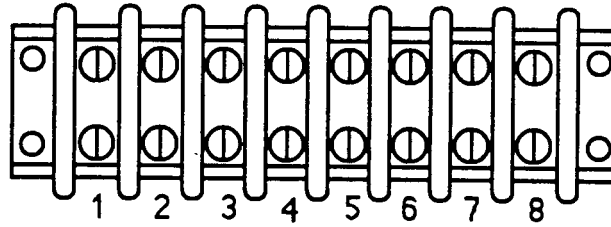
- Fault
- AC power on
- Bias gating on.
- Fault reset
- Gating

**Rear Panel Connectors**

- AC line cord
- Remote Control IN/OUT
- RF Input
- RF Output
- HPA and System Interface
- RF Sample
- Gating Input
- Equipotential ground stud

# Terminal Block Connections

#	Color	Function
1	black purple	AC line Common Fan
2		
3		
4	white	AC line/circuit breaker
5		
6		
7	gray	fuse
8	black	AC line/circuitbreaker



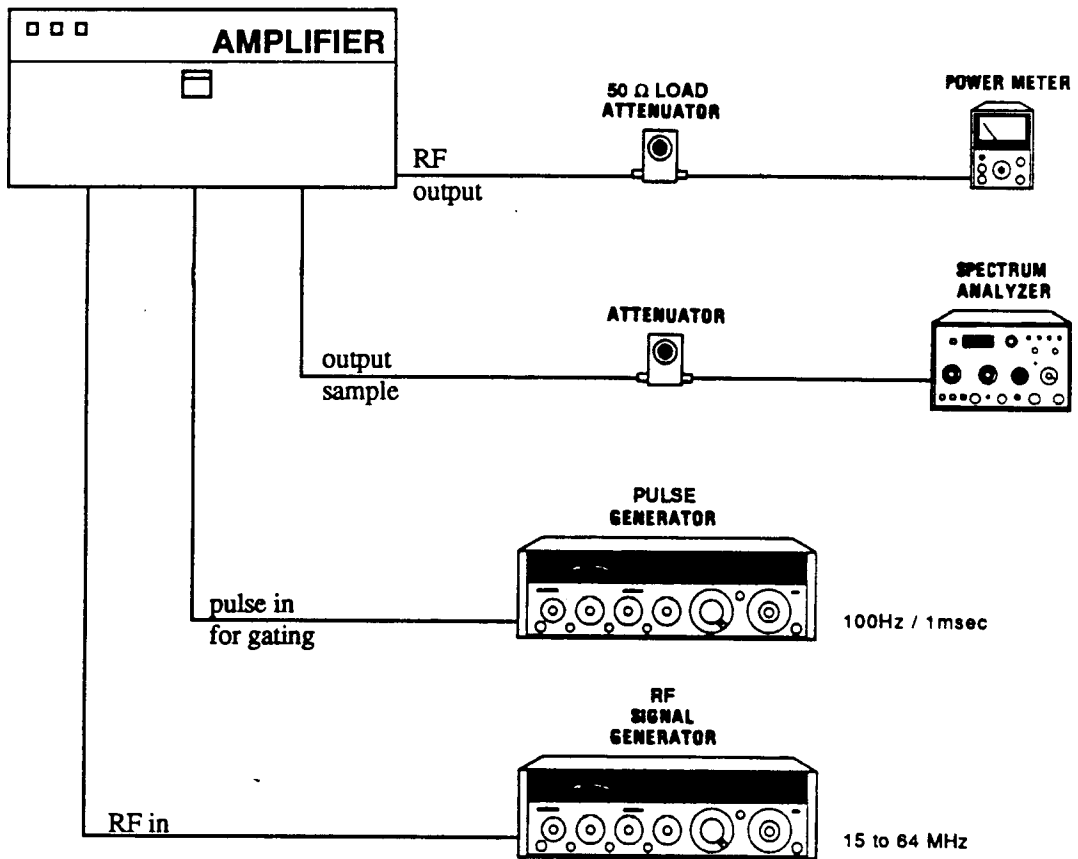
#	Color	Function
1	black black	Common 50V supply
2	white red	115V fuse
3	red	190V
4	orange	208V
5	yellow red	220V fuse
6	blue	240V
7	black red	5V standby control fan
8	black black	5V standby control 50V supply

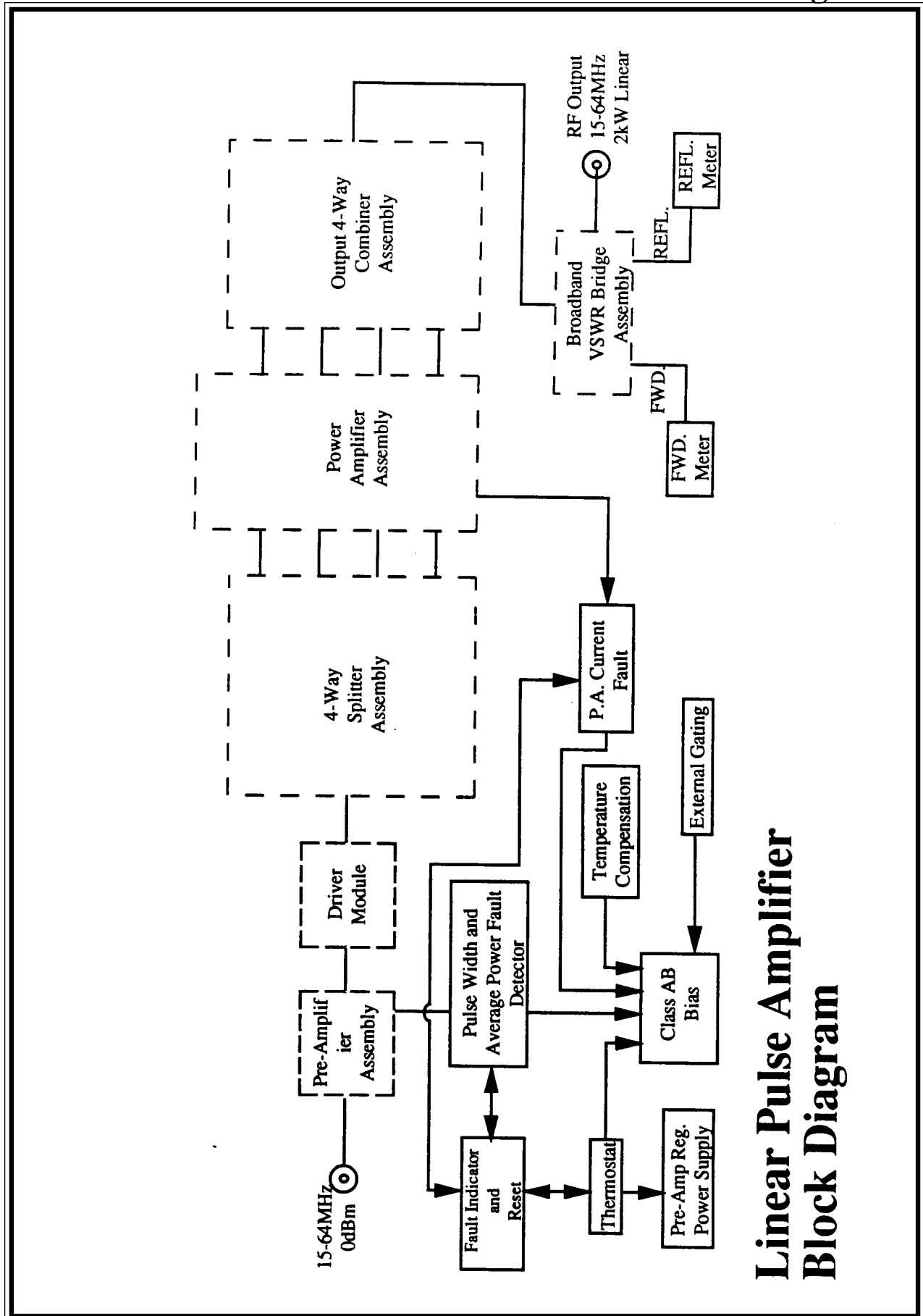


Do not change any taps except the white wire on tap 4 (208V). This may be moved to taps 3, 5 and 6 for 190, 220 or 240VAC operation respectively.

