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MODEL PRT73
Precision Ratio Transformer

Instruction and Service Manual

PN# 70581

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SAFETY INFORMATION

Safety Information & Precautions: **S**

Read and follow the **WARNINGS** and *CAUTIONS* in this manual. They emphasize safety during all phases of operation and maintenance.

Some of the important safety terms you will find in this manual and on the equipment are:

CAUTION Statements identify conditions or practices that will result in damage to the equipment or property.

WARNING Statements identify conditions or practices that can cause personal injury or death. Damage to property or equipment can also result from these practices or conditions.

DANGER Statements indicate that an immediate hazard exists that can result in personal injury or death.

Safety Notices Appearing in this Manual

Operation – Section 3…

CAUTION: Even though the over-voltage circuit protects the Model PRT73 from damage due to a sustained overload, there is a chance that the first decade toroid transformer might saturate and magnetize the core. Should the core be magnetized, linearity can be degraded to approximately double the specified maximum error. To assure the overload did not affect linearity, demagnetize the core by using the "Over-voltage Circuit Test and Input Transformer Demagnetization" procedure in Section 8.

Installation – Section 6…

CAUTION: Components used in the Model PRT73 can be damaged by an electro-static discharge (ESD) when the covers are removed. To prevent ESD damage, the installation of the 2.5 V/Hz Option must be performed on a static-free worksurface. The person performing this procedure should also wear a conductive wrist strap connected to the static-free worksurface.

WARNING: Electrical Shock Hazard. Disconnect the power cord and other test equipment connected to the Model PRT73 before performing this procedure. Failure to do so can result in severe injury or death from contact with line voltage or high voltage from other test equipment.

Maintenance – Section 7…

WARNING: Removal of instrument covers may constitute an electrical hazard and should be accomplished by qualified service personnel only. Remove AC power to the Model PRT73 before attempting to clean or perform a visual inspection.

CAUTION: Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Do not apply any solvent containing ketones, esters, or halogenated hydrocarbons. To clean, use only water soluble detergents, ethyl, methyl, or isopropyl alcohol.

Performance Check and Calibration – Section 8…

WARNING: Electrical Shock Hazard. Disconnect the power cord and other test equipment connected to the Model PRT73 before performing this procedure. Failure to do so may result in severe injury or death from contact with line voltage or high voltage from other test equipment.

Troubleshooting – Section 9…

WARNING: Troubleshooting and repair of the Model PRT73 should be done only by qualified service representatives or by qualified service technicians.

CAUTION: Components used in the Model PRT73 can be damaged by an electrostatic discharge (ESD) when the covers are removed. To prevent ESD damage, all work must be performed on a static-free work-surface. The person performing this procedure should also wear a conductive wrist strap connected to the wrist strap connected to the static-free worksurface.

CAUTION: Use a bladed tool to remove transformer cables from the bottom of the Analog Cka. DO NOT pull on the wires to remove the connectors or they may be damaged. Refer to detail A in Figure 9-8

Repair – Section 10…

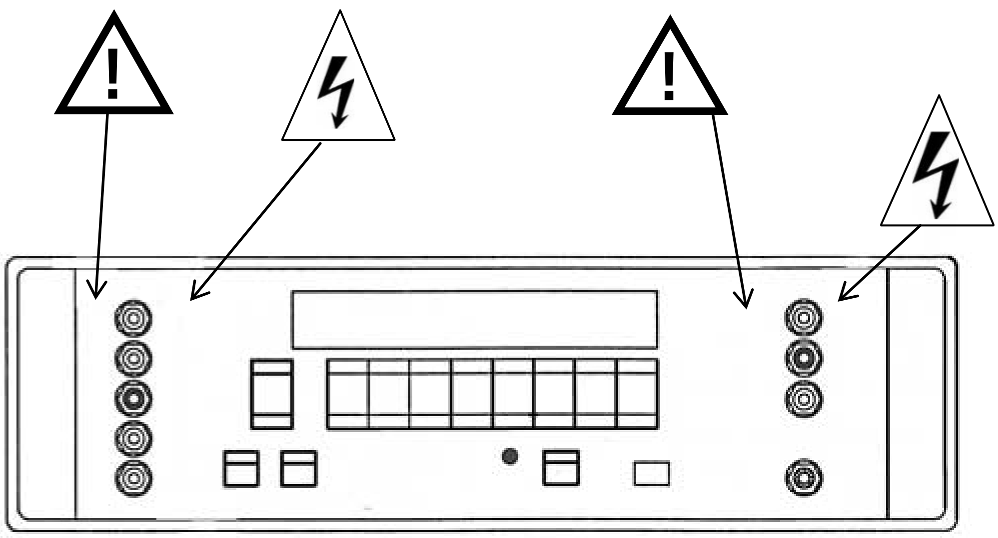
WARNING: Troubleshooting and repair of the Model PRT73 should be done only by qualified service representatives or by qualified service technicians.

WARNING: Remove AC power from Model PRT73 and other instruments connected to it before replacing any component. Removing the Model PRT73 covers while AC power is still connected may constitute an electrical shock hazard. Failure to remove AC power may result in severe electrical shock or death.

Safety Notices Appearing on the Model PRT73

High voltages generated from other equipment can be present at the INPUT and OUTPUT terminals even when power to the Model PRT73 is switched off.

Refer to “Section 3 – Operation” before using this instrument.

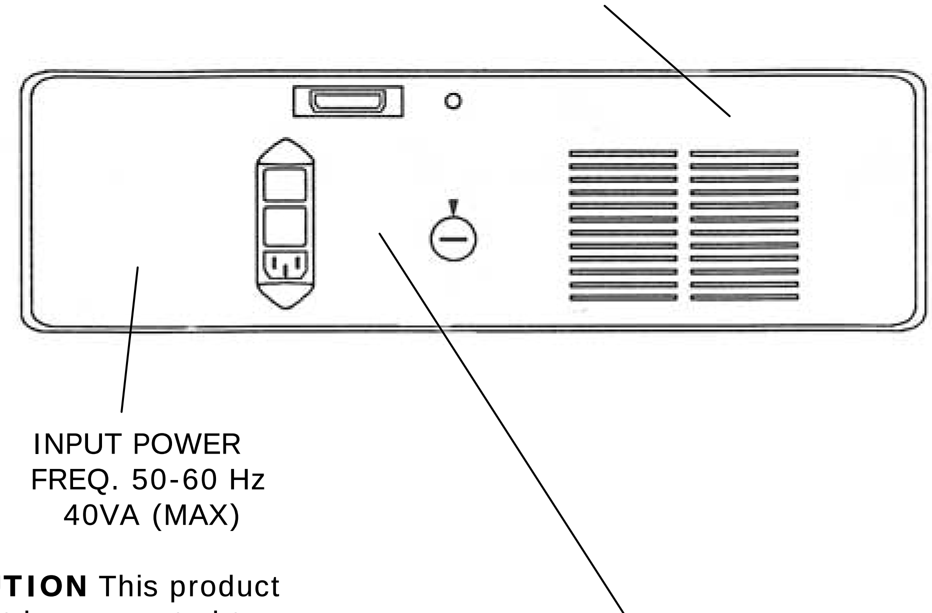


350 VRMS Max Input
Any Terminal to Ground

User applied voltage should not exceed 350 VRMS between the 1.1, 0.0., -.01 or GUARD inputs and Chassis Ground.

Figure S-1, Front Panel Safety Label

CAUTION To prevent electrical shock, do not remove cover. Refer service to qualified personnel. For continued fire protection, use specified type and rating of fuse. Disconnect power input before replacing fuse.



INPUT POWER
FREQ. 50-60 Hz
40VA (MAX)

CAUTION This product must be connected to earth ground.

NOM	RANGE
100V	90-110V
FUSE	
	TT 500mA

NOM	RANGE
220V	198-242V
FUSE	
	TT 250mA

NOM	RANGE
120V	108-132V
FUSE	
	TT 500mA

NOM	RANGE
240V	216-264V
FUSE	
	TT 250mA

Figure S-2 Rear Panel Notices and Labels

Top View

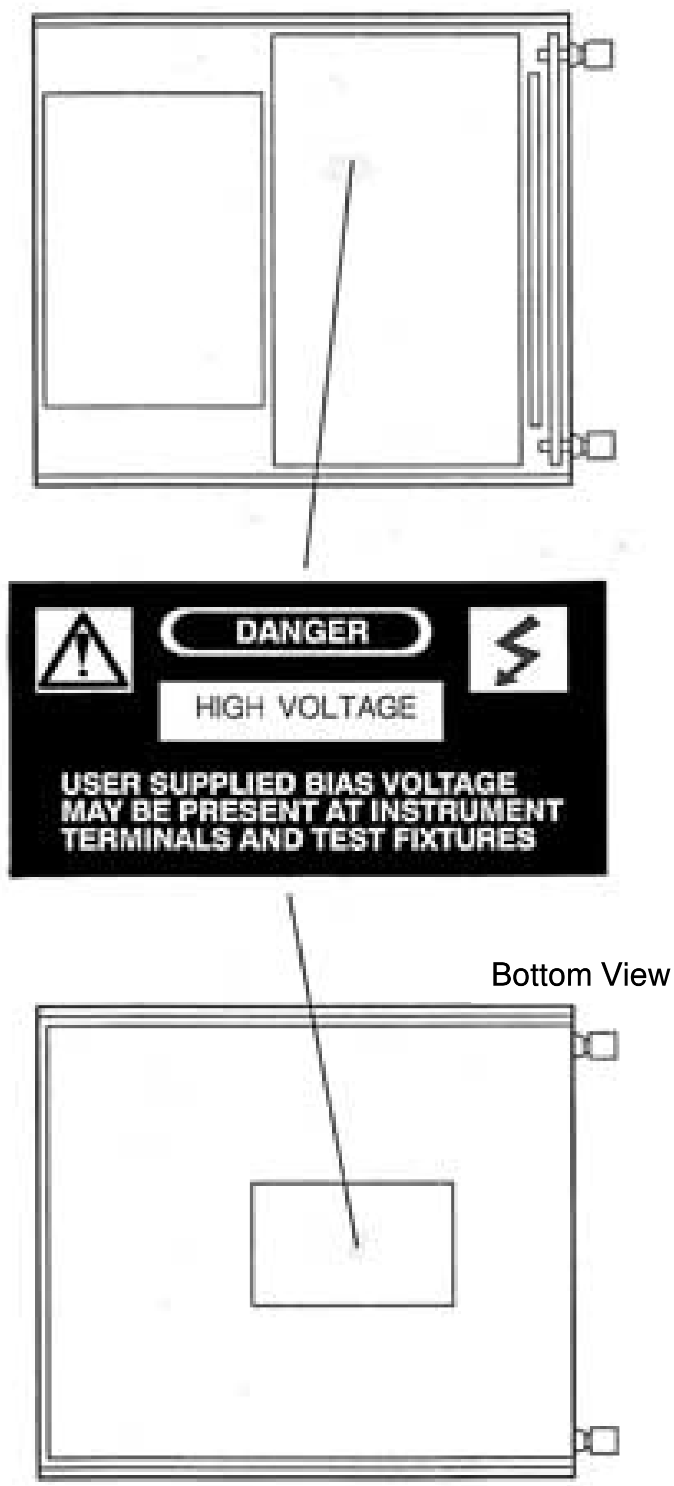


Figure S-3. Safety Label with Top and Bottom Covers Removed

General Description

General Description

Model PRT73 Precision Ratio Transformer (PRT) is a remotely programmable AC voltage divider for use in the calibration of other ratio transformers, voltmeters, servo components, and devices that require precise division of AC signals in the audio frequency range. The Model PRT73 is a seven-decade AC divider with 0.9 ppm (±0.0000009) terminal linearity and 0.1 ppm of resolution for ratio settings from -0.0010000 to 1.0009999. Designed for calibration laboratories, the performance of the Model PRT73 is traceable to the National Institute of Standards and Technology (N.I.S.T.)

Features of the Model PRT73 include:

- 2.5 V/Hz low frequency option
- Standard IEEE-488 interface
- REMOTE/LOCAL control
- Over-voltage protection
- Rear-panel terminal option

An optional 2.5 V/Hz option increases the input voltage potential, extends the low frequency range, and adds another decade of resolution to your measurements. The 2.5 V/Hz option converts the Model PRT73 to an eight-decade transformer and expands measurement capabilities to such applications as calibration of synchro-resolver standards and ratio measurements up to 150 V at 60 Hz. The additional transformer is switched in series with the seven-decade transformer, yielding an additional digit of resolution: 8 ½ digits or 0.01 ppm of input.

Standard functions of the Model PRT73 can be programmed remotely through a standard IEEE-488 GPIB interface. This gives you the ability to automate your test processes or integrate the Model PRT73 into an automated test system. All manual functions of the Model PRT73 can be controlled or monitored remotely. GPIB message terminators and GPIB address settings are changed by entering a menu mode that uses the front panel controls and display.

An added feature to the programmable functions of the Model PRT73 is the REMOTE/LOCAL front panel control. In many applications the Model PRT73 is used to null a sensitive measurement that requires manual operation. To accommodate this in an automated process the front panel REMOTE/LOCAL control switches the Model PRT73 from remote control to the local or manual mode of operation without sending commands to a host controller.