Figure 2

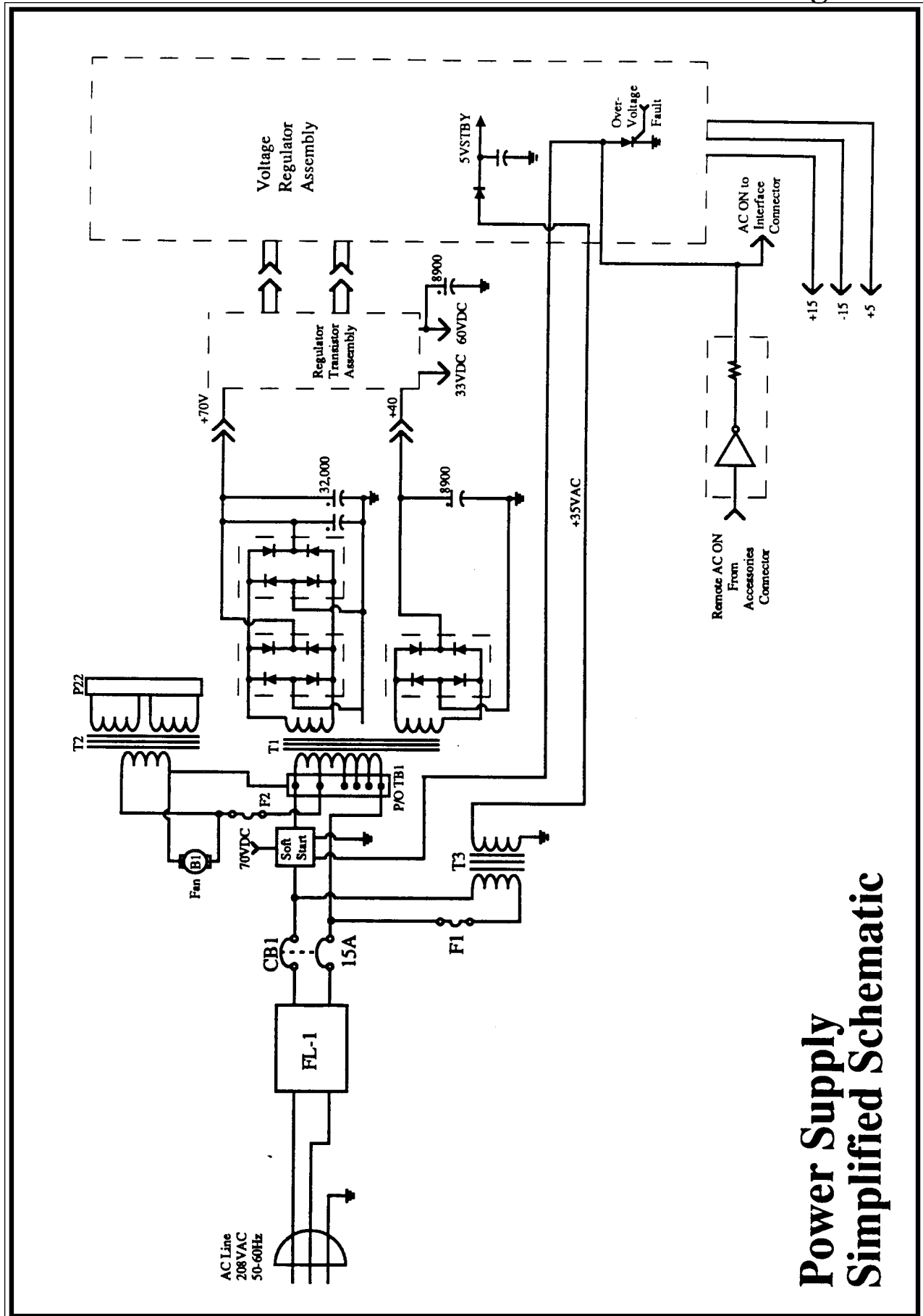
# Linearity test



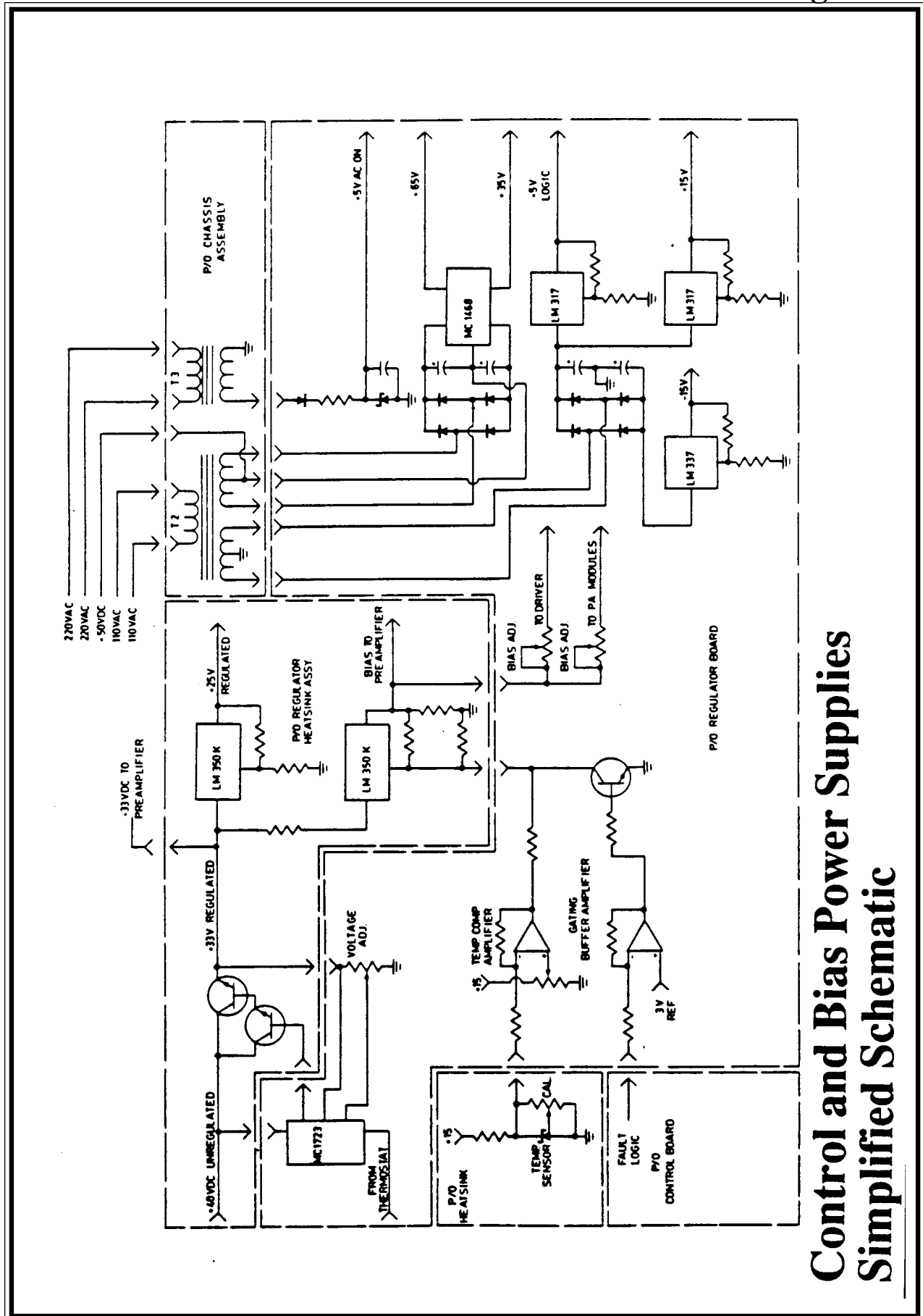


**Linear Pulse Amplifier  
Block Diagram**

Figure 5

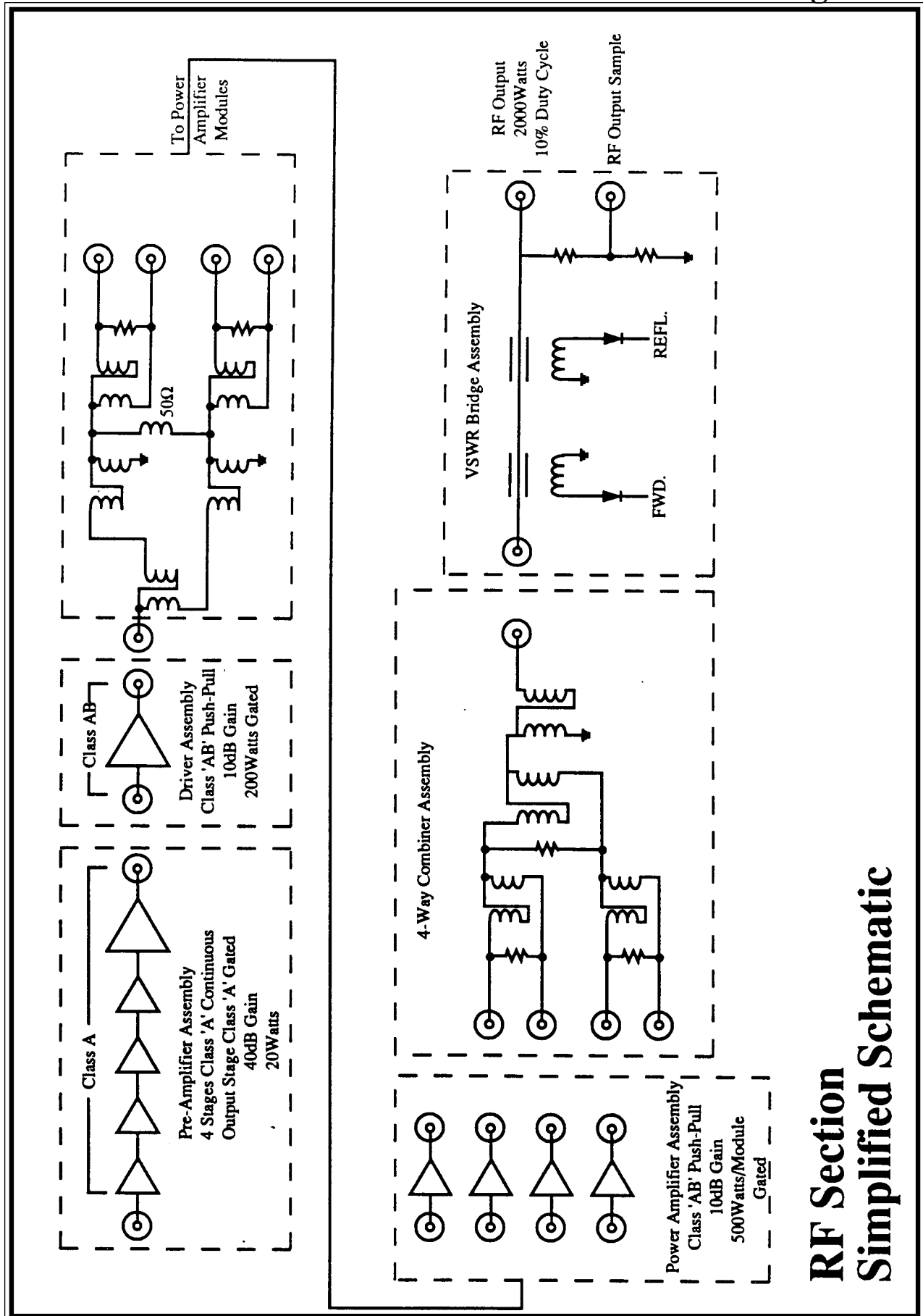


Power Supply  
Simplified Schematic

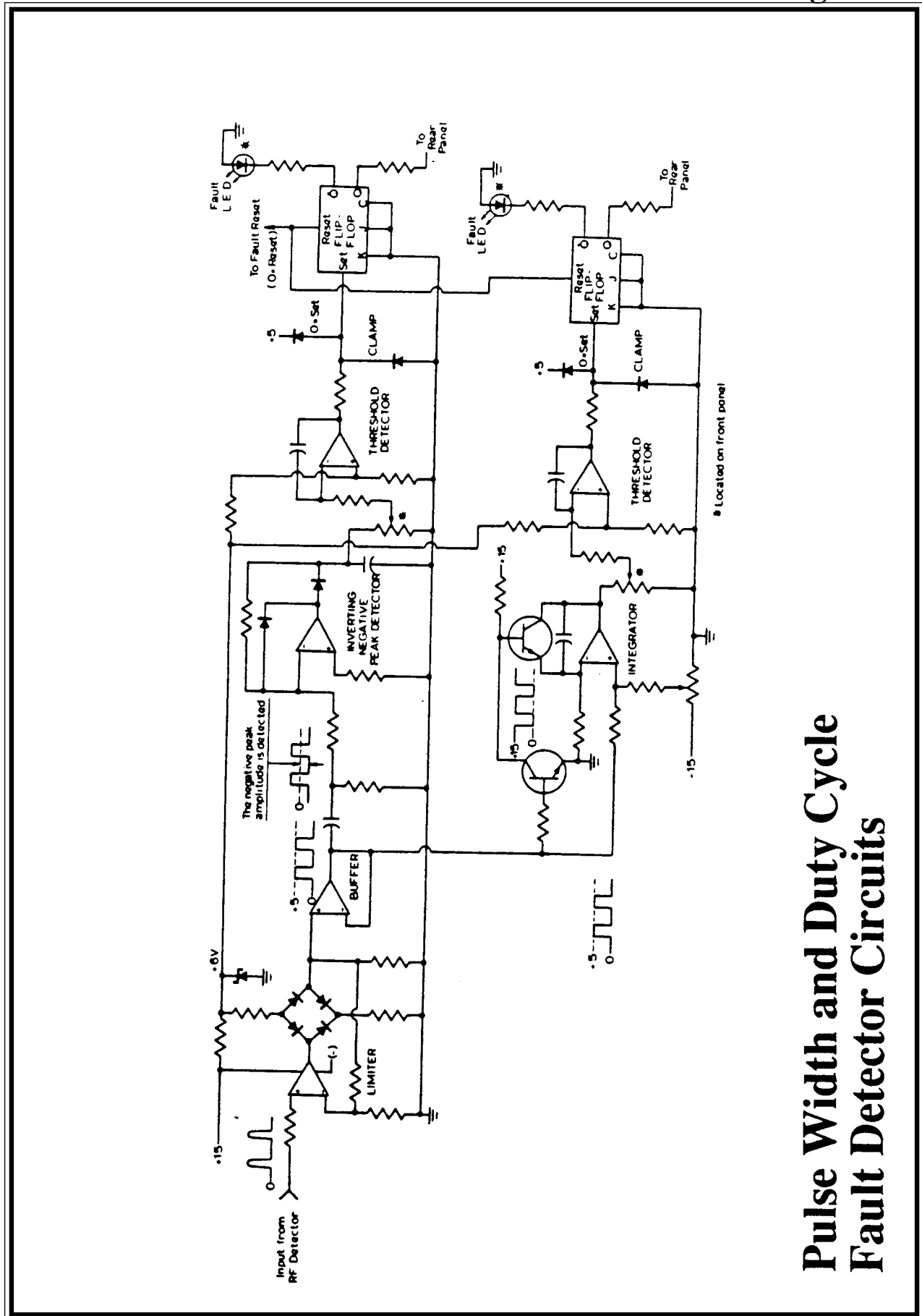


Control and Bias Power Supplies  
Simplified Schematic

Figure 7

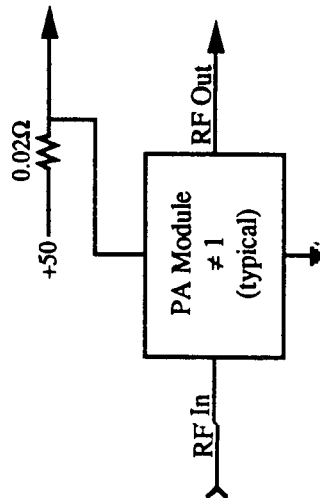
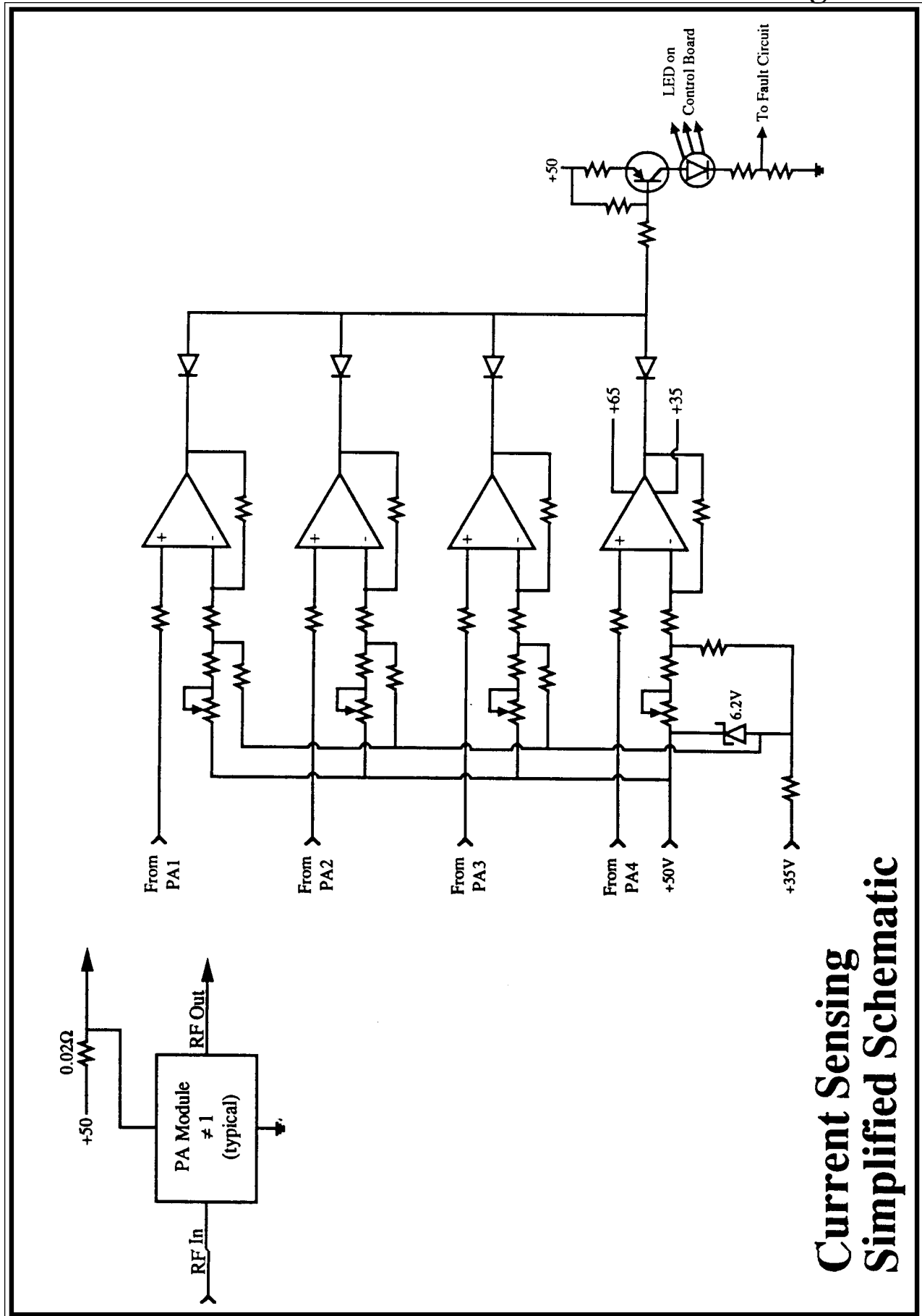


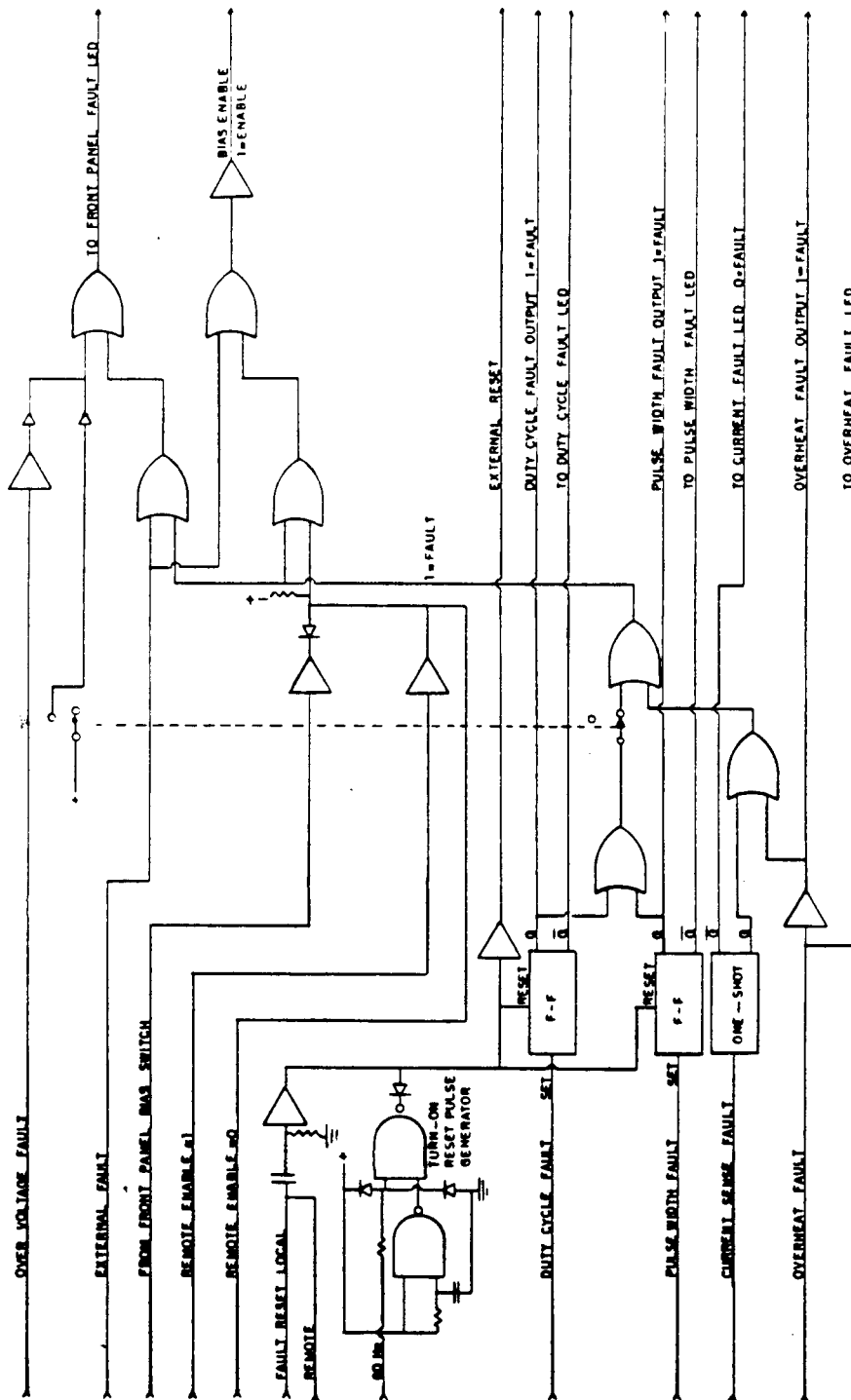
# RF Section Simplified Schematic



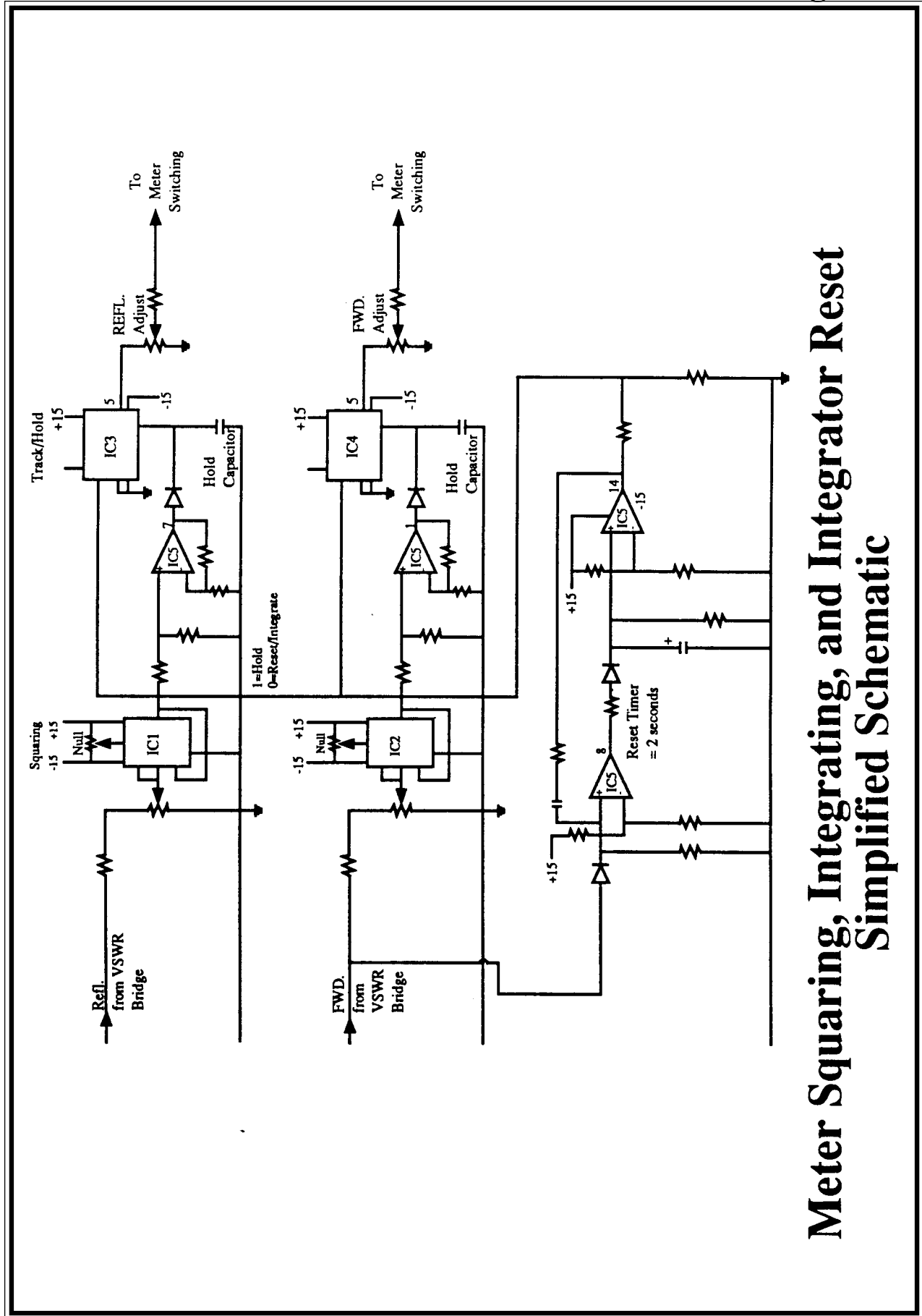
**Pulse Width and Duty Cycle  
Fault Detector Circuits**

Figure 9

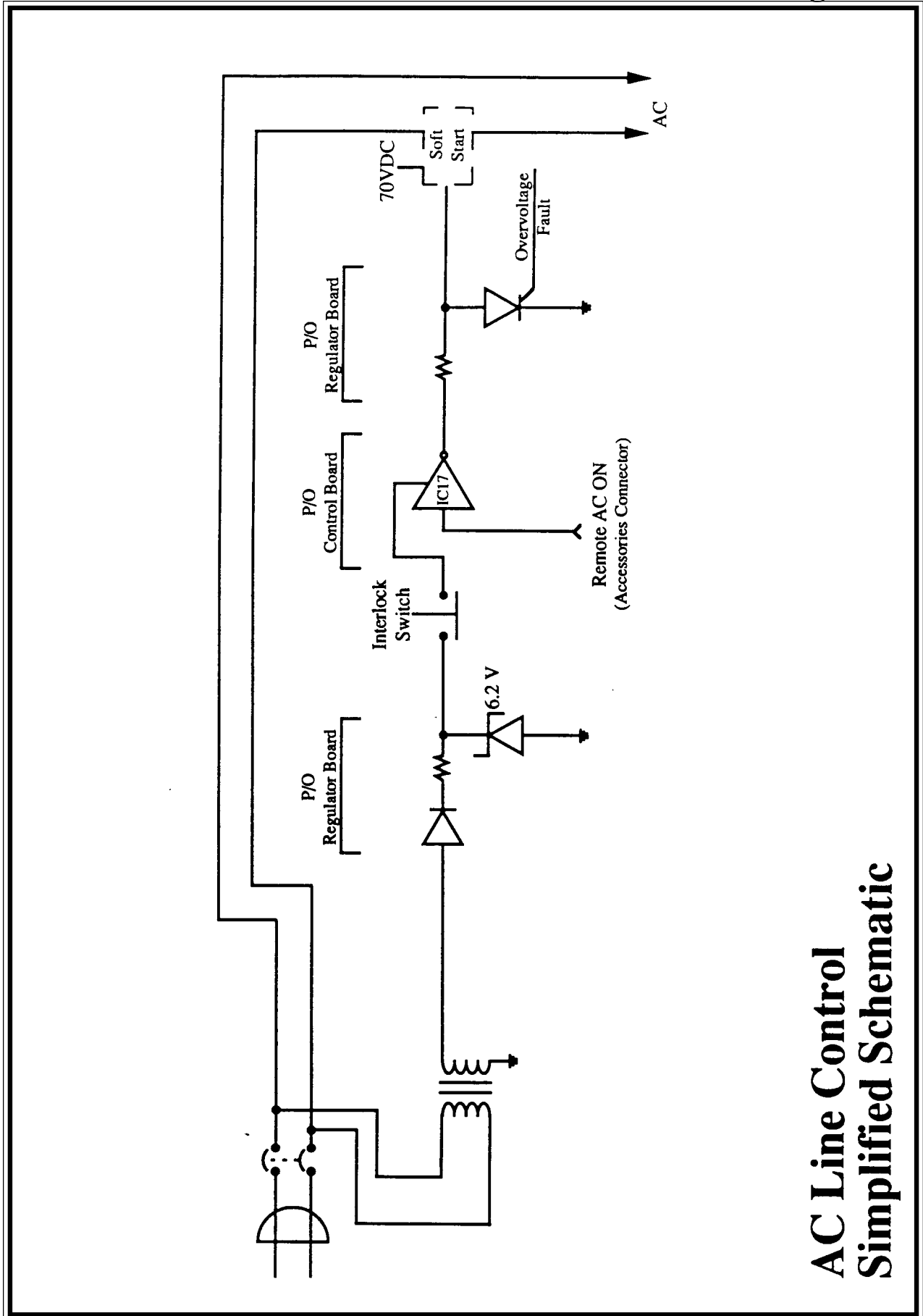




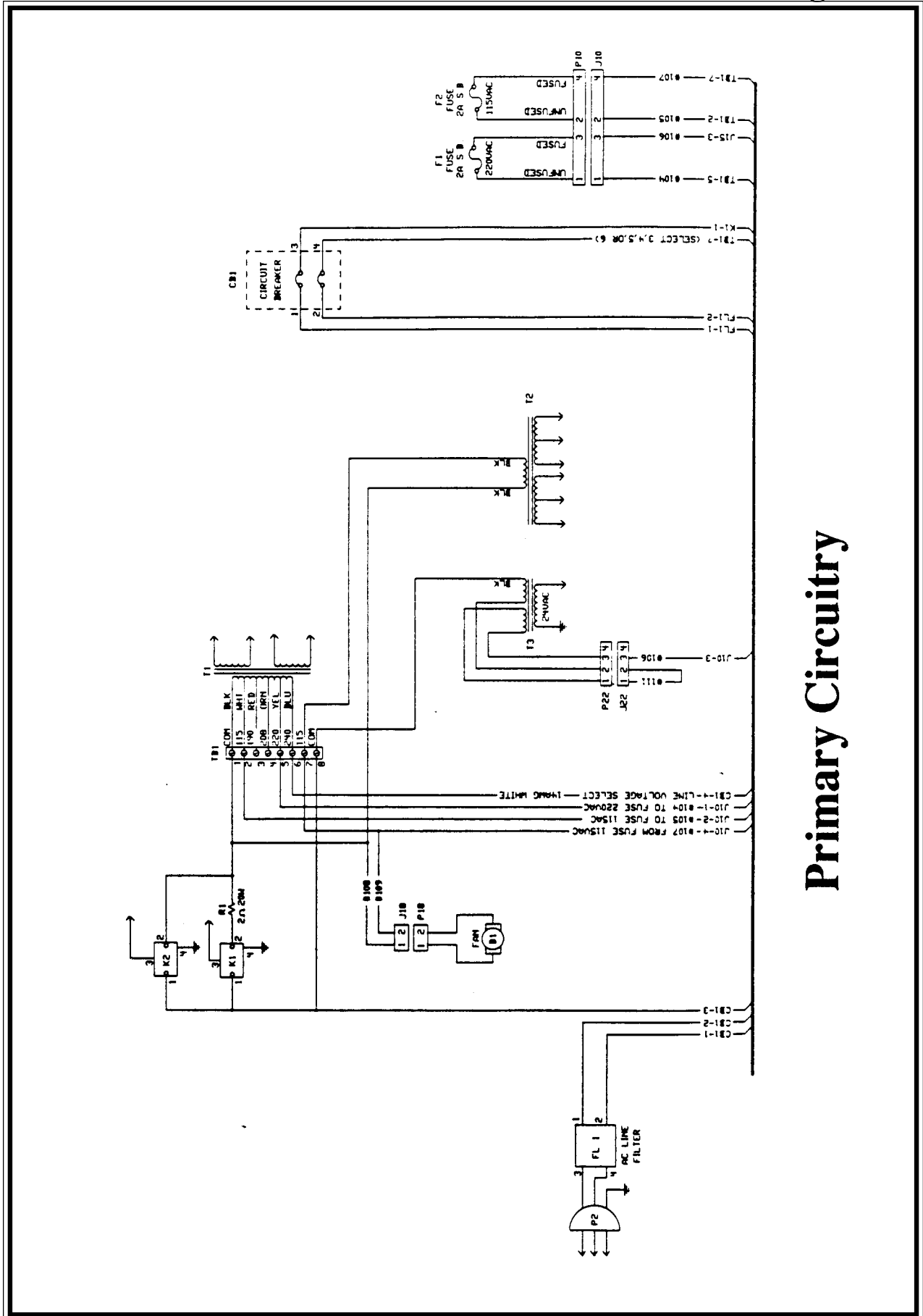
**Bias Enable and Fault Control Logic**



Meter Squaring, Integrating, and Integrator Reset Simplified Schematic



**AC Line Control  
Simplified Schematic**



# Primary Circuitry

# Troubleshooting Guide

Symptom	Probable Cause	Recommendations
<b>AC on light does not light</b>	Circuit Breaker open	Turn on breaker
	Blown fuse	Replace fuse
	Defective Power Supply	See Sections 5.1, 6.2
<b>Fault light on</b>	Internal Protection circuits operating. Check for specific fault indicator light behind lower front panel.	For over-voltage fault, turn circuit breaker off, then on. Press reset switch for all other faults.
<b>No RF output or no RF gain</b>	Broken input or output connectors.	Visually inspect connectors for broken pins.
	Defective input or output cables	Visually inspect cables
	Bias not gated	Check for proper on gating signal level (TTL)
<b>Low RF output</b>	Defective cables	Visually inspect or change cables
	Faulty power Supply voltage	Check power supply with front panel meter. Correct as necessary.
	Defective RF Amplifier module	See sections 6.1.1, 6.1.2, and 6.1.4
<b>Excessive Distortion</b>	Defective Power Amplifier module	See section 6.1.4
<b>Amplifier Overheating</b>	Defective fan	Check that fan is operating properly
	Ambient air temperature is to high	If the unit is mounted inside a 19" rack enclosure, measure air temperature inside of enclosure

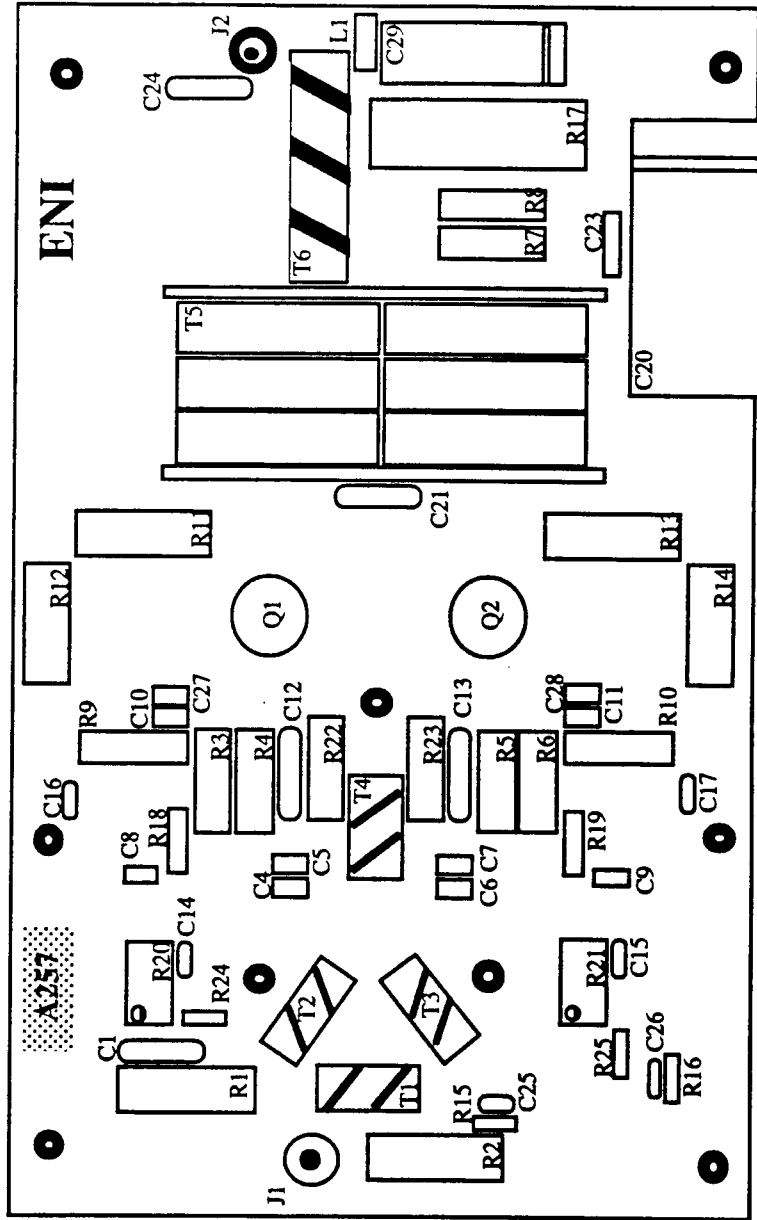
## Recommended Test Equipment

<b>Description</b>	<b>Recommended Type</b>	<b>Use</b>
Power Meter	<b>HP 435B</b>	Power Measurement and Meter Calibration
Attenuator 30dB, 500W	<b>Bird #8325</b>	50 $\Omega$ load and attenuator for HP 435B
Digital VOM	<b>Beckman RMS3030</b>	General voltage and resistance measurements
Analog VOM	<b>Simpson 260</b>	Voltage, current, and resistance measurements
Oscilloscope	<b>Tektronix 2213</b>	Troubleshooting fault and metering circuits
Pulse Generator	<b>HP 8111A</b>	Pulse gating during test and troubleshooting
Signal Generator	<b>Fluke #6060A</b>	RF source for test and troubleshooting.
Spectrum Analyzer	<b>HP 8557A</b>	Spectral purity and linearity checks.