An over-voltage circuit protects the Model PRT73 from harmful or excessive AC and DC voltages. In the event the maximum operating voltage is exceeded, a relay in series with the input transformer will open and an “OVERLOAD” message will appear on the front panel display.

The Model PRT73 can be used on the bench or in a rack with the addition of a rack mount option. All necessary hardware is supplied for rack mounting the Model PRT73 in a standard 19 inch width rack mount console. A rear terminal option is also available to accommodate your other test equipment configurations.

Specifications

Specifications 2

Maximum Ratings

Characteristic	Performance Requirement	Supplemental Information
Maximum Input Voltage 0.35 V/Hz Range	0.35 VRMS/Hz, 350 VRMS maximum	The maximum allowable voltage between any input terminal and chassis ground.
2.5 V/Hz Range	2.5 VRMS/Hz, 350 VRMS maximum	
Maximum DC Input Current 0.35 V/Hz Range	200 µA	For best performance no DC current should be permitted. DC input of 20µA will decrease AC input voltage rating about 10% and increase distortion slightly
2.5 V/Hz Range	200 µA	
Maximum Output Current 0.35 V/Hz Range	100 mA	
2.5 V/Hz Range	100 mA	

Technical Specifications

The following specifications apply for operation over a temperature of +15°C to 30°C (+59°F to +86°F) with 20% to 50% relative humidity, and DC input current < 1µA.

Characteristic	Performance Requirement	Supplemental Information
Linearity Error (3-Terminal) 0.35 V/Hz Range 50Hz to 1.0 kHz	±0.9 ppm for settings 0.1 to 1.0000999 $\pm(0.9\sqrt{10 \text{ x Setting}} + 0.01\text{ppm})$ for settings 0.01 to 0.1	Linearity errors are given in parts per million (ppm) of input. Verification of linearity errors is traceable to N.I.S.T. uncertainty of 0.5 ppm of input.
200 Hz to 1 kHz	$\pm(0.9\sqrt{10 \text{ x Setting}} + 0.01\text{ppm})$ for settings -0.001 to 0.01	
50 Hz to 200 Hz	$\pm(0.9\sqrt{100 \text{ x Setting}} + 0.01\text{ppm})$ for settings -0.001 to 0.01	

Technical Specifications (continued)

Characteristic	Performance Requirement	Supplemental information
Linearity Error (3-Terminal) 0.35 V/Hz Range 1.0 kHz to 20 kHz	Multiply the 50 Hz to 1.0 kHz values by a factor of f^2 , where f= frequency in kHz	Linearity errors are given in parts per million (ppm) of input.
10 Hz to 50 Hz	Multiply the 50 Hz to 1.0 kHz values by a factor of 50/f, where f=frequency in kHz	Verification of linearity errors is traceable to N.I.S.T. uncertainty of 0.5ppm of input.
Linearity Error (3-Terminal) 2.5 V/Hz Range 50 Hz to 400 Hz	± (1 ppm + 0.9ppm x Ratio)	Linearity errors are given in parts per million (ppm) of input.
400 Hz to 1 kHz	Multiply the 50 Hz to 400 Hz values by a factor of $\left(\frac{f}{400}\right)^2$ where f = frequency in Hz	Verification of linearity errors is traceable to N.I.S.T. uncertainty of 0.5ppm of input.
10 Hz to 50 Hz	Multiply the 50 Hz to 400 Hz values by a factor of 50/f where f = frequency in Hz	
Incremental Linearity 0.35 V/Hz Range	±0.1ppm of input for operation ±100 ppm of all cardinal points, at a frequency of 1 kHz and at ratio settings ≥0.1	Cardinal points are all settings in multiples of 0.01 from 0.00 to 1.00 (i.e. 0.00, 0.01, 0.02…,0.99, 1.00)
2.5 V/Hz Range	±0.1ppm of input for operation ±100ppm of all cardinal points, at a frequency of 100Hz and at ratio settings≥0.1	
Maximum Phase Shift 0.35 V/Hz Range 10 Hz to 100 Hz	5µrad at 100 Hz, increasing to 50 µ rad at 10 Hz	Applies for settings above 0.1 1 mrad = 1j ppm of input
100 Hz to 20 kHz	50 µrad at 1 kHz, increasing to 1 mrad at 20 kHz	Verification with NIST traceability limited to 5.0 ppm of input.
2.5 V/Hz Range 10 Hz to 100 Hz	20 µrad at 100 Hz, increasing to 200 µrad at 10 Hz	Applies for settings above 0.1 1 mrad = 1 j ppm of input
100 Hz to 1 kHz	20 µrad at 100 Hz, increasing to 200 µ rad at 1 kHz	Verification with NIST traceability limited to 5.0 ppm of input.

Technical Specifications (continued)

Characteristic	Performance Requirement	Supplemental Information
Output Noise		Output noise not harmonically related to the input signal.
0.35 and 2.5 V/Hz Range 10 Hz to 10 kHz	Less than 5 µ VRMS	
10 kHz to 1 MHz	Less than 100 µ VRMS	
Common Mode Isolation Output Low to Chassis		
0.35 and 2.5 V/Hz Range	>100 MΩ in parallel with < 1000pF	
Input Impedance		Applies for inputs > 10 VRMS
0.35 V/Hz Range 50 Hz to 1 kHz	>40 k Ω	
2.5 V/Hz Range 10 Hz to 100 Hz	>100 k Ω	
Above 100 Hz	100 k Ω decreasing with frequency	
Number of Decades		
0.35 V/Hz Range	Seven	
2.5 V/Hz Range	Eight	
Resolution		
0.35 V/Hz Range	0.1 ppm of input	
2.5 V/Hz Range	0.01 ppm of input	
Range		
0.35 V/Hz Range	-0.0010000 to + 1.0009999	
2.5 V/Hz Range	-0.00010000 to + 1.00009999	
Input Inductance		
0.35 V/Hz Range	100 H to 400 H	
2.5 V/Hz Range	700 H to 2.1 kH	

Technical Specifications (continued)

Characteristic	Performance Requirement	Supplemental Information
Input Capacitance		
0.35 V/Hz Range	2 n F typical	
2.5 V/Hz Range	12 n F typical	
Output Series Inductance		
0.35 V/Hz Range	2 µH to 30 µH	Measurements valid with input shorted.
2.5 V/Hz Range	2 µH to 70 µH	The series inductance will vary with ratio setting.
Output Series Resistance		
0.35 V/Hz Range	400 mΩ to 7 Ω	Measurements valid with input shorted.
2.5 V/Hz Range	500 mΩ to 12 Ω	The series inductance will vary with ratio setting.

GPIB Communications

Characteristics	Performance Requirement	Supplemental Information
IEEE-488 (GIPB) Interface		
General	Conforms to IEEE-488.1	
Character Set	Standard ASCII (USA)	
Operating Modes	Basic Talker and Basic Listener	
Input Line Terminators	EOI, EOI, on CR, EOI, on LF, LF, CR, CR + LF, and CR + EOI on LF accepted as input terminators	CR or Ignore CR must be properly selected in the GPIB configuration screen to setup adjacent terminator combinations. See Section 4 GPIB Parameter Screens (p. 4-10) for further information.
Output Line Terminators	Selectable output terminators are EOI, on CR,EOI on LF, and CR+EOI on LF	Output line terminator options must be properly selected in the GPIB configuration screen to setup adjacent terminator combinations. See Section 4 GPIB Parameter Screens (p. 4-10) for further information.
Interface Function Codes	SH1,AH1,T6,L4,SR1,RL1,PP0,DC1, DT1,C0,E2	See Section 4 GPIB Interface Function Codes (p. 4-9) for further information.
Connector Type	Female 24-pin, D shell	

Environmental Specifications

Characteristics	Performance Requirement	Supplemental Information
Temperature		
Operating	+59°F – +86°F (15°C-30°C)	
Storage	+32°F – +122°F (0°C – 50°C)	
Relative Humidity		
Operating	20% - 50% (non-condensing)	
Storage	15% - 80% (non-condensing)	

Power Requirements and Physical Dimensions

Characteristics	Performance Requirement	Supplemental Information
AC Power Input	100/120 VAC ±10%, 50-60 HZ, 0.5 A Max	Fuses required: 0.5 A Timelag
	220/240 VAC ±10%, 50-60 HZ, 0.25 A Max.	Fuses required: 0.25 A Timelag
Dimensions	Height: 5.25 in. (13.3 cm)	
	Width: 17 in. (43.2 cm)	
	Depth: 20 in. (50.8 cm)	
Weight		
Net Without Options	30 lbs (13.8 kg)	
Shipping Weight	40 lbs (18 kg)	

OPERATION

Operation **3**

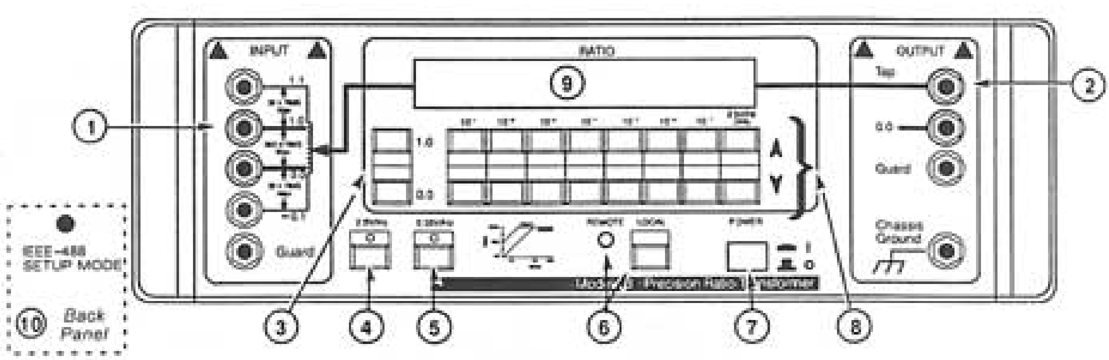
Information in this section describes how to operate the Model PRT73 using the front and rear panel controls. For information on programming commands and communication, refer to Section 4 – Remote Communication.

Table 3-1. Operation Section Contents

Using the Front and Rear Panel Controls

Figure 3-1 shows the Model PRT73's control panel. The panel includes a nine-character LED display and a set of controls and indicators that allow you to:

- Set the ratio
- Configure the IEEE-488 interface
- View system status



① INPUT: Primary AC source input terminals. See Input on page 3-3 for further information.

② OUTPUT: AC signal output. See Output on page 3-7 for further information.

③ 1.0, 0.0: Momentary push button controls that set the output ratio setting to 1.0000000 or to 0.0000000.

④ 2.5 V/Hz Range Control – Momentary push button with LED indicator that enables the 2.5 V/Hz input range option when installed. The LED indicator is illuminated when the optional range is enabled.

⑤ 0.35 V/Hz Range Control – Momentary push button with LED indicator that enables the 0.35 V/Hz input range. The LED indicator is illuminated when the range is enabled.

⑥ LOCAL, REMOTE: The REMOTE LED illuminates when the GPIB has asserted remote operation. The front panel may be partially locked out (remote mode with LOCAL button enabled) or totally locked out (remote mode with local lockout). The REMOTE LED remains off in all other modes. The LOCAL control is a momentary push button used to switch the Model PRT73 from the remote mode (with local lockout) to the local mode.

⑦ Power switch controls line power to the Model PRT73.

⑧ Ratio controls – Momentary push buttons used to increment and decrement each decade of ratio setting.

⑨ Front Panel Display – An 8 ½ character display providing ratio setting and IEEE-488 configuration information. Seven and one-half characters are displayed when the 0.35 V/Hz range is enabled and 8 ½ characters are displayed when the 2.5 V/Hz option is installed and enabled.

⑩ MENU – Rear panel push button that switches the Model PRT73 into the menu mode for setting the GPIB address and message terminators. The Model PRT73 must be in local mode (GPIB REN line (0)) to enable menu mode. In the menu mode, the left most ratio controls switch between the GPIB address and message terminator screens. The right most ratio controls change the parameter settings. Pressing the 2.5 V/Hz, 0.35 V/Hz, LOCAL, 1.0 or 0.0 front panel controls will return the Model PRT73 to local mode. (The Model PRT73 will return to the local mode automatically if no activity at the front panel is detected after 30 seconds.)

Figure 3-1. Measurement Control Panel Controls and Indicators.