## **Layout Drawings and Parts List**

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# Power Amplifier Board (MRI-2K-14691) Layout



## Power Amplifier Board (MRI-2K-14691)

### *Resistors:*

Code	Description	ENI #
R1	12Ω, 2W	2000002
R2	390Ω, 2W	2000033
R3	6.8Ω, 1W	1000001
R4	6.8Ω, 1W	1000001
R5	6.8Ω, 1W	1000001
R6	6.8Ω, 1W	1000001
R7	6.8Ω, 1W	1000001
R8	6.8Ω, 1W	1000001
R9	10Ω, 1W	1000002
R10	10Ω, 1W	1000002
R11	20Ω, 2W	2000005
R12	20Ω, 2W	2000005
R13	20Ω, 2W	2000005
R14	200Ω, 2W	2000005
R15	200Ω, 0.25W	140022
R16	20Ω, .25W	140022
R17	0.02Ω, 5W	11335
R18	51Ω, 0.50W	120007
R19	51Ω, 0.50W	120007
R20	Potentiometer, 500Ω	11534
R21	Potentiometer, 500Ω	11534
R22	10Ω, 1W	2000002
R23	10Ω, 1W	2000002
R24	200Ω, 0.25W	140022
R25	200Ω, 0.25W	140022

### *Capacitors :*

C1	270pF	10958
C4	1000pF	10834
C5	1000pF	10834
C6	1000pF	10834
C7	1000pF	10834
C8	1000pF	10834
C9	1000pF	10834
C10	1000pF	10834
C11	1000pF	10834
C12	390pF	10090
C13	390pF	10090
C14	0.033μF	10063
C15	0.033μF	10063
C16	0.01μF,50V	11037

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
C17	0.01 $\mu$ F, 50V	11037
C20	470 $\mu$ F, 80V	151029
C21	68pF	10081
C23	0.1 $\mu$ F	11062
C24	12pF	10070
C25	0.033 $\mu$ F	10063
C26	0.033 $\mu$ F	10063
C27	1000pF	10834
C28	1000pF	10834
C29	47 $\mu$ F, 63V	10108

***Transformers:***

T1	'U' core
T2	'A' core
T3	'A' core
T4	'U' core
T5	Tube, 'V' core
T6	'V' core

***Transistors :***

Q1	ENI-30	11287
Q2	ENI-30	11287

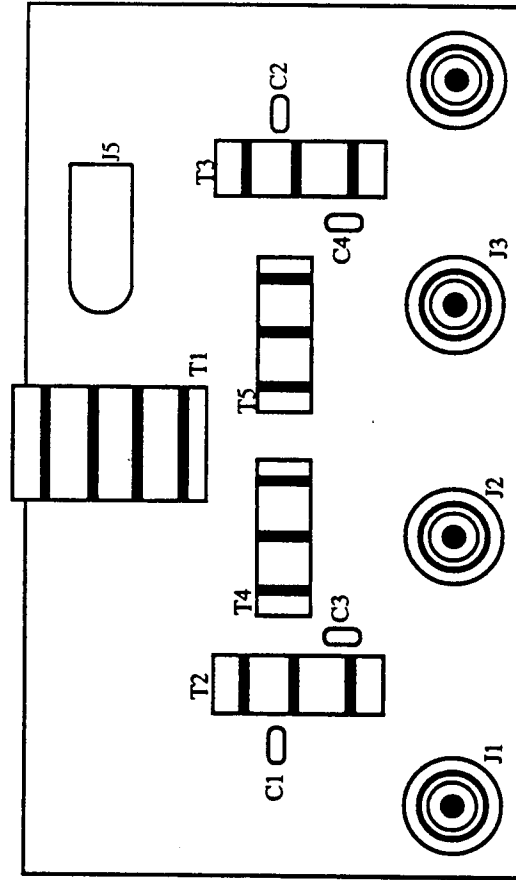
***Chokes :***

L1	22 $\mu$ H	10145
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***Miscellaneous :***

A257	P.C. Board	11315
31	Connector	10217
32	Connector	10173

# 4-Way Combiner Board (MRI-2K-14692) Layout



## 4-Way Combiner (MRI-2K-14692)

### *Capacitors:*

C1	27pF	10075
C2	27pF	10075
C3	27pF	10075
C4	27pF	10075

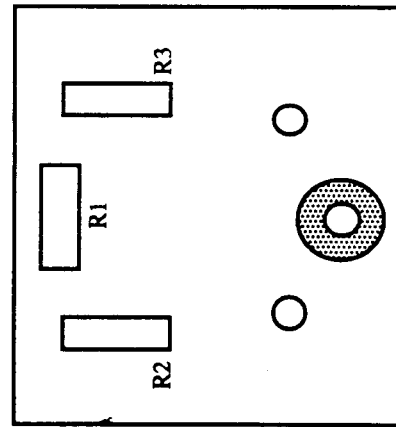
### *Transformers:*

Code	Description	ENI #
T1	“V” core	
T2	“V” core	
T3	“V” core	
T4	“V” core	
T5	“V” core	

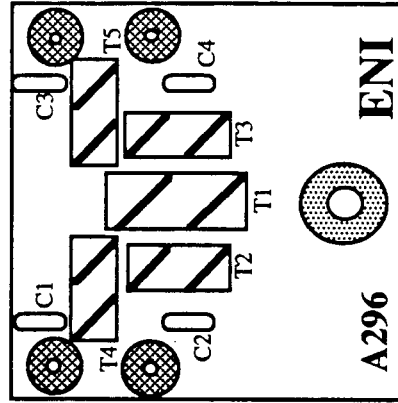
### *Miscellaneous*

A295	P.C. Board	11289
J1	Connector	10173
32	Connector	10173
J3	Connector	10173
34	Connector	10173
J5	Connector	10181

# Splitter Board (LPI-10-14693) Layout



**back**



**front**

# Splitter Board (LPI-10-14693)

## *Resistors:*

Code	Description	ENI #
	51 $\Omega$ , 2W, 5%	2000010
	100 $\Omega$ , 1W, 5%	1000009
	100 $\Omega$ , 1W, 5%	1000009

## *Capacitors:*

C1	5 $\mu$ F	10102
C2	5 $\mu$ F	10102
C3	5 $\mu$ F	10102
C4	5 $\mu$ F	10102

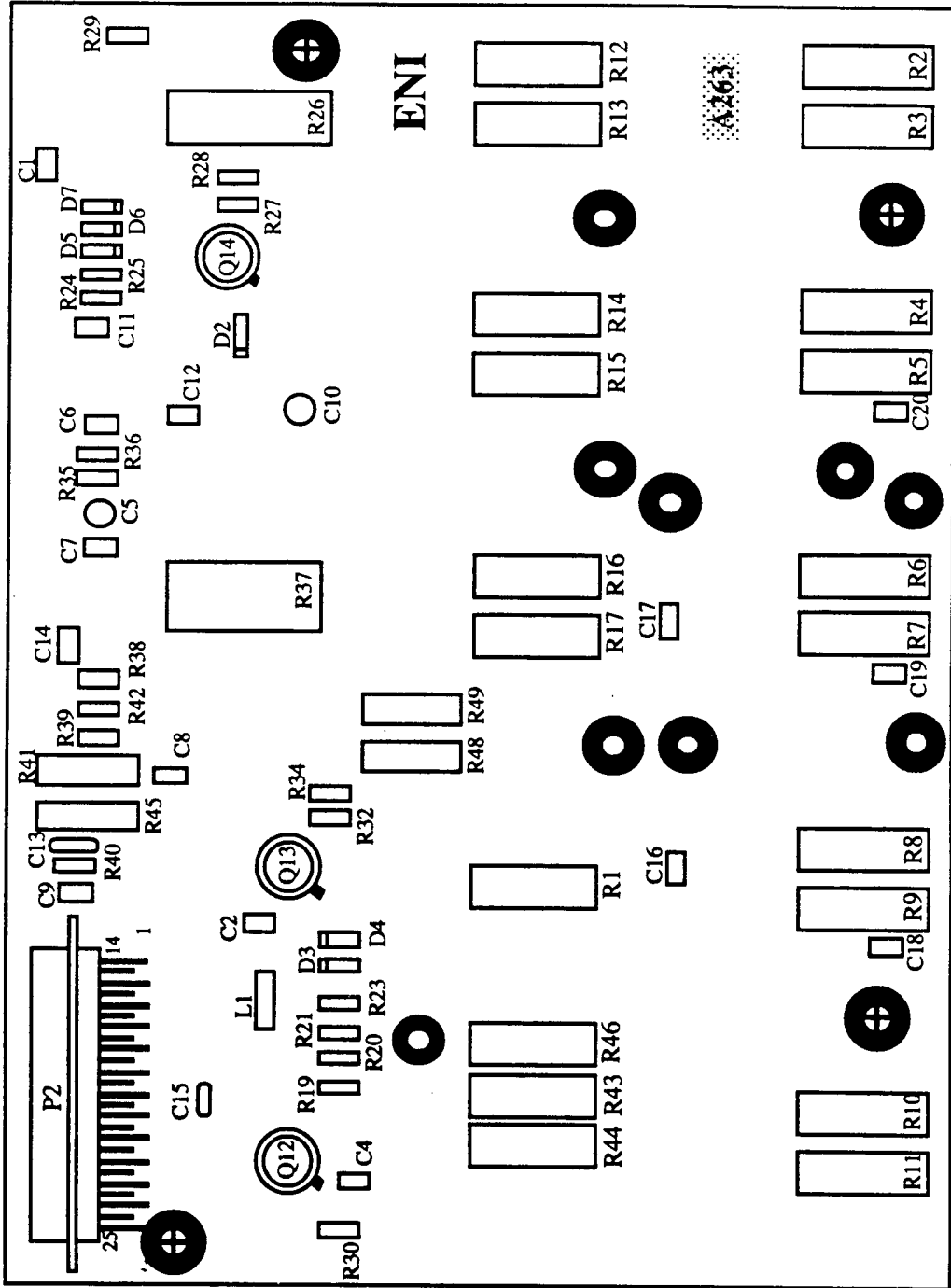
## *Transformers:*

T1	'U' Core
T2	'U' Core
T3	'U' Core
T4	'U' Core
T5	'V' Core

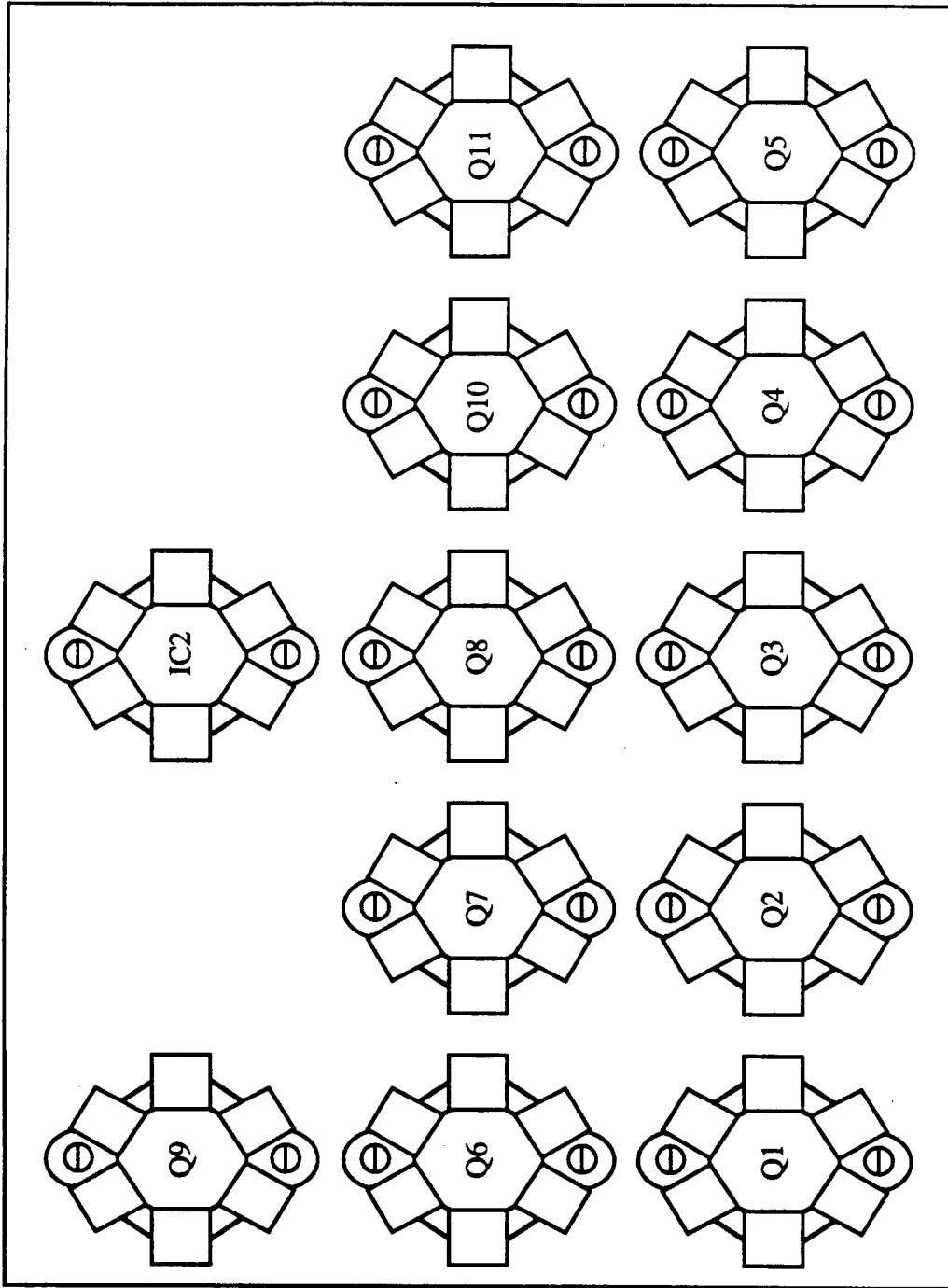
## *Miscellaneous:*

A296	P.C. Board	11322
J1	Connector	10173
J2	Connector	10217
J3	Connector	10217
J4	Connector	10217
J5	Connector	10217

# Power Supply (front) Board (LPI-10-24001) Layout



**Power Supply (back) Heatsink (LPI-40-14855) Layout**



## Power Supply Assembly Board (LPI-10-24001)

### *Resistors:*

Code	Description	ENI #
R1	0.16Ω, 2W, 5%	10581
R2	0.16Ω, 2W, 5%	10581
R3	0.16Ω, 2W, 5%	10581
R4	0.16Ω, 2W, 5%	10581
R5	0.16Ω, 2W, 5%	10581
R6	0.16Ω, 2W, 5%	10581
R7	0.16Ω, 2W, 5%	10581
R8	0.16Ω, 2W, 5%	10581
R9	0.16Ω, 2W, 5%	10581
R10	0.16Ω, 2W, 5%	10581
R11	0.16Ω, 2W, 5%	10581
R12	0.16Ω, 2W, 5%	10581
R13	0.16Ω, 2W, 5%	10581
R14	0.16Ω, 2W, 5%	10581
R15	0.16Ω, 2W, 5%	10581
R16	0.16Ω, 2W, 5%	10581
R17	0.16Ω, 2W, 5%	10581
R19	22Ω, 0.25W, 5%	140007
R21	33Ω, 0.25W, 5%	140010
R23	68Ω, 0.25W, 5%	140015
R24	470Ω, 0.25W, 5%	140029
R25	470Ω, 0.25W, 5%	140029
R26	12Ω, 5W	10591
R27	4.7kΩ, 0.25W, 5%	140048
R28	4.7kΩ, 0.25W, 5%	140048
R29	4.7kΩ, 0.25W, 5%	140048
R30	4.7kΩ, 0.25W, 5%	140048
R32	22kΩ, 0.5W, 5%	140061
R34	10Ω, 0.25W, 5%	140003
R35	270Ω, 0.25W, 5%	140024
R36	5.1kΩ, 0.25W, 5%	140049
R37	5.1Ω, SW, 5%	10588
R38	10Ω, 0.25W, 5%	140003
R39	560Ω, 0.25W, 5%	140030
R40	1kΩ, 0.25W, 5%	140035
R41	20Ω, 2W, 5%	2000005
R42	560Ω, 0.25W, 5%	140030
R43	0.24Ω, 2W, 5%	10582
R44	0.24Ω, 2W, 5%	10582
R45	20Ω, 2W, 5%	2000005
R46	10Ω, 2W, 5%	2000001
R47	82Ω, 0.25W, 5%	140017
R48	3.9K ohm, 1W, 5%	1000020
R49	3.9K ohm, 1W, 5%	1000020

### ***Capacitors :***

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
C1	1000pF, 200V	10834
C2	1000pF, 200V	10834
C4	1000pF, 200V	10834
C5	10 $\mu$ F, 35V	10106
C6	1000pF, 200V	10834
C7	1000pF, 200V	10834
C8	1000pF, 200V	10834
C9	1000pF, 200V	10834
C10	3.3 $\mu$ f, 35V	10880
C11	1000pF, 200V	10834
C12	1000pF, 200V	10834
C13	270pF, 500V	10958
C14	1000PF, 200V	10834
C15	470pF, 50V	11437
C16	0.1 $\mu$ F, 100V	11062
C17	0.1 $\mu$ F, 100V	11062
C18	0.1 $\mu$ F, 100V	11062
C19	0.1 $\mu$ F, 100V	11062
C20	0.1 $\mu$ F, 100V	11062

### ***Chokes:***

L1	22 $\mu$ H	10145
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### ***Diodes :***

D2	1N914B	10239
D3	1N914B	10239
D4	1N914B	10239
D5	1N914B	10239
D6	1N914B	10239
D7	4.7V Zener	11102

### ***Integrated Circuits :***

IC1	Voltage Regulator, LM350K	11099
IC2	Voltage Regulator, LM350K	11099

### ***Transistors :***

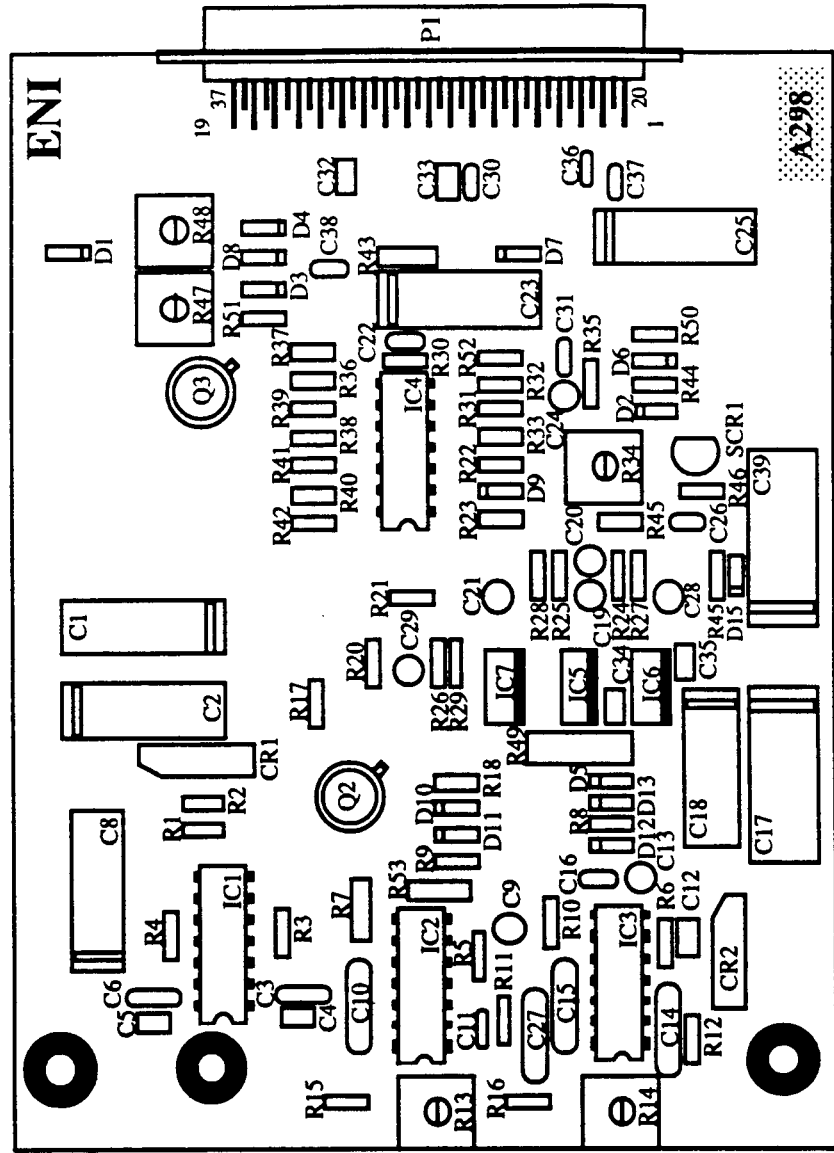
Q1	ENI-1	10684
Q2	ENI-1	10684
Q3	ENI-1	10684
Q4	ENI-1	10684
Q5	ENI-1	10684
Q6	ENI-1	10684

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
Q7	ENI-1	10684
Q8	ENI-1	10684
Q9	ENI-1	10684
Q10	ENI-1	10684
Q11	ENI-1	10684
Q12	2N3439	10673
Q13	2N3439	10673
Q14	2N3439	10673

***Miscellaneous :***

A263	PC Board	11323
	Transistor sockets (13)	11324
	25 pin receptacle	11333
	Heatsink	LPI-10-027
	Spacer (4-40 x 3/8 hex) (3)	2331
	Heat dissipator (13)	10867
	Binding Post Term (9)	11567

# Power Supply Regulator Board (MRI-2K-14695) Layout



## Power Supply Regulator Board (MRI-2K-14695)

### *Resistors:*

Code	Description	ENI #
R1	100Ω, 0.25W, 5%	140018
R2	100Ω, 0.25W, 5%	140018
R3	10Ω, 0.25W, 5%	140003
R4	10Ω, 0.25W, 5%	140003
R5	1600Ω, 0.25W, 5%	140038
R6	1600Ω, 0.25W, 5%	140038
R7	1500Ω, 0.5W, 5%	120027
R8	5100Ω, 0.25W, 5%	140049
R9	1000Ω, 0.25W, 5%	140035
R10	10Ω, 0.25W, 5%	140003
R11	11000Ω, 0.5W, 2%	10573
R12	1000Ω, 0.25W, 5%	140035
R13	Potentiometer, 1000Ω	10411
R14	Potentiometer, 500Ω	10410
R15	1000Ω, 0.25W, 5%	140035
R16	1500Ω, 0.25W, 5%	140037
R17	1000Ω, 0.25W, 5%	140035
R18	1000Ω, 0.25W, 5%	140035
R20	237kΩ, 0.125W, 5%	10561
R21	25500Ω, 0.125W, 1%	561016
R22	10000Ω, 0.25W, 5%	140056
R23	240000Ω, 0.25W, 5%	140085
R24	240Ω, 0.25W, 5%	140023
R25	240Ω, 0.25W, 5%	140023
R26	240Ω, 0.25W, 5%	140023
R27	2700kΩ, 0.25W, 5%	140043
R28	750Ω, 0.25W, 5%	140033
R29	2700Ω, 0.25W, 5%	140043
R30	3010Ω, 0.25W, 5%	10556
R31	1000Ω, 0.125W, 1%	11380
R32	1000Ω, 0.125W, 1%	11380
R33	5600Ω, 0.25W, 5%	140050
R34	Potentiometer 1000Ω	10411
R35	2200Ω, 0.25W, 5%	140041
R36	1000Ω, 0.25W, 5%	140035
R37	1000Ω, 0.25W, 5%	140035
R38	22000Ω, 0.25W, 5%	140061
R39	12000Ω, 0.25W, 5%	140057
R40	3300Ω, 0.25W, 5%	140045
R41	1000, 0.25W, 5%	140056
R42	5100, 0.25W, 5%	140049
R43	1500Ω, 0.5W, 5%	120027
R44	100Ω, 0.25W, 5%	140018
R45	2.7kΩ, 0.25W, 5%	140043
R46	3.01Ω, 0.125W, 5%	140029
R47	Potentiometer 50Ω	11326
R48	Potentiometer 50Ω	11326

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
R49	39Ω, 2W, 5%	2000009
R50	240Ω, 0.25W, 5%	140023
R51	1000Ω, 0.25W, 5%	140035
R52	7.5k, 0.5W, 5%	120032
R53	470Ω, 0.5W, 5%	120018

**Capacitors :**

C1	47μF, 50V	10108
C2	47μF, 50V	10108
C3	0.47μF, 50V	10066
C4	1000pF, 200V	10834
C5	1000pF, 200V	10834
C6	0.47μF, 50V	10066
C8	20μF	10107
C9	3.3μF, 35V	10880
C10	0.51μF,500V	10092
C11	0.1μF	10065
C12	1000PF, 200V	10834
C13	3.3μF, 35V	10880
C14	0.15μF, 500V	10086
C15	0.15μF, 500V	10086
C16	0.01μF, 500V	11037
C17	220μF, 35V	11232
C18	220μF, 35V	11232
C19	3.3μF, 35V	10880
C20	3.3μF, 35V	10880
C21	3.3μF, 35V	10880
C22	0.22μF, 50V	10735
C23	47μF, 50V	10108
C24	22μF, 10V	10105
C25	47μF, 50V	10108
C26	0.01μF, 50V	11037
C27	0.15μF, 500V	10086
C28	10μF, 35V	10106
C29	10μF, 35V	10106
C30	0.01μF, 50V	11037
C31	0.01μF, 40V	11037
C32	1000pF, 200V	10834
C33	1000pF, 200V	10834
C34	1000pF, 200V	10834
C35	1000pF, 200V	10834
C36	0.01μF, 50V	11037
C37	0.01μF, 50V	11037
C38	0.01μF, 50V	11037
C39	220μF, 35V	11232

### ***Diodes :***

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
D1	Diode, 5082-2800	10249
D2	Diode, 5082-2800	10249
D3	Diode, 1N914B	10239
D4	Diode, 1N914B	10239
D5	Diode, 1N914B	10239
D6	Diode, 1N914B	10239
D7	Diode, 1N4001	10242
D8	6.2V Zener	10238
D9	6.2V Zener	11145
D10	51V Zener, 1N4757A	261007
D11	Diode, 1N914B	10239
D12	12V Zener	10846
D13	12V Zener	10846
D14	6.2V Zener	11145
D15	Diode, 1N914B	10239

### ***Integrated Circuits :***

IC1	MC 1468L	10326
IC2	MC 1723CG	11042
IC3	MC 1723CG	11042
IC4	MC 34074P	11329
IC5	LM317T	11066
IC6	LM317T	11066
IC7	LM337T	11067