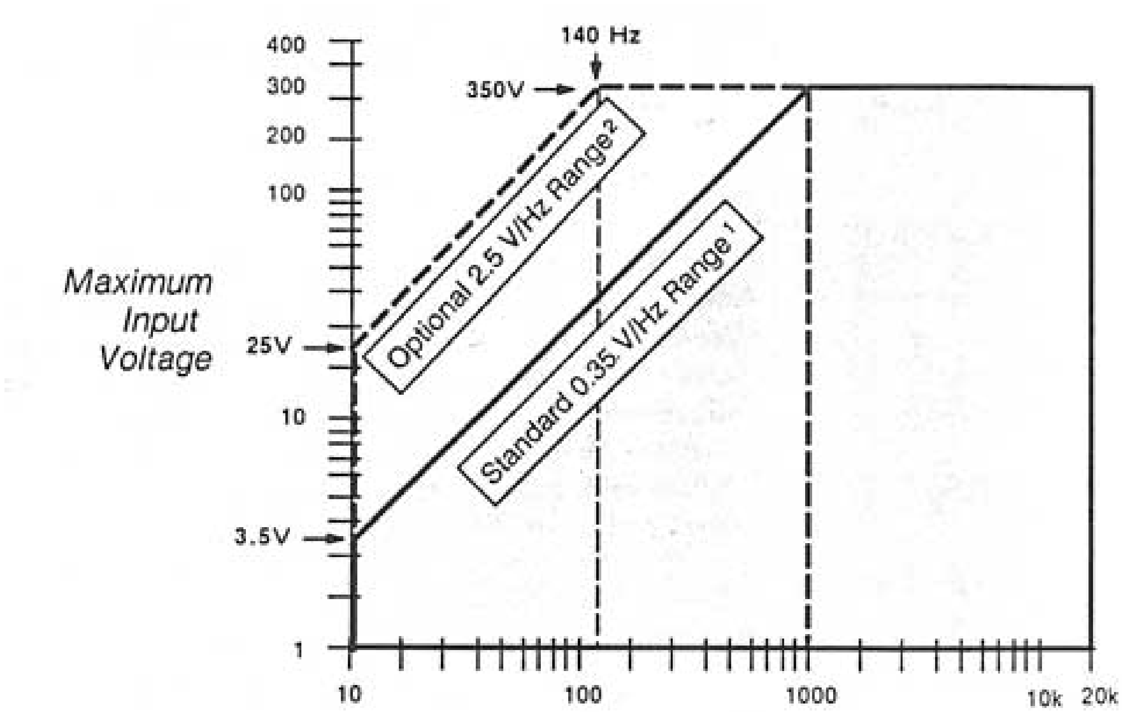
Input

The binding posts in the INPUT section of the Model PRT73 are not all used as voltage inputs. Only the 1.0 and 0.0 binding posts are normally used as inputs from AC signal sources. The 1.1 and -0.1 binding posts are used as outputs to drive phase correcting devices when making ratio comparison measurements. The GUARD terminal is typically connected to the 0.0 input terminal.

1.0 and 0.0 Input Terminals

The 1.0 and 0.0 binding posts are the main inputs to the Model PRT73. The Model PRT73 is designed to accept low distortion AC signals in the audio frequency range with no DC component.

Both the input frequency and the magnitude of applied AC voltage have specific limits determined by the operating range selected. The Model PRT73 comes standard with one 0.35 V/Hz operating range. An optional 2.5 V/Hz range is available as a factory or a field installed option. Maximum input voltage for both ranges is 350 VRMS. Figure 3-2 illustrates the relationship of maximum input voltage versus frequency.



Frequency (Hz)

1. Max Volts RMS at 0.35 V/Hz Range = F x 0.35 VRMS (up to 350 VRMS)
2. Max Volts RMS at 2.5 V/Hz Range = F x 2.5 VRMS (up to 350 VRMS)

Figure 3-2. Maximum Input Voltage Versus Frequency

Typically the 0.0 binding post input will be connected to the Model PRT73's GUARD input. This places the shield, which surrounds the analog circuitry and transformers at the same potential as the 0.0 input terminal. It is recommended that the 0.0 and GUARD inputs be connected to chassis ground at one point within the test setup.

Typical input signal sources are provided by precision AC calibrators and low distortion AC signal generators. These types of instruments are designed to output low noise and low distortion AC signals with no DC offsets.

Function generators are not recommended as signal sources due to higher distortion specifications and DC offset voltages. If a function generator is to be used, be certain to use an isolation transformer between the generator and the Model PRT73 to remove any DC voltages.

Over-voltage Protection

An over-voltage circuit protects the Model PRT73 from damage due to excessive AC and DC voltages. In the event the maximum input voltage (shown in Figure 3-2) is exceeded, a relay in series with the Model PRT73 transformers will open and "Overload" will appear on the front panel display. The circuit will also activate when a DC voltage greater than 40 mV is detected.

CAUTION

Even though the over-voltage protects the Model PRT73 from damage due to a sustained overload, there is a chance that the first decade toroid transformer might saturate and magnetize the core. Should the core be magnetized, linearity can be degraded to approximately double the specified maximum error. To assure the overload did not affect linearity, demagnetize the core by using the "Over-voltage Circuit Test and Input Transformer Demagnetization" procedure in Section 8.

Internal firmware supporting the over-voltage circuitry continuously monitors the input once an overload condition is detected. The circuit will remain active until the excessive voltage is removed, normal operation is restored. When the excessive voltage is removed, normal operation is restored.

An added feature of the over-voltage circuit is its ability to change from the 0.35 V/Hz range to the 2.5 V/Hz range in the event of an overload at frequencies below 1 kHz. For example, if the over-voltage circuit is activated when the Model PRT73 is in the 0.35 V/Hz range and the 2.5 V/Hz option is installed, the software will open the input relay and then check to see if an overload condition would exist in the 2.5 V/Hz range. If the input signal is within the 2.5 V/Hz operating range, the software will automatically change ranges then close the input relay. Once the software makes the change, the Model PRT73 will stay in the higher 2.5 V/Hz range until it is manually changed back to the 0.35 V/Hz range at the front panel or by the **Range .35** remote programming command.

Important Notes about the Over-voltage Circuit and Your Generator

Generators with a standby mode and generators with digital amplitude control can accidentally cause an overload:

Generators with a Standby Mode can cause an overload when coming out of standby. The startup response of some AC generators may contain DC voltages and distortion large enough to activate the over-voltage circuitry. If this occurs, try to avoid the standby mode or lower the output voltage before coming out of standby.

Generators with Digital Amplitude Control can cause an overload when a large change in amplitude is made to a voltage close to the maximum operating range. Signal output distortion containing either large peak AC or DC components is usually the cause. To avoid an overload, increase the voltage in smaller increments until the desired output is achieved.

When an overload is detected and the input relays open, the load on the generator is reduced. The amplitude of the generator will then increase creating even a greater over-voltage condition. To recover from the overload, the amplitude of the generator must be reduced until the over-load is relieved. If the signal source is a current source, the amplitude may need to be reduced to zero.

1.1 and -0.1 Signal Requirements and Restrictions

The 1.1 and -0.1 binding posts are not intended to be used as inputs. They are generally used as outputs for phase correcting devices when making ratio comparison measurements.

GUARD

The input and output GUARD binding posts are connected to the shield that surrounds the Model PRT73's analog circuitry and toroid transformers. Typically, GUARD will be connected to the 0.0 (low) transformer input of the Model PRT73. This places the shield, which surrounds the analog circuitry and transformers at the same potential. For this reason, it is recommended that the 0.0 and GUARD terminals be connected to chassis ground somewhere in the test setup. This can be done at the Model PRT73 by connecting the 0.0, GUARD, and Chassis Ground together.

If the generator providing the 1.0 and 0.0 input has a common mode component with respect to earth ground (the power line ground at the Model PRT73), common-mode currents are eliminated by using a separate connection between the GUARD terminal and the AC terminal connected to 0.0.

In applications where the 0.0 input is floating above ground, the GUARD terminal can be used to improve high-frequency performance. In such cases, connect the GUARD terminal separately to the AC source terminal that is connected to the Model PRT73 0.0 input terminal.

Output

The output of the Model PRT73 is an accurate portion of the applied input signal as displayed by the multiplier set on the front panel. The nominal voltage output is calculated by (V_{in} x ratio setting). Ratio settings between -0.001 and +1.0009999 are possible.

TAP and 0.0 Signal Output

Typically the TAP and 0.0 outputs are connected to a phase sensitive AC null detector or an AC voltmeter. The TAP output provides the ratio voltage and the 0.0 output is internally connected to the 0.0 input. When connecting the TAP and 0.0 outputs to a voltmeter, loading effects should be considered. Best results are obtained if the voltmeter has an input resistance > 100 kΩ and capacitance <100 pF.

GUARD

The input and output GUARD binding posts are connected to the shield that surrounds the Model PRT73's analog circuitry and toroid transformers. Typically, GUARD will be connected to the 0.0 (low) transformer input of the Model PRT73. This places the shield, which surrounds the analog circuitry and transformers at the same potential. For this reason, it is recommended that the 0.0 and GUARD terminals be connected to chassis ground somewhere in the test setup. This is done at the Model PRT73 by connecting the 0.0, GUARD, and Chassis Ground together.

The error corrections on the "PRT Calibration Certificated of Test", are measured with the 0.0 and GUARD connected to Chassis Ground.

If the generator providing the 1.0 and 0.0 input has a common mode component with respect to earth ground (the power line ground at the Model PRT73), common-mode currents are eliminated by using a separate connection between the GUARD terminal and the AC terminal connected to 0.0.

In applications where the 0.0 input is floating above ground, the GUARD terminal can be used to improve high-frequency performance. In such cases, connect the GUARD terminal separately to the AC source terminal that is connected to the Model PRT73 0.0 input terminal.

Chassis Ground

Chassis Ground is connected to the case of the Model PRT73 and to the earth ground prong of the power cord.

Operating Modes

The Model PRT73 has four different modes of operation:

- Local – All front and rear panel controls are active. The GPIB interface does not control the Model PRT73.
- IEEE-488 Setup – A local mode of operation used to set the IEEE-488 address and input/output message terminators. See "IEEE-488 Setup Mode" below for further information. A host controller cannot communicate with the Model PRT73 when in this mode.
- Remote – The GPIB has control of the Model PRT73 (all front panel push buttons, except for the LOCAL button, are locked out). To enter this mode, the host controller must set the REN line on the IEEE-488 bus low and address the Model PRT73.

  When queried by the remote command **Status**, the Model PRT73 will respond with the parameter 0 to indicate the remote mode of operation.

- Remote with Lockout (no front or rear controls active) – The GPIB has control of the Model PRT73 (all front panel push buttons are inactive). To enter this mode, the host controller must set the REN line on the IEEE-488 bus low, address the Model PRT73, and send the local lockout command (specific to your host controller IEEE interface).

  When queried by the remote command **Status**, the Model PRT73 will respond with the parameter 0 to indicate the remote mode of operation.

IEEE-488 Setup Mode

The IEEE-488 setup mode is entered by pressing the rear panel IEEE-488 Setup Mode push button when the Model PRT73 is in the local mode. Once in the IEEE-488 mode, the GPIB address and input/output message terminators can be selected. There are three main screens that are changed by using the left most ratio push buttons. The parameter settings for each of the main screens are changed by using the right most ratio push buttons.

Refer to GPIB Address and Message Terminators on page 4-9 for additional information on selecting the GPIB message terminators and address.

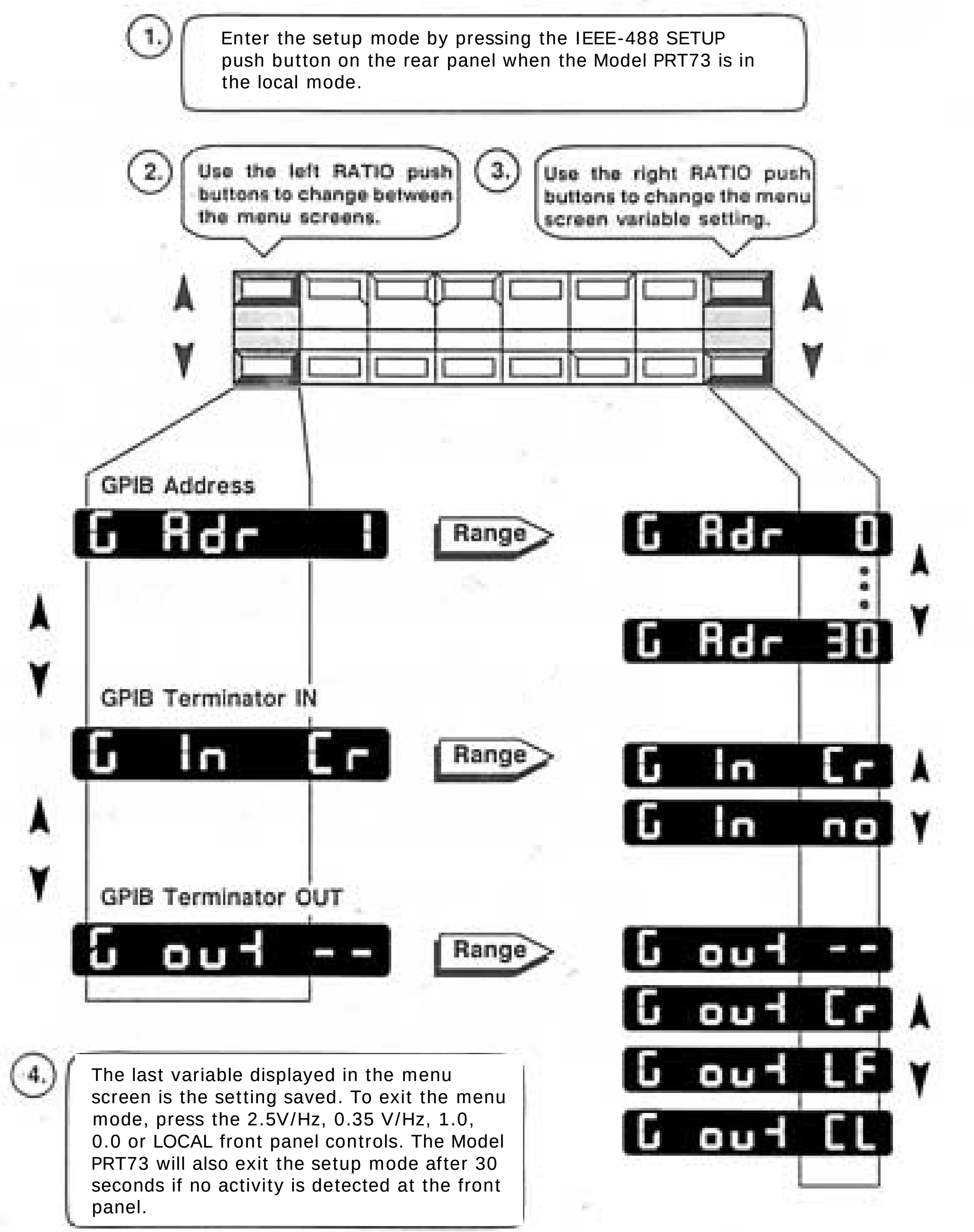


Figure 3-3 IEEE-488 Setup Mode Screens and Parameter Settings

Applications of the Model PRT73

Ratio Transformers have established a firm position in the standards and calibration laboratory as a standard technology for AC voltage division. Featuring linearity and stability that equal or exceed resistive dividers, they form the heart of the preferred method for several common calibrations.

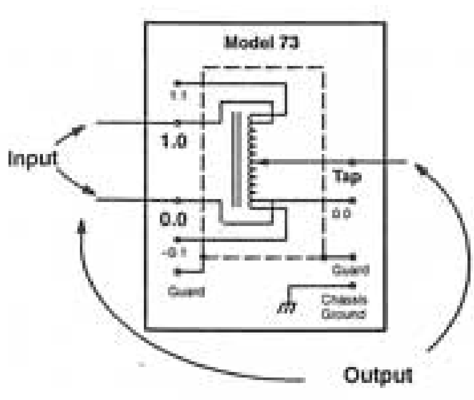
Being a passive device, the Model PRT73 is used with other instruments to form unique calibration test systems. The accuracy and quality of measurements produced by these test systems rely heavily on the type of test equipment used, and how the test equipment is configured. The following information covers the most critical considerations in three common test system applications and also explains how and when to use the three-terminal and four-terminal correction values found in the “PRT73 Calibration Certificate of Test.”

Three-terminal and Four-terminal Device Definition

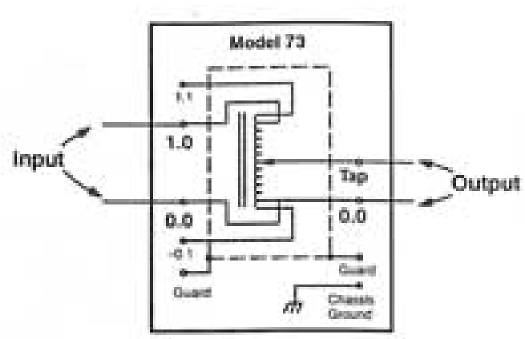
The major difference between applications hinges on whether the divider is configured as a three-terminal or four-terminal device.

As a three-terminal device, the Model PRT73 is effectively an AC potentiometer, using the 1.0 and 0.0 INPUT terminals and one TAP OUTPUT terminal. The TAP OUTPUT voltage is referenced to the 0.0 INPUT (the 0.0 OUTPUT terminal is not used). The most common application where the Model PRT73 is used as a three-terminal device is as part of an AC ratio bridge. In an AC ratio bridge the Model PRT73 becomes the standard for direct comparison to another device.

The Model PRT73 is considered a four-terminal device when used as an attenuator to generate a highly accurate low level voltage. In this application, a known stable voltage is applied between the 1.0 and 0.0 INPUT terminals and the output voltage is taken from the TAP and 0.0 OUTPUT. Two applications where you’ll find the Model PRT73 used as a four-terminal device are in test systems designed to calibrate AC voltmeters and AC calibrators.



Three-terminal Device



Four-terminal Device

Figure 3-4. Three- and Four-terminal Definition

Using the Model PRT73 in an AC Ratio Bridge (A Three-terminal Application)

A typical setup using the Model PRT73 in an AC ratio bridge is shown in Figure 3-5. An AC ratio bridge is commonly used to calibrate the following devices:

Other Ratio Transformers. The AC ratio bridge is calibrated by comparing the bridge ratio transformer against a standard ratio transformer. The corrections generated from the comparison are then used to add to the measured deviation values when calibrating another ratio transformer or device under test. This is a common practice at primary standards laboratories to calibrate ratio transformers for secondary labs. To calibrate the Model PRT73 or the DT72A, the bridge should ideally be equipped with phase compensation circuitry and a phase sensitive null detector to achieve full resolution.

Synchro-resolvers. These are electromechanical angle to ratio devices used in many aircraft control systems. In a typical calibration, a mechanical fixture is used to maintain or adjust the angular alignment of the rotating shaft.

Resistive dividers. Many types of resistive dividers, those that have suitable AC characteristics, wideband 50 Ω dividers, and even high impedance dividers such as 100 kΩ Kelvin-Varley dividers may be calibrated with a low frequency AC voltage. An advantage of calibrating a resistive divider at AC frequencies versus DC is the elimination of thermal EMF errors and the ease of making the comparison measurements. This application benefits from using a lock-in amplifier as a null detector, which resolves errors as low as 10 nV, yielding 0.01 ppm resolution at 1 Vrms input.

Comparison of standard resistors, inductors, or capacitors. Accurate comparison of two different passive standards is possible by placing them in series in place of the device under test. Separate ratio measurements of the potential at each terminal of each component may be made, allowing computation of the ratio of the two values. Note that each such application requires specific attention of reduction or guarding of stray capacitance and other sources of error.

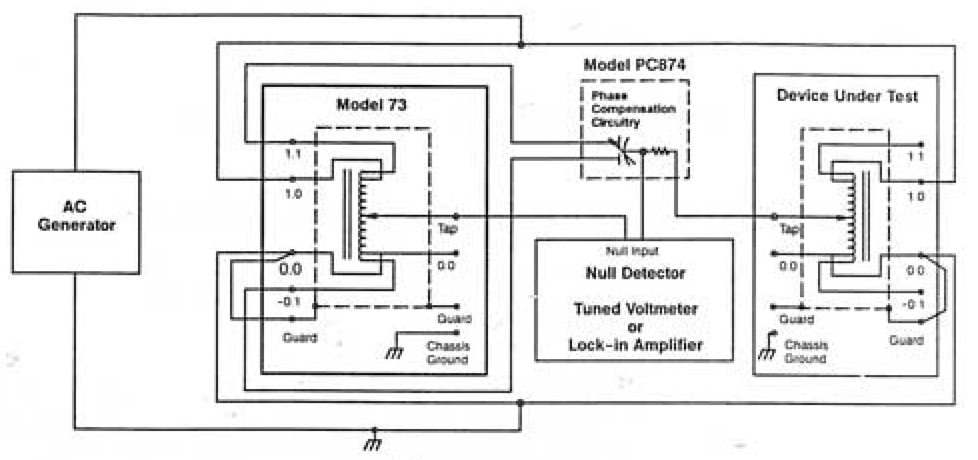


Figure 3-5. Typical AC Ratio Bridge Test Setup

Components of a Ratio Bridge

The equipment used to make an AC ratio bridge must contain, a ratio transformer (Model PRT73), an AC generator, a null detector (tuned voltmeter or lock-in amplifier), and phase compensating circuitry. See Figure 3-5. The AC generator and null detector can be purchased from many different companies. IEEE-488 communication options are usually offered as part of these instruments which will allow you to automate part of your AC ratio bridge test setup.

AC Generator. An AC generator for use with the Model PRT73 needs to output a low distortion sine-wave with no DC component at 2 – 200 Vrms over a frequency range of 10 Hz to 20 kHz. The instability of the generator's output voltage should be $\leq$ 1%.

Null Detector. A null detector is required to measure the AC difference signal between the standard and the unknown. The instrument of choice is either a tuned voltmeter or a lock-in amplifier that has a sensitivity of $\leq$ 1 µV. Both types of null detectors are phase sensitive AC voltmeters that reject frequencies other than the measurement frequency. While the tuned voltmeter must be manually tuned to the measurement frequency, the lock-in amplifier automatically synchronizes to the AC source frequency and may offer IEEE-488 communication capability.

Overall system resolution is limited by the resolution of the Model PRT73, the null detector's ability to discriminate the null point of the difference signal, and the technique used to achieve a null indication at the null detector. There are basically three different techniques used to achieve a null indication at the null detector. You can either use the Model PRT73 ratio setting to achieve a null or "0" reading, use the meter on the null detector to directly read the difference signal, or use a voltmeter connected to the null detector to directly read the difference signal. Using the last two techniques requires a mathematical calculation to convert the meter readings to ppm values.

When using the Model PRT73 to achieve a null, a resolution of 1×10^{-7} or 0.1 ppm of input is obtained. Use of the 2.5 V/Hz Option with the Model PRT73 will extend the resolution to 1×10^{-8} or 0.01 ppm.

Null detector resolution of better than 1 µV is easily achieved, yielding 0.01 ppm resolution using a 100 V source voltage. Null detector limitations occur when lower source voltages must be used, for instance when the ratio device being calibrated is transformer based and has a saturation voltage limit. As an example: at 50 Hz, the Model PRT73 input is limited to 17.5 Vrms, yielding 0.06 ppm resolution from a 1 µV detector sensitivity. (This can be compensated for by using the Model PRT73's 2.5 V/Hz option and allowing the Model PRT73 to operate at higher inut voltage at low frequencies.)

Phase Compensating Circuitry. To achieve best system accuracy, a means of correcting for the phase differences between the two input signals to the tuned detector is required. A simple technique to compensate for phase difference uses the 1.1 INPUT and -0.1 INPUT signals as outputs driving a capacitive phase shifter, which sums a small quadrature voltage with the difference signal. Without quadrature error compensation, the null of a non phase-sensitive tuned voltmeter will be no better than the quadrature voltage difference. Most of devices used for the phase compensating circuitry are in-house products designed in the standards laboratories. For further information regarding phase compensation circuitry, contact Tegam, Inc.

Applying Three-terminal Corrections to AC Ratio Bridge Measurements

The Model PRT73 linearity accuracy is specified as better than 0.9 ppm of input for tap settings from 0.1 to 1.0009999. Each unit is measured at the factory against standard dividers calibrated at the National Institute of Standards and Technology (NIST). A report of corrections, "PRT Calibration Certificate of Test," is shipped with each Model PRT73. Apply these corrections for calibrations that require an uncertainty of better than approximately 5 ppm. For less accurate calibrations, it is sufficient to use the nominal ratio setting as accurate without correction.

Two sets of corrections, C and C', are given to the nearest 0.01 ppm of input for the tap settings of the first three significant digits. In AC ratio bridge applications where measurements require this type of accuracy, you will probably be using the Model PRT73 as a standard to calibrate you bridge setup. Whether you use the C or C' corrections to calibrate your test setup depends on how you will compensate for test lead errors caused by imbalanced resistances between the test leads to the ratio transformer used in you AC ratio bridge and the standard ratio transformer (Model PRT73).

The errors induced by test lead resistance imbalances contribute to gain and offset errors of the AC ratio bridge test setup. To remove these errors you need to linearize your test data. Refer to Figure 3-6. Two techniques are used to linearize test data and remove these gain and offset errors. One technique uses a mathematical process while the other technique uses a mechanical adjustment to balance the test lead resistances. Depending on what type of process your AC ratio bridge uses to take measurements will determine which correction (C or C') to use when calibrating your AC ratio bridge setup.

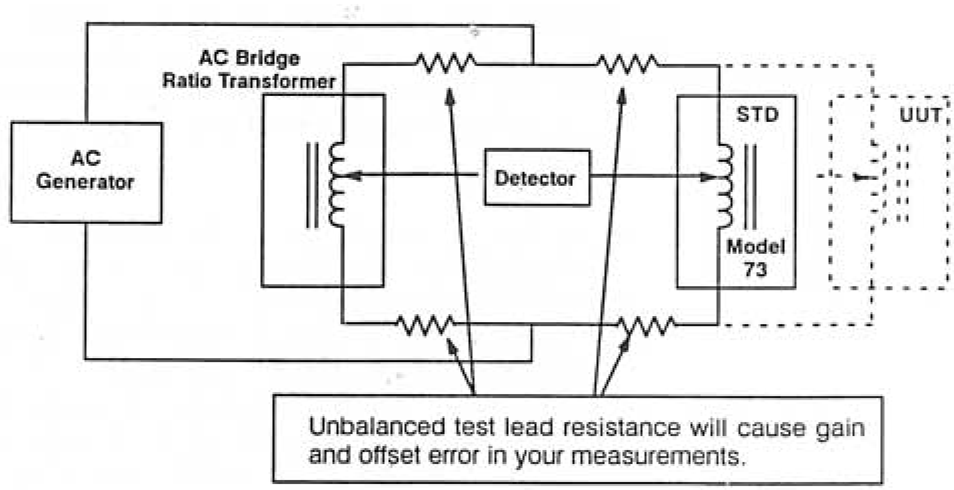


Figure 3-6. Errors Induced by Unbalanced Test Lead Errors

You must use the C' (End Adjusted Linearity Correction) if your AC ratio bridge uses a potentiometer for lead balancing. If you use a mathematical approach to compensate for test lead induced errors, use either the three-terminal C (Transfer Ratio Correction) or C' (End Adjusted Linearity Correction).