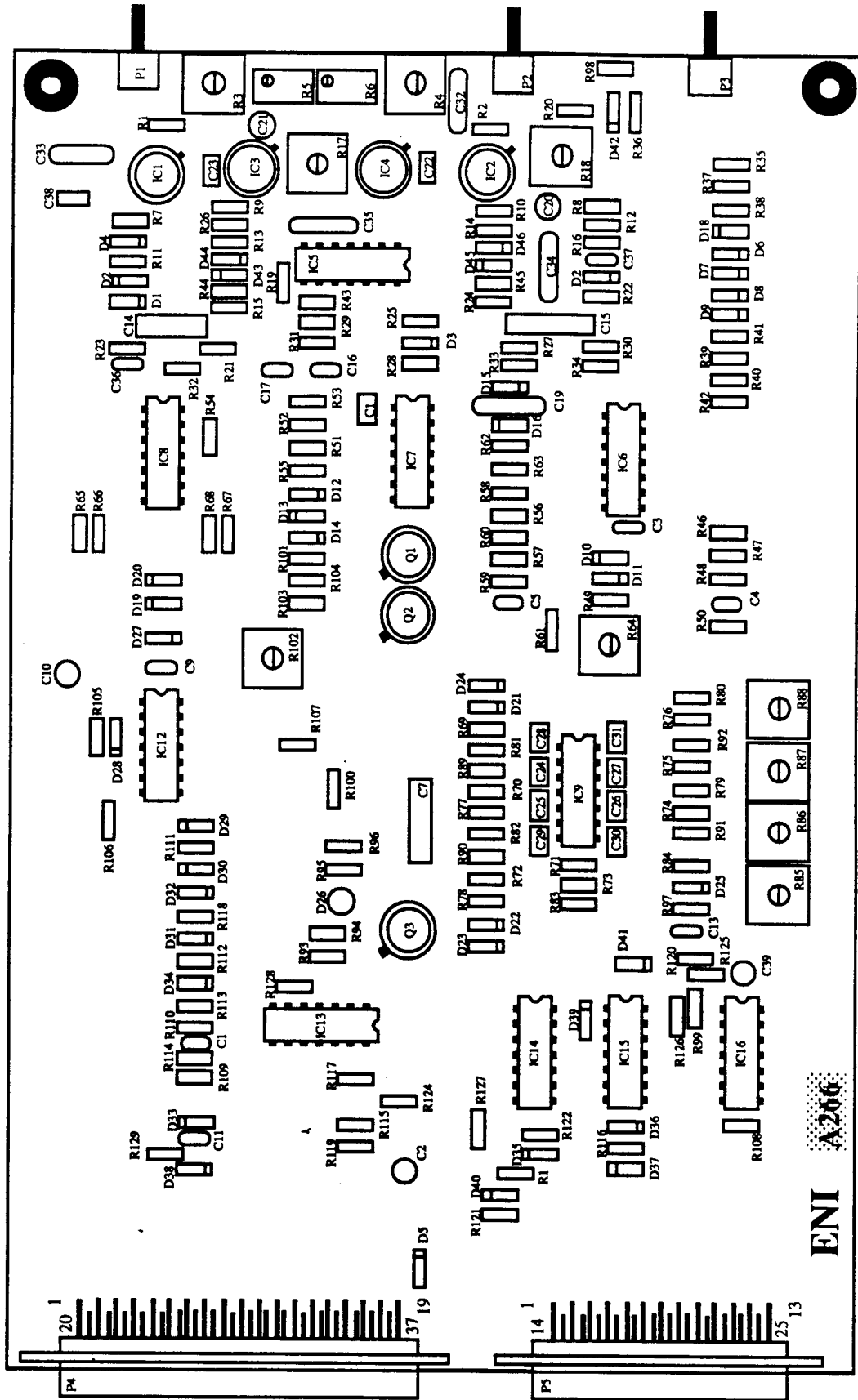
### ***Transistors :***

Q2	2N3439	10673
Q3	2N1613	10670

### ***Miscellaneous :***

A298	P.C. Board	11325
SCR1	Silicon Controlled Rectifier	11328
CR1	Bridge Rectifier	11441
CR2	Bridge Rectifier	11441
	Connector (1)	11083

# Control Board (LPI-10-14696) Layout



ENI A286

## Control board (LPI-10-14696)

### *Resistors:*

Code	Description	ENI #
R1	30k $\Omega$ , 0.25W, 5%	140062
R2	30k $\Omega$ , 0.25W, 5%	140062
R3	Potentiometer 50k $\Omega$	10418
R4	Potentiometer 50k $\Omega$	10418
R5	Potentiometer 20k $\Omega$	11299
R6	Potentiometer 20k $\Omega$	11299
R7	4.7k $\Omega$ , 0.25W, 5%	140048
R8	4.7k $\Omega$ , 0.25W, 5%	140048
R9	4.7k $\Omega$ , 0.25W, 5%	140048
R10	4.7k $\Omega$ , 0.25W, 5%	140048
R11	22k $\Omega$ , 0.25W, 5%	140061
R12	22k $\Omega$ , 0.25W, 5%	140061
R13	47k $\Omega$ , 0.25W, 5%	140064
R14	47k $\Omega$ , 0.25W, 5%	140064
R15	100 $\Omega$ , 0.25W, 5%	140018
R16	100 $\Omega$ , 0.25W, 5%	140018
R17	Potentiometer 10k $\Omega$	10413
R18	Potentiometer 10k $\Omega$	10413
R19	2k $\Omega$ , 0.25W, 5%	140040
R20	2k $\Omega$ , 0.25W, 5%	140040
R21	3.01k $\Omega$ , 0.125W, 1%	10556
R22	3.01k $\Omega$ , 0.125W, 1%	10556
R23	1.5k $\Omega$ , 0.125W, 1%	10613
R24	1.5k $\Omega$ , 0.125W, 1%	10613
R25	100k $\Omega$ , 0.25W, 5%	140070
R26	100k $\Omega$ , 0.25W, 5%	140070
R27	100k $\Omega$ , 0.25W, 5%	140070
R28	1M $\Omega$ , 0.25W, 5%	140074
R29	10k $\Omega$ , 0.25W, 5%	140056
R30	10k $\Omega$ , 0.25W, 5%	140056
R31	200 $\Omega$ , 0.25W, 5%	140022
R32	1M $\Omega$ , 0.25W, 5%	140074
R33	8.2k $\Omega$ , 0.25W, 5%	140054
R34	4.7k $\Omega$ , 0.25W, 5%	140048
R35	10k $\Omega$ , 0.25W, 5%	140056
R36	10k $\Omega$ , 0.25W, 5%	140056
R37	1.5k $\Omega$ , 0.25W, 5%	140037
R38	10k $\Omega$ , 0.25W, 5%	140056
R39	10k $\Omega$ , 0.25W, 5%	140056
R40	100k $\Omega$ , 0.25W, 5%	140070
R41	10k $\Omega$ , 0.25W, 5%	140056
R42	68k $\Omega$ , 0.25W, 5%	140066
R43	750 $\Omega$ , 0.25W, 5%	140033
R44	510k $\Omega$ , 0.25W, 5%	140079

Code	Description	ENI #
R45	510k $\Omega$ , 0.25W, 5%	140079
R46	510k $\Omega$ , 0.25W, 5%	140079
R47	510k $\Omega$ , 0.25W, 5%	140079
R48	510k $\Omega$ , 0.25W, 5%	140079
R49	1M $\Omega$ , 0.25W, 5%	140074
R50	1k $\Omega$ , 0.25W, 5%	140035
R51	100k $\Omega$ , 0.25W, 5%	140070
R52	100k $\Omega$ , 0.25W, 5%	140070
R53	100k $\Omega$ , 0.25W, 5%	140070
R54	3k $\Omega$ , 0.25W, 5%	140044
R55	1k $\Omega$ , 0.25W, 5%	140035
R56	1k $\Omega$ , 0.25W, 5%	140035
R57	100k $\Omega$ , 0.25W, 5%	140070
R58	100k $\Omega$ , 0.25W, 5%	140070
R59	10k $\Omega$ , 0.25W, 5%	140056
R60	510k $\Omega$ , 0.25W, 5%	140079
R61	100k $\Omega$ , 0.25W, 5%	140070
R62	10k $\Omega$ , 0.25W, 5%	140056
R63	1k $\Omega$ , 0.25W, 5%	140035
R64	Potentiometer 50k $\Omega$	10418
R65	390 $\Omega$ , 0.25W, 5%	140028
R66	390 $\Omega$ , 0.25W, 5%	140028
R67	390 $\Omega$ , 0.25W, 5%	140028
R68	390 $\Omega$ , 0.25W, 5%	140028
R69	2k $\Omega$ , 0.25W, 5%	140040
R70	2k $\Omega$ , 0.25W, 5%	140040
R71	2k $\Omega$ , 0.25W, 5%	140040
R72	2k $\Omega$ , 0.25W, 5%	140040
R73	2k $\Omega$ , 0.25W, 5%	140040
R74	2k $\Omega$ , 0.25W, 5%	140040
R75	2k $\Omega$ , 0.25W, 5%	140040
R76	2k $\Omega$ , 0.25W, 5%	140040
R77	100 $\Omega$ , 0.25W, 5%	140018
R78	100 $\Omega$ , 0.25W, 5%	140018
R79	100 $\Omega$ , 0.25W, 5%	140018
R80	100 $\Omega$ , 0.25W, 5%	140018
R81	7.5k $\Omega$ , 0.25W, 5%	140053
R82	7.5k $\Omega$ , 0.25W, 5%	140053
R83	7.5k $\Omega$ , 0.25W, 5%	140053
R84	7.5k $\Omega$ , 0.25W, 5%	140053
R85	Potentiometer 500 $\Omega$	10410
R86	Potentiometer 500 $\Omega$	10410
R87	Potentiometer 500 $\Omega$	10410
R88	Potentiometer 500 $\Omega$	10410
R89	300k $\Omega$ , 0.25W, 5%	140087
R90	300k $\Omega$ , 0.25W, 5%	140087
R91	300k $\Omega$ , 0.25W, 5%	140087
R92	300k $\Omega$ , 0.25W, 5%	140087
R93	4.7k $\Omega$ , 0.25W, 5%	140048
R94	470 $\Omega$ , 0.25W, 5%	140029
R95	7.5k $\Omega$ , 0.25W, 5%	140053
R96	2k $\Omega$ , 0.25W, 5%	140040

Code	Description	ENI #
R97	1.5k $\Omega$ , 0.25W, 5%	140037
R98	2.7k $\Omega$ , 0.25W, 5%	140043
R99	10k $\Omega$ , 0.25W, 5%	140056
R100	510k $\Omega$ , 0.25W, 5%	140079
R101	10k $\Omega$ , 0.25W, 5%	140056
R102	Potentiometer 500 $\Omega$	10410
R103	4.7k $\Omega$ , 0.25W, 5%	140048
R104	1k $\Omega$ , 0.25W, 5%	140035
R105	75k $\Omega$ , 0.25W, 5%	140067
R106	390 $\Omega$ , 0.25W, 5%	140028
R107	100k $\Omega$ , 0.25W, 5%	140070
R108	10k $\Omega$ , 0.25W, 5%	140056
R109	10k $\Omega$ , 0.25W, 5%	140056
R110	10k $\Omega$ , 0.25W, 5%	140056
R111	390 $\Omega$ , 0.25W, 5%	140028
R112	390 $\Omega$ , 0.25W, 5%	140028
R113	10k $\Omega$ , 0.25W, 5%	140056
R114	10k $\Omega$ , 0.25W, 5%	140077
R115	390 $\Omega$ , 0.25W, 5%	140028
R116	10k $\Omega$ , 0.25W, 5%	140056
R117	1k $\Omega$ , 0.25W, 5%	140035
R118	10k $\Omega$ , 0.25W, 5%	140056
R119	390 $\Omega$ , 0.25W, 5%	140028
R120	10k $\Omega$ , 0.25W, 5%	140056
R121	390 $\Omega$ , 0.25W, 5%	140028
R122	10k $\Omega$ , 0.25W, 5%	140056
R123	47k $\Omega$ , 0.25W, 5%	140064
R124	100 $\Omega$ , 0.25W, 5%	140018
R125	10k $\Omega$ , 0.25W, 5%	140056
R126	10k $\Omega$ , 0.25W, 5%	140056
R127	10k $\Omega$ , 0.25W, 5%	140056
R128	2k $\Omega$ , 0.25W, 5%	140040
R129	1M $\Omega$ , 0.25W, 5%	140074
R130	47K $\Omega$ , .25W, 5%	140064

**Capacitors :**

C1	0.01 $\mu$ F, 50V	11037
C2	3.3 $\mu$ F, 35V	10880
C3	47 $\mu$ F, 50V	10066
C4	47 $\mu$ F, 50V	10066
C5	0.1 $\mu$ F, 50V	10065
C7	0.1mF Mylar, 250V	10059
C9	47 $\mu$ F, 50V	10066
C10	3.3 $\mu$ F, 35V	10880
C11	0.033 $\mu$ F,	10063
C13	47 $\mu$ F, 50V	10066
C14	0.1mF Mylar, 250V	10059
C15	0.1mF Mylar, 250V	10059
C16	0.1 $\mu$ F,50V	10065

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
C17	47 $\mu$ F,50V	10066
C18	1000pF, 200V	10834
C19	100pF	10083
C20	10 $\mu$ F, 35V	10106
C21	10 $\mu$ F, 35V	10106
C22	100pF	10083
C23	100pF	10083
C24	1000pF, 200V	10834
C25	1000PF, 200V	10834
C26	1000PF, 200V	10834
C27	1000PF, 200V	10834
C28	1000PF, 200V	10834
C29	1000PF, 200V	10834
C30	1000PF, 200V	10834
C31	1000PF, 200V	10834
C32	510pF	10092
C33	510pF	10092
C34	56pF	10080
C35	56pF	10080
C36	0.01 $\mu$ F, 50V	11037
C37	0.01 $\mu$ F, 50V	11037
C38	1000PF, 200V	10834
C39	10 $\mu$ F, 35V	10106
C40	0.01 $\mu$ F, 50V	11037
C41	0.01 $\mu$ F, 50V	11037
C42	1000PF, 200V	10834
C43	1000PF, 200V	10834
C44	1000PF, 200V	10834
C45	1000PF, 200V	10834
C46	1000PF, 200V	10834
C47	1000PF, 200V	10834

***Diodes :***

D1	Diode, 1N914B	10239
D2	Diode, 1N914B	10239
D3	Diode, 1N914B	10239
D4	Diode, 1N914B	10239
D5	Diode, 1N914B	10239
D6	Diode, 1N914B	10239
D7	Diode, 1N914B	10239
D8	Diode, 1N914B	10239
D9	Diode, 1N914B	10239
D10	Diode, 1N914B	10239
D11	Diode, 1N914B	10239
D12	Diode, 1N914B	10239
D13	Diode, 1N914B	10239
D14	Diode, 1N914B	10239
D15	Diode, 1N914B	10239
D16	Diode, 1N914B	10239

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
D18	6.2V, Zener	10238
D19	6.2V, Zener	10238
D20	6.2V, Zener	10238
D21	Diode, 1N914B	10239
D22	Diode, 1N914B	10239
D23	Diode, 1N914B	10239
D24	Diode, 1N914B	10239
D25	6.2V, Zener	10238
D26	LED, Yellow	11068
D27	4.7V, Zener	11102
D28	Diode, 1N914B	10239
D29	Diode, 5082-2800	10249
D30	Diode, 1N914B	10239
D31	Diode, 1N914B	10239
D32	Diode, 1N914B	10239
D33	Diode, 1N914B	10239
D34	Diode, 1N914B	10239
D35	Diode, 1N914B	10239
D36	Diode, 1N914B	10239
D37	Diode, 1N914B	10239
D38	Diode, 1N914B	10239
D39	Diode, 1N914B	10239
D40	6.2V, Zener	10238
D41	Diode, 1N914B	10239
D42	6.2V, Zener	10238
D43	Diode, 1N914B	10239
D44	Diode, 1N914B	10239
D46	Diode, 1N914B	10239
D47	Diode, 1N914B	10239
D48	Diode, 1N914B	10239
D49	Diode, 1N914B	10239

***Integrated Circuits :***

IC1	8013 CCTZ	11008
IC2	8013 CCTZ	11008
ICE	LF 398	11336
IC4	LF 398	11336
IC5	MC 3407HP	11329
IC6	MC 3407HP	11329
IC7	MC 3407HP	11329
IC8	74 HC 109	11340
IC9	MC 3407HP	11329
IC12	4538	11341
IC13	74 HC .004	11338
IC14	74 HC 32	11339
IC15	74 HC 00	11337
IC16	74 HC 32	11339