When and how you use the correction values can be explained by looking at the process of calibrating you AC ratio bridge using the Model PRT73 as the standard.

In the simplified drawing of Figure 3-7, we see two ratio transformers. The ratio transformer on the right is the Model PRT73 that will be used as the standard to calibrate the AC ratio bridge setup. The ratio transformer on the left is part of the AC ratio bridge.

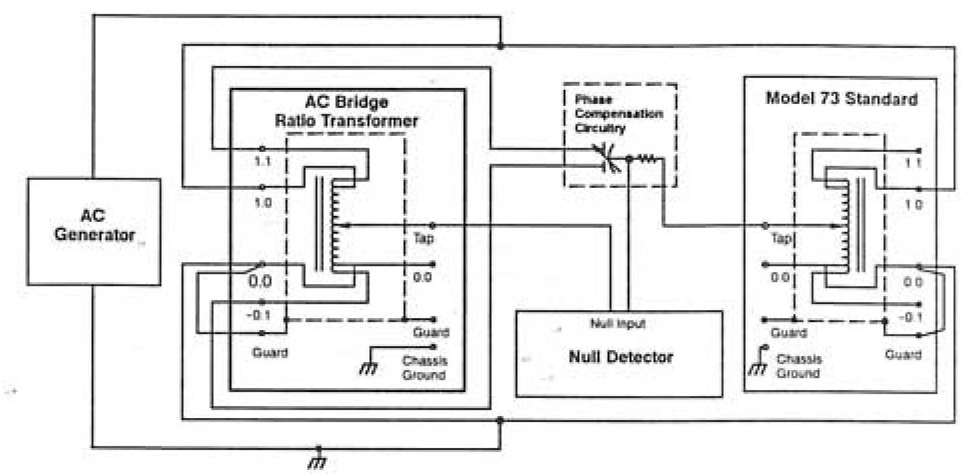


Figure 3-7. Using the Model PRT73 to Calibrate an AC Ratio Bridge

To calibrate the AC ratio bridge, comparison measurements between the AC ratio bridge transformer and the standard Model PRT73 are taken at each ratio setting of the first three decades. Important factors to remember when making measurements with any AC ratio bridge are:

- The output of the AC generator and the input to the null detector are not both referenced to chassis ground.
- Setting the AC generator to the frequency and voltage that the standard is certified.
- Connect the grounds and shields in the same manner the standard was measured.
- You don't exceed the maximum common mode signal input to the null detector.
- All connections are clean and secure.

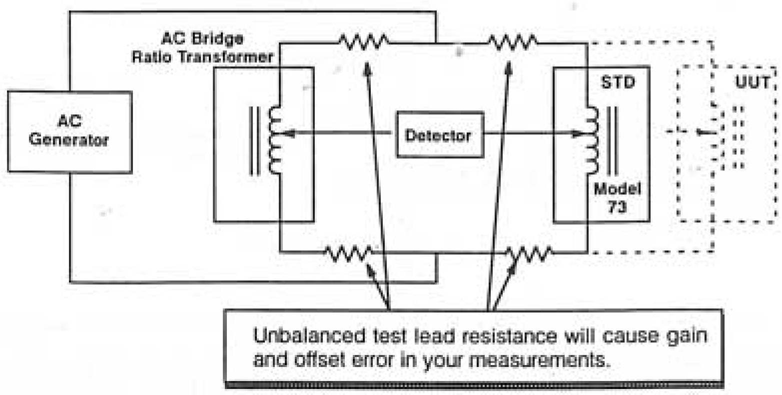
System corrections are obtained and the AC bridge is said to be calibrated by calculating the difference between the measured deviation and the Model PRT73's corrections at each setting of the first three decades (subtracting the measured deviation values from the standard's corrections). Again, use the C corrections if your test setup uses mathematical linearization to remove test lead resistance errors. Use the C' corrections if your test system uses a mechanical lead balancing technique to remove test lead resistance errors. The resulting values are the corrections to use for your AC ratio bridge.

Explanation of Mathematical Linearization and Comparison to Mechanical Linearization

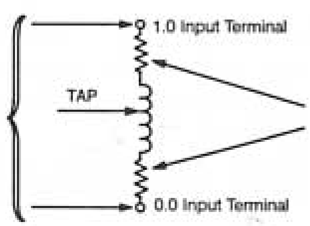
The purpose of linearizing test data is to remove the gain and offset errors, leaving only the non-linear deviations between the 0.0 and 1.0 ratio settings. If measurements of a device under test are taken at 0.0 and 1.0 as well as at desired ratio, the residual gain and offset errors caused by lead resistance can be eliminated mathematically. The same results can be obtained by AC ratio bridges using a mechanical technique (potentiometer attached to test leads) to null the deviation between an AC ratio bridge transformer and the ratio transformer under test at ratio settings of 1.0 and 0.0. The correction data that results from this process are often called end-point corrections; which is listed as the End Adjusted Linearity Error C' data in the "PRT Certificate of Calibration."

Model PRT73's are calibrated using the mathematical technique to linearize the test data. In doing so, two sets of three-terminal corrections are provided. The first column lists the Transfer Ratio Corrections (C); these corrections include both the small gain and offset errors between the 1.0 and 0.0 INPUT terminals and TAP. The second column lists the End Adjusted linearity Corrections (C'); these corrections have the residual gain and offset errors removed and contain only the non-linear deviations between the 0.0 INPUT, 1.0 INPUT, and the 1.0 TAP.

Before performing the linearization calculations, the AC ratio bridge must be calibrated using a standard ratio transformer to obtain system corrections. Additionally, deviation measurements need to be taken between the TAP of the ratio bridge transformer at settings of 0.0 and 1.0, and the INPUT 0.0 and 1.0 terminals of the UUT respectively. Figure 3-8 and Figure 3-9 show the formulas used to perform the mathematical linearization and illustrate what resistances that induce the errors we eliminate by the calculations.



With the 1st linearization calculation you look at the linearity of the UUT tap settings in reference to the 1.0 and 0.0 INPUTs



Errors internal to the ratio transformer between the 1.0 and 0.0 INPUTs and the 1.0 and 0.0 tap settings. These errors are removed in the 2nd linearization calculation to achieve the End Adjusted Linearity Corrections (C').

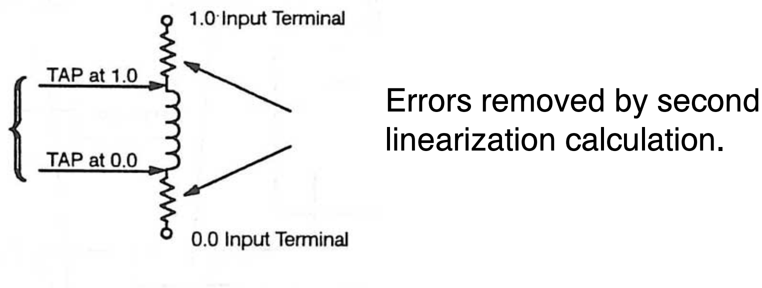
The 1st linearization removes the gain and offset errors of your test setup. The formula shown below will produce the Transfer Ratio Corrections (C).

Formula: $CorrUUT - Dev_{0:0} - S\,(Dev_{1\cdot 0} - Dev_{0\cdot 0}) = C$

CorrUUT = System Corrected UUT values at each tap setting
$Dev_{0.0}$ = Deviation of UUT 0.0 INPUT to AC Bridge transformer 0.0 TAP OUTPUT
$Dev_{1.0}$ = Deviation of UUT 1.0 INPUT to AC Bridge transformer 1.0 TAP OUTPUT
S = Ratio at tap setting
C = Transfer Ratio Correction

Figure 3-8. Measurement Errors Eliminated by 1st Linearization Formula

With the 2nd linearization calculation you look at the linearity of the UUT tap settings in reference to the 1.0 and 0.0 TAP OUTPUT ratio settings.



The 2nd linearization removes the errors internal to the ratio transformer between the 1.0 and 0.0 INPUT terminals and the 1.0 and the 0.0 TAP OUTPUT ratio settings. The corrections that result from the second linearization are called End Adjusted Linearity Corrections (C').

Formula: $C_T - C_{0.0} - S(C_{1.0} - C_{0.0}) = C'$

C_T = Transfer Ratio Correction (C) values at each tap setting

$C_{0.0}$ = Transfer Ratio Correction (C) 0.0 value

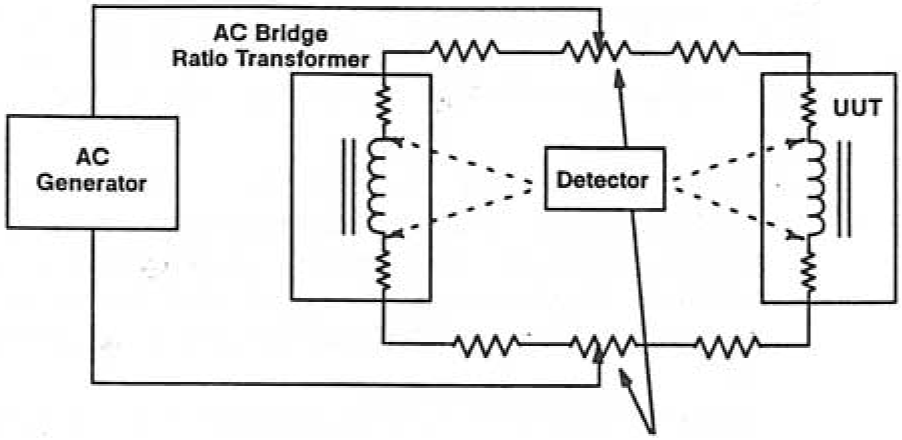
$C_{1.0}$ = Transfer Ratio Correction (C) 1.0 value

S = Ratio at tap setting

C' = End Adjusted Linearity Correction value

Figure 3-9. Measurement Errors Eliminated by 2nd Linearization Formula

Unlike the mathematical technique, when a mechanical lead balance is performed, low value resistive potentiometer are inserted between the AC generator source connections and the unit under test, one for the high side and one for the low side. With both the bridge and unit under test set to 1.0, the potentiometer in the high lead is adjusted to balance the voltage drop in the leads to each divider 1.0 INPUT terminal and their TAP OUTPUT. A similar adjustment is performed at 0.0 with the low lead potentiometer. This end corrects the complete bridge setup including the internal resistances between the 1.0 and 0.0 INPUT terminals and the TAP OUTPUT. Measurements are then taken at the desired ratios and the system corrections are added to obtain correction values. The result of the measurements using the mechanical lead balance are equal to the End Adjusted Linearity Corrections (C') obtained with the mathematical technique. See Figure 3-10.

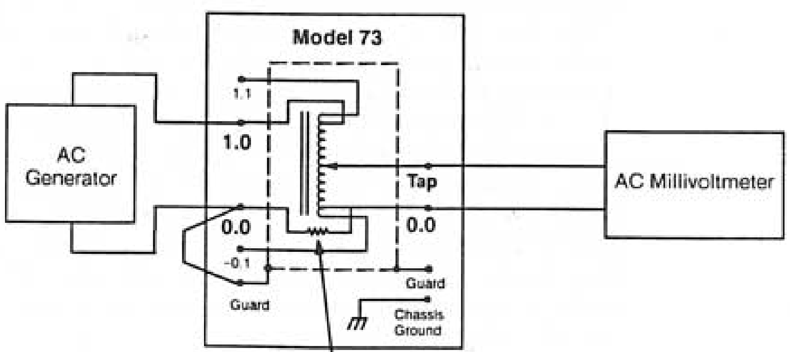


Potentiometers balance out both resistances of the test leads and the small resistances between the ratio transformers 1.0 and 0.0 INPUTS and TAP OUTPUT that cause gain and offset errors.

Figure 3-10. Mechanical Lead Balance Technique

Using the Model PRT73 as a Precision Attenuator (A Four-terminal Application)

Another significant use of the Model PRT73 is a four-terminal attenuator to produce high accuracy AC voltage at low levels. See Figure 3-11. In this application, a known stable voltage is applied to the input terminals, between INPUT 1.0 and INPUT 0.0.



Small errors between the 0.0 INPUT and 0.0 OUTPUT terminals are accounted for with the four-terminal correction values listed in the “PRT Calibration Certificate of Test.”

Figure 3-11. Four-terminal Precision Attenuator Application

The desired gain factor is set on the divider, and the low level output measured with a high-resolution AC millivoltmeter. This application differs from the use with the AC ratio bridge in several ways:

1. The ratio of importance with four-terminal device is the output voltage; the output voltage divided by the input voltage; the output voltage is taken from the two output terminals. For the highest possible accuracy, error corrections are supplied which take into account the small voltage that may exist between the INPUT 0.0 and OUTPUT 0.0 terminals.

2. In three-terminal measurements, ratio errors are traditionally given in relation to the input, e.g. ppm of input. In contrast, with four-terminal applications it is more common to need to know the error of the output signal as a fraction of its nominal value. The two expressions of error are simply related by the nominal divider setting, S, as follows:

As a fraction of input:

$Vout/Vin = S + (D \times 10^{-6})$ (with D given in ppm of input)

As a fraction of output:

$Vout = (Vin)S[1 + (D' \times 10^{-6})]$ (with D' given in ppm of output)

Calibration of an AC Voltmeter

Most laboratory Digital Voltmeters (DVMs) have AC voltage ranges as sensitive as 100 mV full scale, while wideband AC voltmeters may have ranges to as low as 100 µV full scale. To calibrate these devices, an AC standard or an AC calibrator is required. However, many AC calibrators have best accuracy at 1V and higher. Usually either their accuracy degrades rapidly at lower levels, or they may lack low voltage ranges entirely. To compensate for the limitations of an AC standard or AC calibrator, the ratio transformer is used as an attenuator to produce the lower voltages at greater accuracies. Compared to resistive attenuators or micropots, a ratio transformer is more stable, has a lower output impedance, and eliminates difficult DC measurements needed to characterize the other devices.

Calibration of an AC voltmeter at millivoltmeter levels requires applying a known voltage at the input of the Model PRT73. This may be accomplished by direct connection to an accurate AC calibrator using short, heavy leads, or more preferably by using the remote sensing (if available) from the generator to establish the generator output at the plane of the input terminals of the divider. See Figure 3-12.

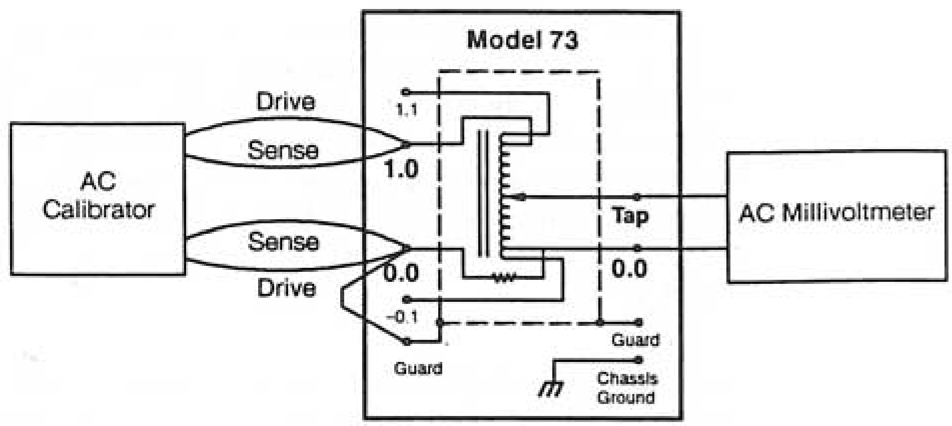


Figure 3-12. Setup for Calibrating an AC Voltmeter

The voltmeter is connected directly to the output terminals of the divider (OUTPUT 1.0 and OUTPUT 0.0). While the AC calibrator may be grounded at its output low terminal, under no circumstances should the input to the voltmeter be also grounded, as this will cause a ground loop. If the input to the voltmeter is grounded (as is true for many wideband voltmeters), an ungrounded source must be used.

As an alternative to a remotely sensed AC calibrator, any stable source may be used if an accurate method exists to measure the voltage at the Model PRT73 input terminals.

A possible source of error in this hookup is the loading of the voltmeter on the output of the Model PRT73. Assuming the Model PRT 73 is driven by an AC source with an output impedance below 10 Ohms, the worst case equivalent impedance between the OUTPUT 1.0 and 0.0 terminals will approach 7 Ohms in series with 30 microhenries. At the likely tap settings of 0.1, 0.01, or 0.001, the typical output impedance of the Model PRT 73 be 1.0 Ohm or less. Thus the common AC Millivoltmeter input impedance of 1 Megohm will result in errors of 1 ppm of output or less.

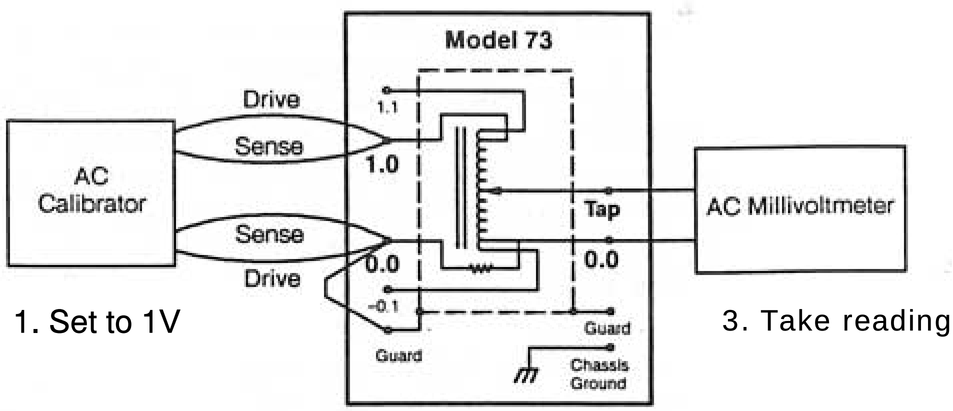
For the highest possible accuracy, corrections from the four-terminal “PRT Calibration Certificate of Test” may be applied.

Calibration of mV Ranges on AC Calibrators

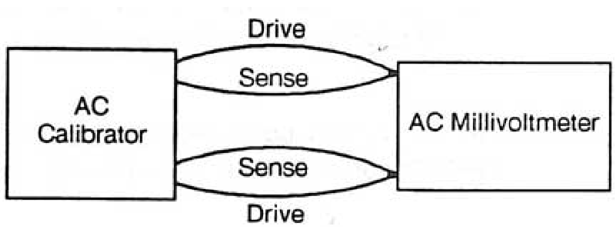
An operation similar to the voltmeter calibration can be used to calibrate AC voltage calibrators with millivolt outputs such as the Fluke 5700A, 5200A, Datron 4708 or 4200. A high resolution millivoltmeter with good short term stability (such as the HP 3458) is required as a transfer measurement device. The voltmeter is first temporarily calibrated through the Model PRT 73 at the first low voltage calibration point, for example 100 mV. Then the calibrator is switched to output 100 mV directly into the voltmeter and the reading compared to the previous value. The difference may be recorded as a deviation from the higher voltage level, or the calibrator may be adjusted to make the two readings the same. See Figure 3-13.

Two different methods may be used to calibrate lower ranges of the calibrator. In the first method, the divider may be set to progressively lower ratios of 0.01 0.001, etc., and each range compared to the known 1 V level. The second method is to divide the (now) calibrated 100 mV output of the calibrator by leaving the PRT set to 0.1 to obtain the next range calibration of 10 mV. The choice depends on the output impedance of the calibrator's millivolt ranges and the noise floor of the calibrator. If either is large, it is preferable to change the setting of the Model PRT73.

For the highest possible accuracy, corrections from the four-terminal "PRT Calibration Certificate of Test" may be applied.



2. Set ratio to 0.1



4. Reduce output of AC calibrator to 100 mV and adjust for same reading on AC millivoltmeter or record deviation.

Figure 3-13. Calibrating Lower Ranges of an AC Millivoltmeter

REMOTE COMMUNICATION

Remote Communication **4**

This section provides the following information:

- Basic operating information on the IEEE-488 interface
- Interface protocol options
- Detailed explanations of the remote programming commands.

Table 4-1 Remote Communications Contents

IEEE-488 (GPIB) Interface

The following sections describe both the basic and optional operation characteristics of the IEEE-488 (GPIB) interface. Refer to Programming Commands on page 4-12 for information about the system control commands that are common to both interfaces.

The GPIB interface follows the IEEE Standard 488-1978 for Programmable instrumentation. The following provides a general description of the GPIB bus signal lines and information relating to the configuration screens used to select GPIB message terminators and device address. For detailed information regarding other GPIB requirements refer to the ANSI/IEEE Standard 488-1978 titled, “IEEE Standard Digital Interface for Programmable Instrumentation.

GPIB General Description

The GPIB interface is designed to communicate through a parallel port, as defined by the IEEE-488 Interface Specification. This allows the exchange of commands and responses between a host controller and the Model PRT73. For information on the commands used to control the Model PRT73 refer to Programming Commands on page 4-12.

The GPIB interface communicates through a set of 16 signal lines that can be separated functionally into three dedicated groups:

- An eight-bit bi-directional data bus
- Three data transfer (handshake) lines—DAV, NRFD, and NDAC
- Five general management lines—ATN, EOI, IFC, REN, and SRQ

Information is transferred along the bus in bit-parallel, byte-serial fashion by an asynchronous handshake. Data transfer (handshake) signals (DAV, NRFD, and NDAC) regulate the transfer of each byte of data between devices. The five general management lines perform such tasks as designate device function, initialize the bus devices, signal interrupts, identify end of data string, and enable or disable remote only operation of devices.

A device connected to the bus is classified by the function it performs. Devices on the bus are classified as talkers, listeners, and controllers. A talker transmits data; there can be only one talker at a time to avoid confusion in message and data transfer. A listener can only receive data; there can be more than one listener at a time. A controller designates which devices are to talk or listen and exercises other bus management functions; there can be only one controller at a time.

> Note: Most devices can alternate between any two or three functions. Those devices that have the capability to talk and listen are designated as slaves.

The Model PRT73 is only capable of being a basic talker or a basic listener (Slave). The way the controller designates what function each slave performs is by addressing the slave and issuing an interface message. Interface messages are covered in the IEEE Standard 488-1978 specifications. The Model PRT73's address is programmed through the address select screen. The address can be set in decimal format from 0 to 30.

Signal Lines

The 16 lines of the GPIB are subdivided by function into three separate buses: an eight-line data bus, a three-line transfer (handshake) bus, and a five-line management bus (see Figure 4-1).

The data bus (signal lines DIO 1 through DIO 8) conveys data or device-dependent messages. DIO 1 represents the least significant bit in the transmitted byte; DIO 8 represents the most significant bit. One eight-bit word can be transmitted bi-directionally in bit-parallel, byte-serial fashion. The data lines are considered active when their signal level is LOW.

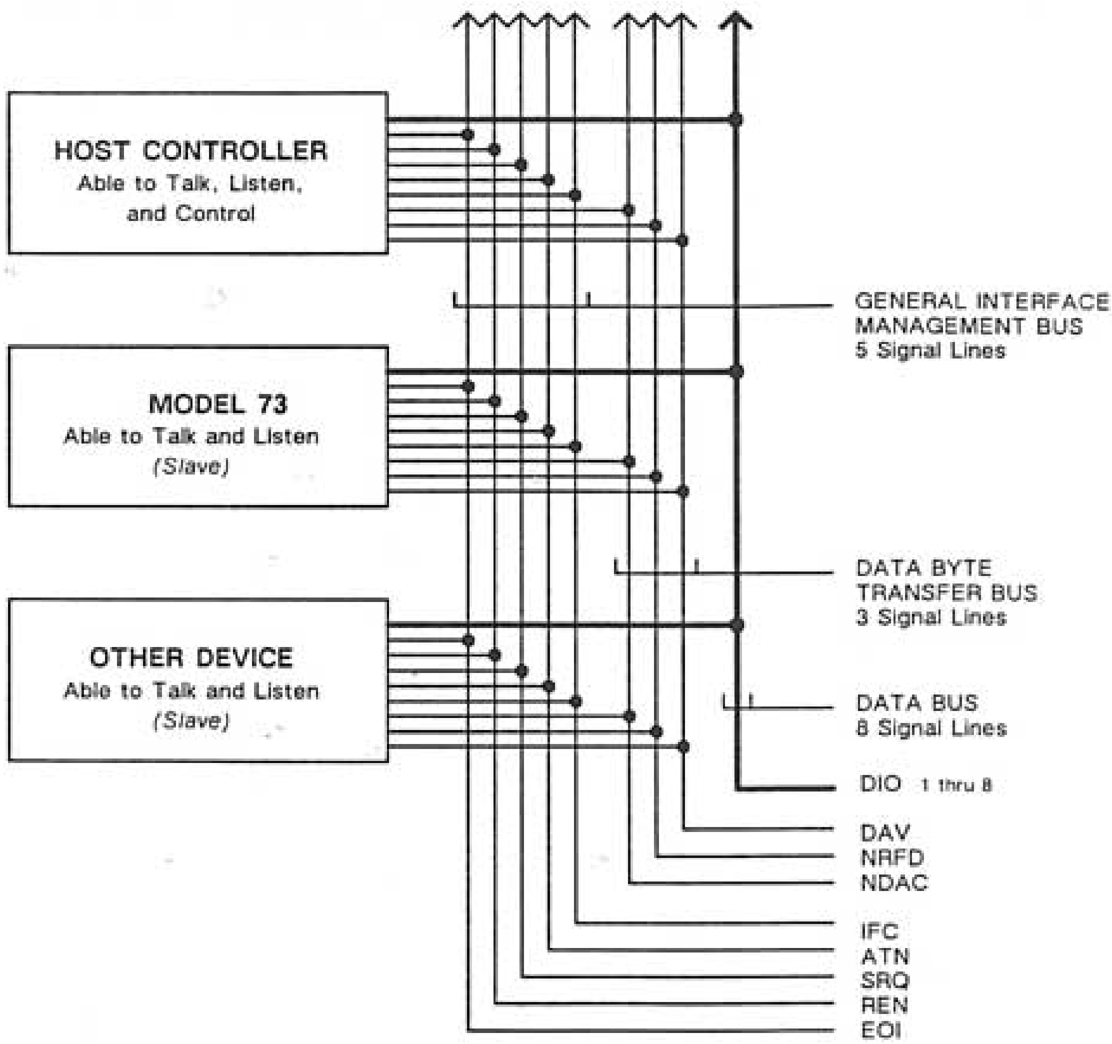
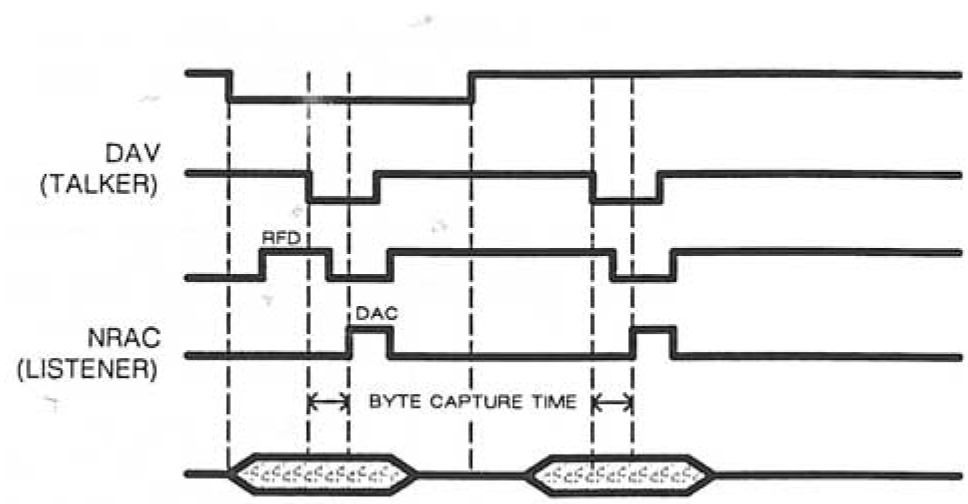