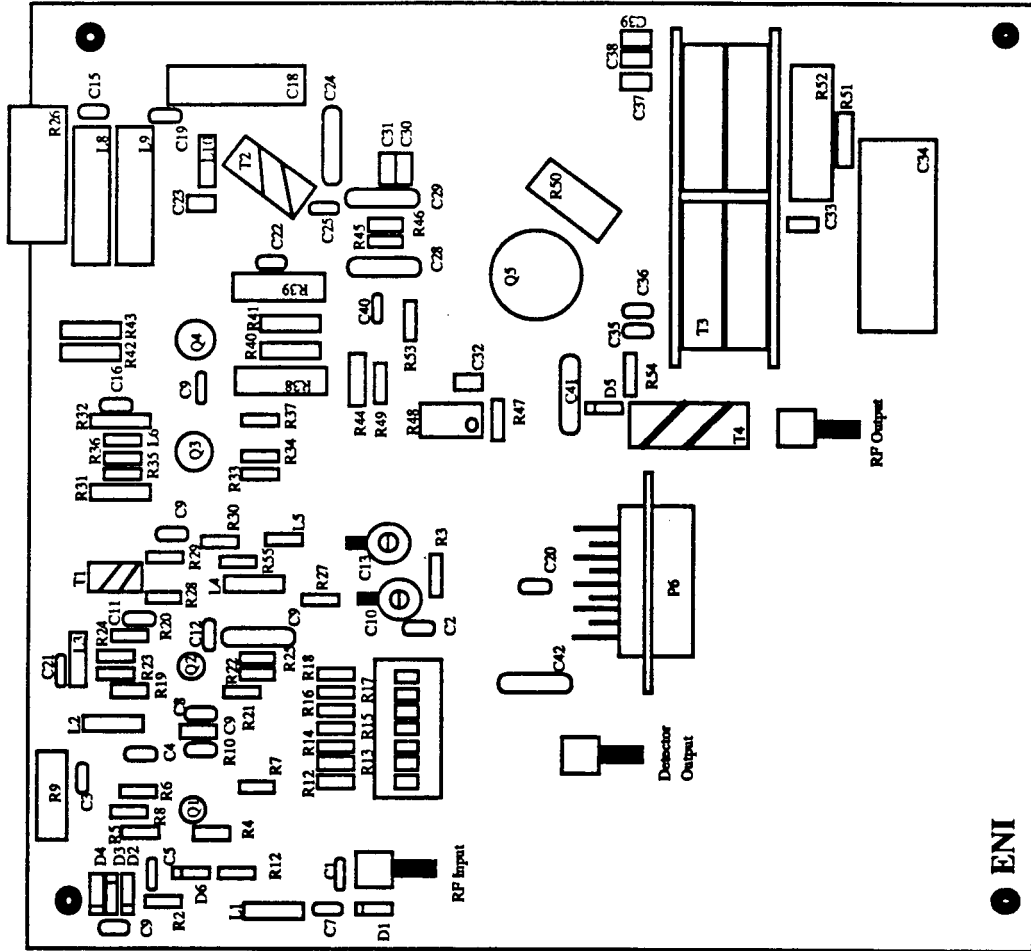
***Transistors :***

Q1	2N1613	10670
Q2	2N1613	10670
Q3	2N4405	681004

***Miscellaneous :***

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
A266	P.C. Board	11330
	I.C. Socket, 14 pin (8)	10912
	I.C. Socket, 16 pin (2)	11331
	I.C. Socket, 10 pin (2)	11162
	I.C. Socket, 8 pin (2)	11332
P1	Connector	10210
P2	Connector	10210
P3	Connector	10210
P4	Connector	11083
P5	Connector	11333

# Preamplifier Board (MRI-2K-14697) Layout



## Pre-amplifier Board (MRI-2K-14697)

### *Resistors:*

Code	Description	ENI#
R1	12 $\Omega$ , 1/4W, 5%	140004
R2	390 $\Omega$ , 1/4W, 5%	140028
R3	100 $\Omega$ , 1/4W, 5%	140018
R4	300 $\Omega$ , 1/4W, 5%	140025
R5	270 $\Omega$ , 1/4W, 5%	140024
R6	2K $\Omega$ , 1/4W, 5%	140040
R7	27 $\Omega$ , 1/4W, 5%	140008
R8	27 $\Omega$ , 1/4W, 5%	140008
R9	68 $\Omega$ , 2W, 5%	2000011
R10	33 $\Omega$ , 1/4W, 5%	140010
R12	270 $\Omega$ , 1/4W, 5%	140024
R13	120 $\Omega$ , 1/4W, 5%	140019
R14	82 $\Omega$ , 1/4W, 5%	140017
R15	62 $\Omega$ , 1/4W, 5%	140014
R16	33 $\Omega$ , 1/4W, 5%	140010
R17	22 $\Omega$ , 1/4W, 5%	140007
R18	15 $\Omega$ , 1/4W, 5%	140005
R19	240 $\Omega$ , 1/4W, 5%	140023
R20	2K $\Omega$ , 1/4W, 5%	140040
R21	470 $\Omega$ , 1/4W, 5%	140029
R22	62 $\Omega$ , 1/4W, 5%	140014
R23	62 $\Omega$ , 1/4W, 5%	140014
R24	62 $\Omega$ , 1/4W, 5%	140014
R25	62 $\Omega$ , 1/4W, 5%	140014
R26	5.1 $\Omega$ , 1/4W, 5%	10588
R27	120 $\Omega$ , 1/4W, 5%	140019
R28	39 $\Omega$ , 1/4W, 5%	140011
R29	22 $\Omega$ , 1/4W, 5%	140007
R30	51 $\Omega$ , 1/4W, 5%	140013
R31	150 $\Omega$ , 1W, 5%	1000024
R32	390 $\Omega$ , 1W, 5%	1000015
R33	10 $\Omega$ , 1/2W, 5%	120001
R34	10 $\Omega$ , 1/2W, 5%	120001
R35	10 $\Omega$ , 1/2W, 5%	120001
R36	10 $\Omega$ , 1/2W, 5%	120001
R37	75 $\Omega$ , 1/4W, 5%	140016
R38	68 $\Omega$ , 2W, 5%	2000011
R39	360 $\Omega$ , 2W, 5%	2000032
R40	10 $\Omega$ , 1W, 5%	1000002
R41	10 $\Omega$ , 1W, 5%	1000002
R42	10 $\Omega$ , 1W, 5%	1000002
R43	10 $\Omega$ , 1W, 5%	1000002
R44	10 $\Omega$ , 1W, 5%	1000002
R45	12 $\Omega$ , 1/2W, 5%	120002

<b>Code</b>	<b>Description</b>	<b>ENI#</b>
R46	12 $\Omega$ , 1/2W, 5%	120002
R47	51 $\Omega$ , 1/4W, 5%	140013
R48	POT 500 $\Omega$	11534
R49	200 $\Omega$ , 1/4W, 5%	140022
R50	39 $\Omega$ , 2W, 5%	2000009
R51	6.8 $\Omega$ , 1W, 5%	1000001
R52	0.02 $\Omega$ , 5W, 5%	11335
R53	51 $\Omega$ , 1/4W, 5%	140013
R54	100 $\Omega$ , 1/4W, 5%	140018
R55	51 $\Omega$ , 1/4W, 5%	140013

**Capacitors :**

<b>Code</b>	<b>Description</b>	<b>ENI#</b>
C1	0.033 $\mu$ F, 50V	10063
C2	0.033 $\mu$ F, 50V	10063
C3	0.1 $\mu$ F, 50V	10065
C4	0.033 $\mu$ F, 50V	10063
C5	4700pF	11091
C6	0.033 $\mu$ F, 50V	10063
C7	4700 pF	11091
C8	0.033 $\mu$ F, 50V	10063
C9	0.01 $\mu$ F, 50V	11037
C10	5.545 pF	10055
C11	0.033 $\mu$ F, 50V	10063
C12	0.033 $\mu$ F, 50V	10063
C13	5.5-45 pF	10055
C14	0.033 $\mu$ F, 50V	10063
C15	0.1 $\mu$ F, 50V	10065
C16	0.1 $\mu$ F, 50V	10065
C17	0.01 $\mu$ F, 50V	11037
C18	20 $\mu$ F,	10107
C19	0.1 $\mu$ F, 50V	10065
C20	0.01 $\mu$ F, 50V	11037
C21	0.1 $\mu$ F, 50V	10065
C22	0.1 $\mu$ F, 50V	10065
C23	0.47 $\mu$ F, 50V	10864
C24	100pF	10083
C25	4700 pF	11091
C26	0.1 $\mu$ F, 50V	10065
C27	240 pF	10088
C28	150 pF	10086
C29	150 pF	10086
C30	1000 pF, 200V	10834
C31	1000 pF, 200V	10834
C32	0.1 $\mu$ F, 100V	11062
C33	0.47 $\mu$ F, 50V	10864
C34	470 $\mu$ F, 50V	10109
C35	0.1 $\mu$ F, 50V	10065

<b>Code</b>	<b>Description</b>	<b>ENI#</b>
C36	0.1 $\mu$ F, 50V	10065
C37	0.1 $\mu$ F, 100V	11062
C38	0.1 $\mu$ F, 100V	11062
C39	0.1 $\mu$ F, 100V	11062
C40	0.01 $\mu$ F, 50V	11037
C41	100 pF	10083
C42	150 pF	10086

***Diodes:***

<b>Code</b>	<b>Description</b>	<b>ENI#</b>
D1	DIODE UM4001B	11036
D2	DIODE 1N914B	10239
D3	DIODE 1N914B	10239
D4	DIODE 1N914B	10239
D5	DIODE 5082-2800	10249
D6	DIODE UM4001B	11036

***Chokes:***

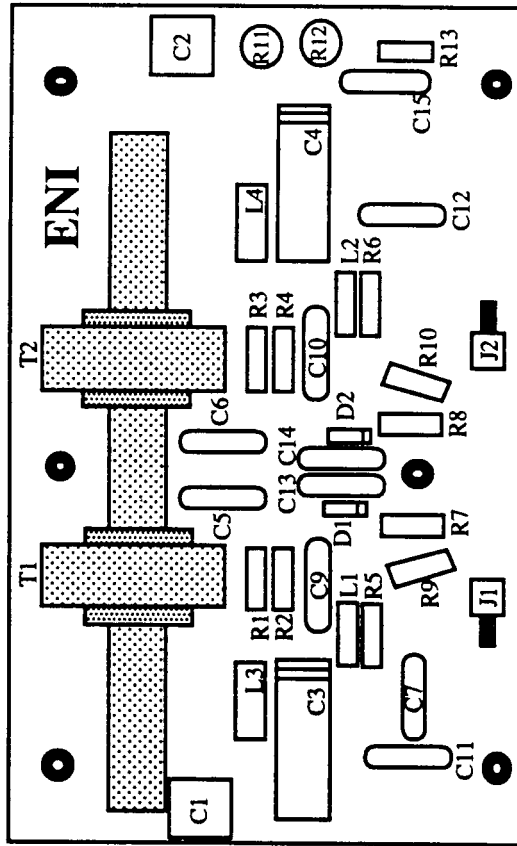
<b>Code</b>	<b>Description</b>	<b>ENI#</b>
L1	CHOKE 22 $\mu$ H	10145
L2	CHOKE 22 $\mu$ H	10145
L3	CHOKE 22 $\mu$ H	10145
L4	CHOKE 3.3 $\mu$ H	10142
L5	CHOKE 0.15 $\mu$ H	10132
L6	CHOKE 0.15 $\mu$ H	10132
L8	CHOKE 27 $\mu$ H	10146
L9	CHOKE 27 $\mu$ H	10146
L10	CHOKE 0.68 $\mu$ H	10138

***Miscellaneous:***

<b>Code</b>	<b>Description</b>	<b>ENI#</b>
A262	P.C. BOARD	11344
A258	P.C. BOARD	11316
A259	P.C. BOARD	11317
A261	P.C. BOARD	11319
A302	P.C. BOARD	11345
J1	CONNECTOR 5064-5003-09	10210
J2	CONNECTOR 5064-5003-09	10210
J3	CONNECTOR 5064-5003-09	10210
P3	CONNECTOR 9-PIN	11342
	“B” CORE	10223

<b>Code</b>	<b>Description</b>	<b>ENI#</b>
	"S" CORE	10787
	"V" CORE	11085
	7-POS. DIP SWITCH	11343
LPI-10-041	0.375 O.D. TUBE	
LPI-10-042	0.500 O.D. TUBE	

# VSWR Bridge Board (LPI-40-14698) Layout



## LPI-10 VSWR bridge (LPI-40-14698)

### *Resistors:*

Code	Description	ENI #
R1	22 $\Omega$ , 0.25W, 5%	140007
R2	22 $\Omega$ , 0.25W, 5%	140007
R3	22 $\Omega$ , 0.25W, 5%	140007
R4	22 $\Omega$ , 0.25W, 5%	140007
R5	33 $\Omega$ , 0.25W, 5%	140010
R6	33 $\Omega$ , 0.25W, 5%	140010
R7	2,200 $\Omega$ , 0.25W, 5%	140041
R8	2,200 $\Omega$ , 0.25W, 5%	140041
R9	30,000 $\Omega$ , 0.25W, 5%	140062
R10	30,000 $\Omega$ , 0.25W, 5%	140062
R11	6,200 $\Omega$ , 2W, 5%	2000027
R12	6,200 $\Omega$ , 2W, 5%	2000027
R13	51 $\Omega$ , 0.25W,5%	140013

### *Capacitors :*

C1	12pF	11511
C2	12pF	11544
C3	Variable 0.8 to 12pF	11123
C4	Variable 0.8 to 12pF	11123
C5	5pF	10068
C6	5pF	10068
C7	390pF	10090
C8	390pF	10090
C9	100pF	10083
C10	100pF	10083
C11	5pF	10068
C12	5pF	10068
C13	390pF	10090
C14	390pF	10090
C15	150pF	10086

### *Chokes :*

L1	.15 $\mu$ H	10132
L2	.15 $\mu$ H	10132
L3	47 $\mu$ H	11346
L4	47 $\mu$ H	11346