Figure 4-1. GPIB Signal Lines and Device Functions

The transfer bus performs a three-wire handshake process that is executed between the talker and all designated listeners each time a byte is transferred over the data bus. Figure 4-2 illustrates a typical handshake sequence. This handshake process assures that new data is not placed on the data bus faster than the slowest listener can receive it. The three handshake functions are:

- NRFD (Not Ready For Data) – This signal line is LOW until all addressed listeners are ready to receive the next data byte. When all addressed listeners are ready, they release the NRFD line, the NRFD signal goes HIGH, allowing the talker to place the next byte on the data line.
- DAV (Data Valid) – The DAV signal line is set LOW by the talker a short time after placing a valid byte on the data lines. This signal tells each listener to capture the byte presently on the data lines. DAV cannot be set LOW until the NRFD signal goes HIGH.
- NDAC (Not Data Accepted) – The NDAC signal line is set LOW by each addressed listener until they all have captured the byte currently on the data lines. When all listeners have captured the data byte, the NDAC signal goes HIGH. With the NDAC signal HIGH, the talker is able to remove the byte from the data lines, and at that point set the DAV line HIGH until the handshake cycle is repeated.



NOTE: Data Lines Are Active When Low

Figure 4-2. A Typical Handshake Cycle

The group of signal lines used to control the orderly flow of information across the GPIB is called the management bus. These signal lines perform such tasks as designate device functions, initialize the bus devices, signal interrupts, identify end of data string, and enable or disable remote only operation of devices. The five management bus signals are:

- ATN (Attention) & EOI (End or Identify) – Commands associated with these lines specify how the next data transfer on the bus is to be interpreted. See Table 4-2.
- IFC (Interface Clear)—This signal is set LOW by the system controller to initialize the interface functions of all devices connected to the data bus, i.e., set them to an inactive state, then return control to the system controller. If the Model PRT73 is in the middle of a data transfer, it will clear the bus and then clear the buffered portions of the message.
- SRQ (Service Request)—This signal line is set LOW by a device connected to the data bus to request service from the system controller. The controller conducts a poll to determine which device activated the interrupt. The controller can take the appropriate action by branching to an interrupt service routine.
- REN (Remote enable) – This signal line is set LOW by the system controller to place the Model PRT73 in the GPIB active mode. On the Model PRT73 there is one section of the software dedicated to the GPIB. (This section acts as per the RL2 function [Remote/Local], immediately entering remote mode when asked.)

Table 4-2. ATN and EOI Definition

ATN	EOI	Data Line Definition
0	0	Allows exchange of device-dependent messages from active talker or controller to active listener.
1	0	Active controller can send interface messages (universal commands, addressed commands, etc.). The codes corresponding to these messages are defined in Appendix E of the IEEE-488 standard.
0	1	Indicates the next eight bits are the last bits of a message.
1	1	Initiates parallel poll. This function is disabled in the Model PRT 73 upon initialization.

GPIB Interface Function Codes

The interface function codes are part of the IEEE Standard 488-1978. These codes define an instrument's ability to support various interface functions. There are 12 interface functions (some with as many as 28 subsets identified by a numeric value after the code) supported by, and included in, the interface standard. Table 4-3 identifies the functions supported by the Model PRT73 by listing the 12 function codes and Model PRT73 capabilities defined by the subset number.

Table 4-3 Model PRT73 IEEE-488 Function Codes

SH1	Source Handshake capability
AH1	Acceptor Handshake capability
T6	Basic Talker, serial poll, unaddressed as Listener when it receives MTA (My Talk Address)
TE0	No Extended Talk capability
L4	Basic Listener, unaddressed as talker when it receives MLA (My Listen Address)
LE0	No Extended Listen capability
SR1	Service Request capability
RL1	Remote/Local and local lockout capability
PP0	No Parallel Poll capability
DC1	Device Clear capability – Clears data lines, parser, and insures the Model PRT73 is ready to accept an input message. A 1 ms time delay is required following any command before sending a device clear.
DT1	Device Trigger capability – Model PRT73 can have its operation started by another device or Group Execute Trigger command (same as T Trigger command).
C0	No Controller capability
E2	Three state driver compatible

Serial Poll Status Byte

When a serial poll routine is initiated, the Model PRT73 will return a status byte indicating its current status. The GPIB serial poll status byte is defined in Table 4-4.

Table 4-4. Serial Poll Status Byte Definition

LSB							MSB
1	2	3	4	5	6	7	8
S	S	S	B	O	X	I	X

SSS Status (treat as binary):

SSS		Status (treat as binary):
	0	Reset
	1	Idle state - ready for command line
	2	Receiving - partial line in buffer
	3	Parsing - working on first command
	4	Replay ready
B		Busy - when true (1) Model 73 is busy
O		Over-voltage - when true (1) Model 73 detected an over-voltage condition
X		Not defined, set low
I		Asserted SRQ - When true (1) 5200A set the SRQ line
X		Not defined, set low

Busy Bit (B) – The Busy bit is set whenever the Model PRT73 is actively processing data as a response to a control button being pressed of from a remote command. The **Ratio, Range,** and **Reset** commands cannot be executed when the Busy bit is true. If these commands are issued when the Busy bit is set true an error message !BSY is sent to the host controller.

Over-voltage Bit (O) – If the Model PRT73 detects an over-voltage condition, it asserts a service request. When the host controller polls the Model PRT73, it will see the Busy bit (A), Asserted SRQ bit(I), and the Over-voltage bit set true. The Busy (A) bit remains set true for 5 seconds after the over-voltage condition is removed. The Over-voltage bit remains set true until it is reset by the **OVR** command. Additionally, the Model PRT73 will not assert another SRQ for an over-voltage condition until the Over-voltage bit is reset by the **OVR** command.

Asserted SRQ Bit (I)- The Model PRT73 asserts a service request (SRQ) and sets the Asserted SRQ bit true on two conditions. It asserts an SRQ when the Model PRT73 detects an over-voltage condition, and when a command is ready to be echoed back to the host controller. The Status bits (SSS) identifies when a reply is ready to be echoed to the host controller. The Over-voltage bit identifies that the Model PRT73 detected an over-voltage condition.

Status Bits (SSS) – Three bits are used to identify the status of the Model PRT73 at any time. The Status bits are read as binary numbers.

GPIB Address and Message Terminators

Configuration of the GPIB communication interface involves selecting the GPIB address and the GPIB input and output message terminators.

The selections are accessible by entering the IEEE setup mode by pressing the IEEE-488 SETUP button on the back panel of the Model PRT73. Use the left most ratio push buttons to select the message terminator and address screens and use the right most push buttons to select the desired parameters. Press any non-ratio push buttons on the front panel to exit the IEEE setup mode.

See Section 3 for further information on selecting parameters in the IEEE setup mode.

GPIB Message Terminators

The Model PRT73 accepts many combinations of input and output terminators using the ASCII characters CR, LF, and the EOI bus management line to indicate the end of a data I/O message.

Seven different input terminators are accepted by the Model PRT73. These combinations are listed in Table 4-5.

Table 4-5. GPIB Input Terminator Combinations
and Parameter Setting

Input Terminator Combination	**Input Parameter Terminator Selection**
EOI	CR or no
EOI on CR	CR or no
EOI on LF	CR or no
LF	CR or no
CR	CR
CR + LF	no
CR + EOI on LF	no

Four different output terminator combinations can be selected from the GPIB Output Terminator menu screen. See Table 4-6 for the different combinations.

Table 4-6. GPIB Output Parameter Setting and Terminator Combinations

Output Parameter Terminator Selection	Terminator Combination
--	EOI
LF	EOI on LF
CR	EOI on CR
CL	CR + EOI on lf

GPIB Address selection

The Model PRT73's device address is set decimal format from 0 to 30.

Pin Assignments

The Model PRT73 GPIB interface uses a female, 24-contact trapezoidal, D-shell connector. See Figure 4-3 for contact assignments.

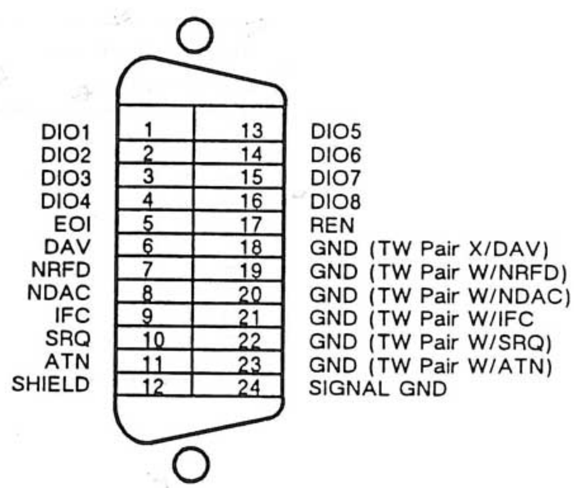


Figure 4-3. GPIB Bus Connector Contact Assignments

Bringing the Model PRT73 Up in GPIB

The following steps describe how to bring up the Model PRT73 GPIB interface. For information on cable connections, GPIB address and message terminator settings, serial poll status byte, and control commands reference the table of contents at the beginning of this selection.

1. Connect the host controller to the Model PRT73.

2. Switch the Model PRT73 POWER ON.

3. Press the MENU button on the Model PRT73's back panel and set the GPIB parameters: address and message terminators (input and output terminators).

4. Activate the host controller and turn on the REN line. At this point, the GPIB will still be in the inactive state. When a listen address is seen by the Model PRT73, it will activate the GPIB interface and the Model PRT73 will switch to the remote mode.

5. To lockout the front panel of the Model PRT73, the IEEE lockout command must be issued.

Programming Commands

The Model PRT73 is designed to be used in an automated system environment and controlled by a PC other form of host controller through an IEEE-488 interface. Typically the Model PRT73 will be controlled by the host controller running an application specific program written by the user.

This section describes the Model PRT73 control commands. The information is written as reference material only. It is not a tutorial. A person using this information should be familiar with their host controller's language and GPIB interface protocol.

Command Class Definition

Commands sent to the Model PRT73 have three class definitions. Each command class is identified in the following command definitions.

- Read Only – The read only class command can be issued by the host controller and a response will be returned.
- Action – The action class command initiates a function or test.
- Set/Read – The set/read class command is used to read or set the command parameters.

Input Command Syntax

Commands sent to the Model PRT73 are input in upper or lower case. Numeric values are entered with or without leading 0s (zeros) using real numbers or real numbers with exponents. For example:

Decimal	Exponent
0.001	1E-3
0.000001	1E-6

For expedience, always use the abbreviated form of the command (shown in "()").

Output Command Syntax

All data transfers or commands require the host controller read back a response (echo) from the Model PRT73 before the next data transfer or command is sent. All numeric responses from the Model PRT73 are in decimal format and are of fixed length.