***Transformers:***

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
T1	'V' core	
T2	'V' core	

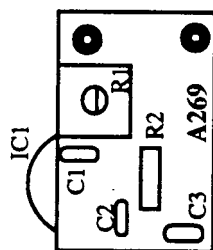
***Diodes :***

D1	5082-2800	10249
D2	5082-2800	10249

***Miscellaneous :***

A297	P.C. Board	11347
J1	Connector	10217
J2	Connector	10217

# Temperature Sensor Board (LPI-10-14700) Layout



## Temperature Sensor (LPI- 10-14700)

### *Resistors:*

Code	Description	ENI #
R1	Pot. 10k $\Omega$ ,	10413
R2	6.8k $\Omega$	140052

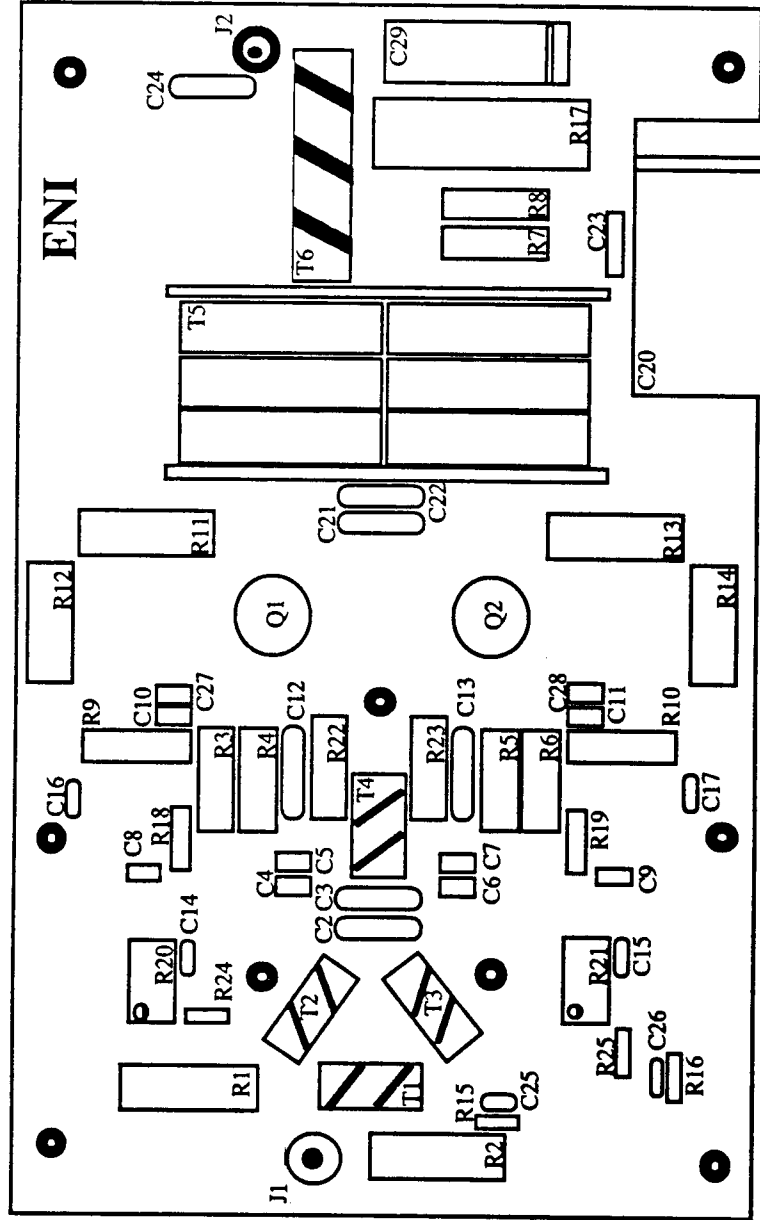
### *Capacitors :*

C1	.01 $\mu$ F	11037
C2	.01 $\mu$ F	11037
C3	.01 $\mu$ F	11037

### *Miscellaneous :*

A269	P.C. Board	11246
	Heatsink	11247
IC1	Integrated Circuit	11245

# Driver Board (MRI-2K-14704) Layout



## Driver board (MRI-2K- 14704)

### *Resistors:*

Code	Description	ENI #
R1	12Ω, 2W	2000002
R2	390Ω, 2W	2000033
R3	6.8Ω, 1W	1000001
R4	6.8Ω, 1W	1000001
R5	6.8Ω, 1W	1000001
R6	6.8Ω, 1W	1000001
R7	6.8Ω, 1W	1000001
R8	6.8Ω, 1W	1000001
R9	10Ω, 1W	1000002
R10	10Ω, 1W	1000002
R11	39Ω, 2W	2000009
R12	39Ω, 2W	2000009
R13	39Ω, 2W	2000009
R14	39Ω, 2W	2000009
R15	200Ω, 0.25W	140022
R16	200Ω, 0.25W	140022
R17	0.02Ω, 5W	11335
R18	51Ω, 0.50W	120007
R19	51Ω, 0.50W	120007
R20	Potentiometer, 500Ω	11534
R21	Potentiometer, 500Ω	11534
R22	10Ω, 1W	2000002
R23	10Ω, 1W	2000002
R24	200Ω, 0.25W	140022
R25	240Ω, 0.25W	140022
R26	4.7Ω, 0.25W, 5%	140089
R27	4.7Ω, 0.25W, 5%	140089

### *Capacitors :*

C2	75pF	10082
C3	30pF	10076
C4	1000pF	10834
C5	1000pF	10834
C6	1000pF	10834
C7	1000pF	10834
C8	1000pF	10834
C9	1000pF	10834
C10	1000pF	10834
C11	1000pF	10834
C14	0.033μF	10063

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
C15	0.033 $\mu$ F	10063
C16	0.01 $\mu$ F, 50V	11037
C17	0.01 $\mu$ F, 50V	11037
C18	0.01 $\mu$ F	11005
C19	0.01 $\mu$ F	11005
C20	470 $\mu$ F, 80V	151029
C21	68pF	10081
C23	0.1 $\mu$ F	11062
C24	12pF	10070
C25	0.033 $\mu$ F	10063
C26	0.033 $\mu$ F	10063
C27	1000pF	10834
C28	1000pF	10834
C29	47 $\mu$ F, 63V	10108

***Transformers:***

T1	'U' core
T2	'A' core
T3	'A' core
T4	'U' core
T5	Tube, 'V' core
T6	'V' core

***Transistors :***

Q1	ENI-30	11287
Q2	ENI-30	11287

***Miscellaneous :***

A257	P.C. Board	11315
J1	Connector (1)	10217
J2	Connector (1)	10173

## Front Panel Board (LPI- 10-24002)

### *Resistors:*

Code	Description	ENI #
R5	15k $\Omega$ , 1/8W, 1%	11357
R6	75 $\Omega$ , 1/8W, 5%	11356
R11	Potentiometer, 50 $\Omega$	11326
R12	Potentiometer, 50k $\Omega$	11348
R13	Potentiometer, 50k $\Omega$	11348
R14	390 $\Omega$ , 0.25W	140028
R15	390 $\Omega$ , 0.25W	140028
R16	390 $\Omega$ , 0.25W	140028

### *Capacitors:*

C1	0.01 $\mu$ F	11037
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### *Diodes:*

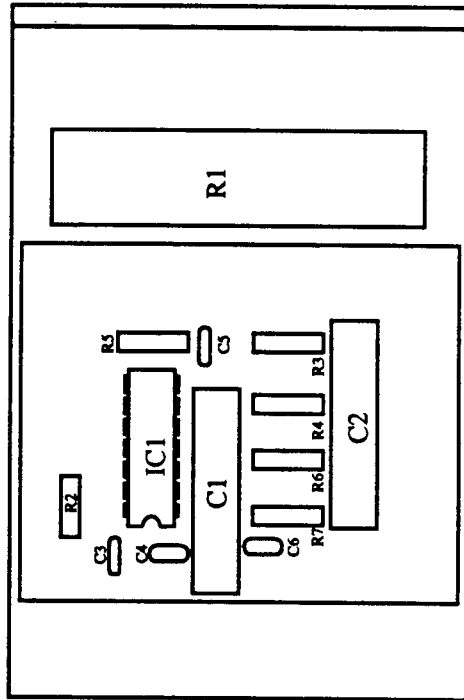
D6	Green high intensity	391003
D7	Green high intensity	391003
D8	Yellow high intensity	391004

### *Miscellaneous:*

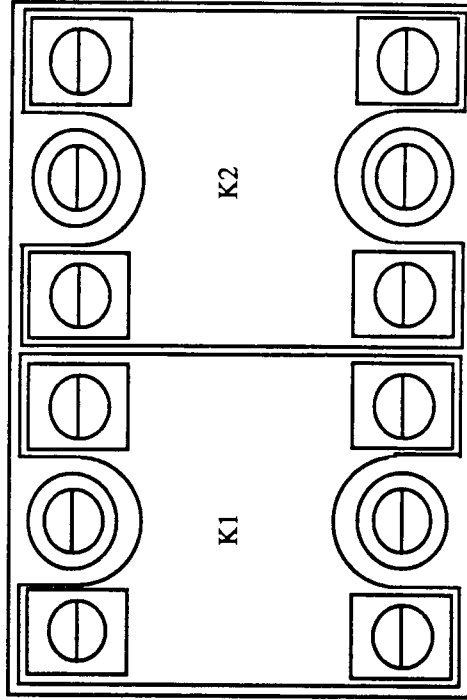
A299	P.C. Board	11354
J1	Connector	11083
P14	Connector, 25pin	11446
S1	Switch SPDT	11350
S3	Switch DPDT	11351
S4	Switch push button	11352
S5	Switch push button	11352
S6	Switch push button	11353
	Switch rotary	641041

# Soft Start Board (MR5K-DA-14702) Layout

**Front**



**Back**



## Soft Start board (MR5K-DA- 14702)

### *Resistors:*

Code	Description	ENI #
R1	2 $\Omega$ , 20W	10612
R2	390 $\Omega$ , 1/4W, 5%	140028
R3	100k $\Omega$ , 1/4W, 5%	140070
R4	100k $\Omega$ , 1/4W, 5%	140070
R5	5.6k $\Omega$ , 1/4W, 5%	140050
R6	1M $\Omega$ , 1/4W, 5%	140074
R7	10k $\Omega$ , 1/4W, 5%	140056

### *Capacitors:*

C1	1 $\mu$ F, 250V	10060
C2	1 $\mu$ F, 250V	10060
C3	0.01 $\mu$ F, 50V	11037
C4	0.01 $\mu$ F, 50V	11037
C5	0.01 $\mu$ F, 50V	11037
C6	0.01 $\mu$ F, 50V	11037

### *Integrated Circuits:*

IC1	I.C. 74HC00	11337
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### *Miscellaneous:*

A334	P.C. BOARD	11566
K1	RELAY, SOLID-STATE	541006
K2	RELAY, SOLID-STATE	541006
LPI-10-040	RELAY BRACKET	
P13	CONNECTOR 2-PIN	10839
	SPACER 4-40 x 1/4" (HEX)	8401
	STAND-OFF	10929

## Other Parts

### *Metal Parts:*

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
B1	Fan	10258
	Chassis, Slide	181000
	Finger STK, CFS-2-4	11685
LPI-10-017	Hinge	
LPI-10-036	Bezel, Spacer	
LPI-10-046	Bus Bar	
LPI-10-204	Right Heatsink Extrusion	
LPI-10-205	Right Heatsink	
LPI-10-207	Heatsink Support Cover	
LPI-10-208	Control Board, Tray	
LPI-10-214	Support Diag. Panel	
LPI-10-215-1	Front Comer Brkt., Left	
LPI-10-215-2	Front Comer Brkt., Right	
LPI-10-216	Bezel	
LPI-10-217-1	Front Panel, Support, Left	
LPI-10-217-2	Front Panel Support, Right	
LPI-10-223	Line Filter Cover	
LPI-10-227	Terminal Block Cover	
LPI-10-229	Power Supply Cover	
LPI-10-230	Front Panel Upper	
LPI-10-231	Fan RFI Shield	
LPI-10-232	Spacer, Slide	
MRI-2K-0113-50	Lower Side Cover, Left	
MRI-2K-0113-51	Lower Side Cover, Right	
LPI-10-234	Cover RF Input	
LPI- 10-238	GND Strap Rear	
LPI-10-239	Pre-amp Insulator	
MRI-2K-0123-50	Top Cover	
MR5K-DA-005-01	Baseplate	
MRI-2K-0106-50	Rear Panel	
LPI-10-043	Rack Mt Bracket	
MRI-2K-0125-01	Upper Front Panel Overlay	
MR5K-DA-010-01	Diagnostic Panel	
MRI-2K-01 15-01	Diagnostic Panel Overlay	
MR5K-DA-012-01	Lower Front Panel	
MRI-2K-0103-50	Support Cover Assy	
MRI-2K-0133-01	Cover Output Network Tray	

### ***Components:***

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
	“B” Core	10223
C1	7800 $\mu$ F	151030
C1	32000 $\mu$ F	151031
C2	8900 $\mu$ F	11221
C2	32000 $\mu$ F	151031
CR1	Bridge Rectifier	10004
CR2	Bridge Rectifier	10004
CR3	Bridge Rectifier	10004
D1	LED, Amber	11068
D2	LED, Amber	11068
D3	LED, Amber	11068
D4	LED, Amber	11068
D5	LED, Amber	11068
ENI-16C	Transistor	10786
ENI-30B	Transistor	11287
ENI-2240	Transistor	10680
	“H” Core	10229
R1	1k $\Omega$ , 8W	10597
R2	1k $\Omega$ , 8W	10597
R1 Rear Panel	1k $\Omega$ , 8W	10597
R2 Rear Panel	1k $\Omega$ , 8W	10597
T1	Transformer, AM-14303	671024
T2	Transformer AM-14281	671021
T3	Transformer AM-14282	671022

### ***Cables and Miscellaneous:***

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
	Cap Clamp	10128
CB1	Circuit Breaker, 15A	201003
	Clamp	10125
	Connector	10997
	Connector, Plug, Linecord	221106
	Connector, 4-pin	10840
	Connector, BNC	10173
	Connector, BNC/SMC	11624
	Connector, Power Inlet	221105
	Copper Washer	11822
F1	Fuse 2A SB	10282
F2	Fuse 2A SB	10282
FL1	Line Filter	401008
	Fuse, 2A	10280
	Fuseholder	11035
	High Performance Tape	3087
J1	Connector, 37-Pin	10915
J2	Connector, 25-Pin	11022

<b>Code</b>	<b>Description</b>	<b>ENI #</b>
J3	Connector, 37-Pin	10915
J4	Connector, 37-Pin	10915
J5	Connector, 25-Pin	11022
J6	Connector, 9-Pin	11018
J7	Connector, RFI-FEMALE	11214
J8	Connector, RFI-FEMALE	11214
J9	12-Pin PLUG	10190
J10	Connector, 4-Pin	10841
J13	Connector, 2-Pin RE	10838
J14	Connector, 25-Pin	11022
J15	Connector, 9-Pin RE	10189
J16	Connector, 15-Pin	10194
J17	Connector, 15-Pin	10194
J18	Connector, 2-Pin RE	10838
J22	Connector, 4-Pin	10841
	Knob	10331
	Latch	11311
	Latch, End Disc	11403
	Latch, Spring	11402
LPI-10-228	Tri Strip	
M1	Meter	451010
	Marker Strip	10652
MR5CAB-027-01	Label, Fuse	
MR5CAB-029-01	Label, High Voltage	
MR5CAB-030-01	Label, Manual	
MR5CAB-034-01	Label, Equipment	
MR5CAB-035-01	Label, Service	
MR5KCAB-031-01	Label, Arrow	
MR5KCAB-036-01	Label, Protective Ground	
MR5KCAB-037-01	Label, Earth Ground	
MR5KCAB-038-01	Label, Protected Environment	
P15	Connector, 9-pin PL	10188
P16	Connector, 15-Pin	10195
P17	Connector, 15-Pin PL	10195
P18	Connector, 2-Pin, PL	10839
P22	Connector, 4-pin PL	10840
	Retainer Kit, SCR,M	221081
	Screwlock Kit, F	221082
	Snap Bushing	11122
	Terminal Block, 4-Term	10644
	Terminal Block, 8-Term	10648

## Glossary of Abbreviations

A	Amperes
AMP	Amperes
ASSY	Assembly
BR	Bridge
CAP	Capacitor
CER	Ceramic
DESIG	Designation
ELECT	Electrolytic
IC	Integrated Circuit
K	Kilohms
k $\Omega$	Kilohms
mV	Millivolts
pF	Picofarad
PIV	Peak Inverse Power
POT	Potentiometer
REF	Reference
REQ	Required
RES	Resistor
S.B.	Slow Blow
uF	Microfarad
$\mu$ F	Microfarad
uH	Microhenry
$\mu$ H	Microhenry
V	Volts
VDCW	DC Working Voltage
w	Watts
WW	Wire Wound