Commands

Identify (ID) Class: Read Only

Description: Returns the model number, software version number, and revision letter.

Input>	ID
Output>	ID ESI, 73,, 1A

Options Class: Read Only

Description: Returns a string of options separated by a comma. Options that can be reported are the 2.5 V/Hz and the rear terminals options.

NOTE: The rear terminal option will only be reported as being installed if the rear input cable is connected to the active input connector (P4) on the Analog circuit assembly. (There is a dummy input connector (P7) and a dummy output connector (P16) that is used to terminate the unused input or output cable.)

Input>	Options
Output>	Options RearTerminals, 2.5

Overloadreset (OVR)

Class: Read Only

Description: Resets the Over-voltage bit in the serial poll status byte. See Serial Poll Status Byte p. 4-9.

Input>	Overloadreset
Output>	Overloadreset

Ratio Class: Set/Read

Parameters: Alpha-numeric string (0-9, E, D,.)

Description: Reads or sets the RATIO setting of the Model PRT73. Returned values will always be 10 characters long with the decimal point in the second character. Parameters are accepted with + or – signs, floating decimal point, variable number of digits, and an exponent (E or D). Values input outside the range of resolution will be rounded to the proper number of digits. Values out of the ratio range will return !IVTS (Value Too Small) or !VTL (Value Too Large) errors.

Legal ratio values for the 0.35 V/Hz range are between -0.001 and +1.0009999.

Legal ratio values for the 2.5 V/Hz range are between -0.0001 and +1.00009999.

```
Set:   Input>  Ratio .707                  }
               Ratio 707e-3                }  Any of these
               Ratio 0.707                 }  inputs will
               Ratio +.707                 }  produce the
               Ratio 0.70700000            }  same ratio
                                              setting.
       Output> Ratio 0.70700000

Read:  Input>  Ratio
       Output> Ratio 0.70700000
```

Range Class: Set/Read

Parameters: .35, 2.5

Description: Reads or sets the operating range to 0.35 V/Hz or 2.5 V/Hz. An error message !ONI (Option Not Installed) will appear if you input 2.5 and the 2.5 V/Hz option is not installed.

```
Set:   Input>  Range 2.5
       Output> Range 2.5

Read:  Input>  Range
       Output> Range .35
```

Reset Class: Action

Description: The **Reset** command clears the current operation, sets the Model PRT73's RATIO to 0.0 and RANGE to 0.35 V/Hz. GPIB parameter settings are left unchanged.

```
Input>  Reset
Output> Reset
```

SelfCalibrate Class: Action

Description: Initiates a dummy self calibration. The Model PRT73 has no means of calibrating itself. Always returns 0.

```
Input>  SelfCalibrate
Output> SelfCalibrate0
```

Selftest Class: Action

Description: Returns whether or not the analog circuit assembly is installed in the Model PRT73. A 0 returned indicates the analog circuit assembly is installed. A 1 indicates the analog circuit card is not connected or missing.

```
Input>  Selftest
Output> Selftest 0
```

Status Class: Action

Description: Returns the remote/local control status of the Model PRT73. A 0 indicates the Model PRT73 is in the remote mode of operation. A 1 indicates the Model PRT73 is in local mode. See Operating Modes p. 3-10.

```
Input>  Status
Output> Status 0
```

Error Messages

Error messages are returned to the host controller in a standard format. The messages start with an exclamation point (!) and are followed by a three letter code and an expanded message. Error messages are as follows:

Table 4-7. Error Messages

!BSY must not be BuSY if changing RATIO or RANGE Action: Wait until BUSY bit in the serial poll status byte is cleared.
!IBF Input Buffer Full – too many characters or commands were sent Action: Send the GPIB Device Clear command and send your command again.
!ILV Illegal Value Action: Check the legal parameters and input again.
!INF Invalid Numeric Format Action: Check the legal command names and input again.
!NSN No Such Name Action: Check the legal command names and input again.
!ONI Option Not Installed Action: The 2.5 V/Hz option is not installed and the range cannot be switched.
!STV Must be in remote to SeT Values Action: Set the Model 73 to the remote mode.
!UEA UnExpected Argument Action: Enter command without using parameter or argument.
!VTL Value Too Large Action: Enter command again using a parameter within the range.
!VTS Value Too Small Action: Enter command again using a parameter within the range.
!WNA Wrong Number of Arguments Action: Check your parameters and input again.

THEORY OF OPERATION

This section contains general operation descriptions of the circuit assemblies contained in the Model PRT73. Reading this section will aid a technician if troubleshooting the Model PRT73 becomes necessary.

Table 5-1. Theory of Operation Contents

Block Diagram

Figure 5-1 shows the functional blocks of the Model PRT73. Each block is functionally modular for ease of test and repair. The Analog circuit assembly contains the precision ratio transformer and relays that form the heart of the instrument. The analog circuitry is isolated from chassis ground and surrounded by a separate guard to support the operation of a common-mode potential without added linearity error. High reliability relays are used for all switching applications. In critical locations, pairs of contacts are connected in parallel for extended-life operation.

The CPU/IEEE circuit card controls all of the functions of the Model PRT73 using an 8088 microprocessor and custom software programmed into ROM. Communication from the microprocessor to the Front Panel circuit assembly is handled by a static bus; no clock signals are present to cause noise interference with sensitive analog signals. Information on this internal bus is passed only when a front panel control is activated by the operator or the ratio setting is changed by a host controller connected to the IEEE-488 communication interface.

The Front Panel circuit assembly interface components include matched high-intensity LED displays and positive feedback data entry switches. A VLSI controller scans the keys, drives the displays, and interfaces with the microprocessor. Binding post terminals are provided on the front panel for input and output signals. A rear terminal option can be installed to accommodate your test system configuration.

Power to these modules is provided by two separate power supplies. Both supplies share a common source input from the Power Entry Module and through the Voltage Select Switch. There are no adjustments required for either supply.

A 2.5 V/Hz option is available to extend the maximum input voltage at low frequencies and extend the Model PRT73 resolution to 0.01 ppm of input. The option plugs into the existing Analog circuit assembly without circuit modifications.

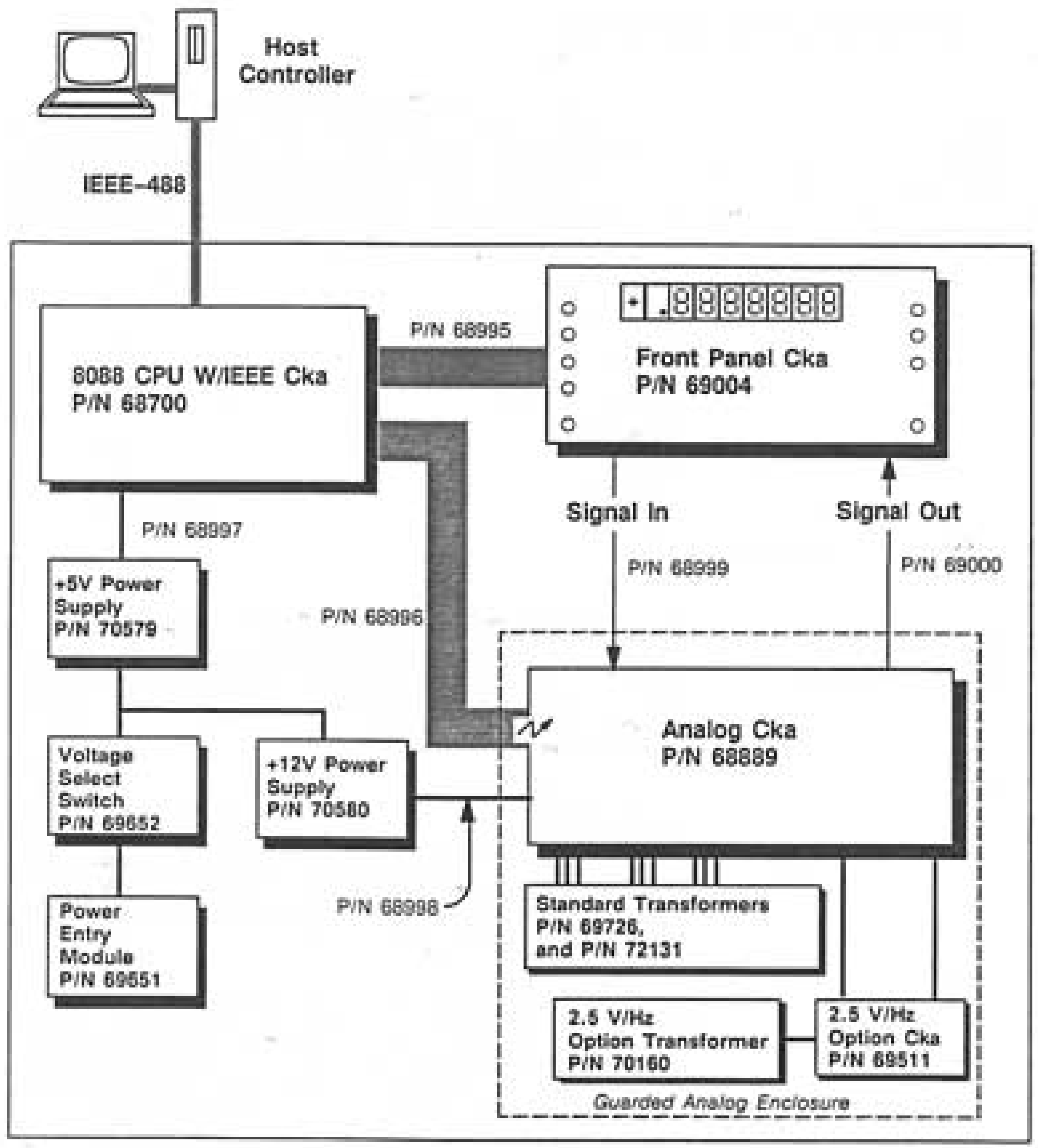


Figure 5-1. Model PRT73 Block Diagram

8088 CPU W/IEEE Circuit Card

Control of all the Model PRT73 operations and the GPIB I/O are provided by the 8088 CPU W/IEEE-488 circuit card. The card basically contains an 8088 microprocessor, an 8k x 8 SRAM, ROM, associated latches and buffers and PALs for address and data I/O, a standard IEEE-488 controller, and IEEE-488 transceivers. Functional blocks of the 8088 CPU W/IEEE circuit card include:

- Control/Memory
- Clock
- Power Monitor
- I/O Monitor
- GPIB

Control/Memory

The Model PRT73 uses an 8088 microprocessor to control IEEE-488 communication, the analog circuit card, and the front panel circuit assembly. It uses various latches, buffers, and custom Programmable Array Logic (PAL) integrated circuits to control two busses; the memory bus and the IBU bus.

The memory bus controls address and data to and from the RAM (U19) and ROM (U20 and U21). Read and write functions of the memory ICs are buffered through U8 and sent to a decoder U9. The decoder outputs are connected to the chip enable inputs of the RAM and ROM. The microprocessor controls memory data input and output directly from its own $\overline{RD}$ and $\overline{WR}$ control lines.

Memory address lines (A0-A7) and data lines (D0-D7) are buffered by U18 and latched by U23 respectively. Addresses (A8-A12, and A13-A15) are not buffered and sent directly to the memory ICs. Address line A13 is inverted by a PAL (U7) so that 8k x 8 SCRAMs can be used; Normally, an 8k x 8 non-volatile SRAM will occupy the RAM sockets.

IBU address lines (A0-A7) and data lines (D0-D7) are buffered by U17 and latched by U22 respectively. The IBU bus controls all the address and data to and from the rest of the instrument.

Connector, J5, is intended for use during manufacturing to test and diagnose problems on the 8088 CPU W/IEEE circuit card. Most of the information on this connector will not be useful for troubleshooting purposes. Signal from the microprocessor to J5 include:

- All 20 address and data lines from the microprocessor
- The RD, WR, XM, IO and DE lines from the microprocessor
- A duplicate bus request line (BUSREQ); pulling this line low will tri-state the microprocessor and buffers
- The HALT line from PAL U7 to view the microprocessor run state
- The TICK line (NMI); this line can be used to check if the timer for the microprocessor is running and on frequency.

Clock

The clock circuitry provides the 4.9152 MHz clock and 1200 Hz TICK signals for the microprocessor. Oscillator (Y1) outputs a 14.7456 MHz signal which is divided-by-three to get a 4.9152 MHz 33% duty cycle clock for the microprocessor. Two JK flip-flops provide the divide-by-three function. The 4.9152 MHz signal is then divided by U4 to get a 1200 Hz TICK clock that is connected to the non-maskable (NMI) interrupt line of the microprocessor for timer synthesis.

Power Monitor

In the event of a power failure, the power sensor (U28) outputs a RESET to the Front Panel circuit card to reset the RATIO to 0.000000 and the GPIB controller (U13) to a non-remote state. Both the +5V supply and the +12V supplies are monitored.

The +5 V supply is monitored from +5 V applied to the 8088 CPU/IEEE circuit card at the SENSE input of U28. The +12 V supply is monitored on the Analog circuit card by U33. If the +12 V power fails a RESET signal is generated and sent to the 8088 CPU W/IEEE circuit card at J2-2. This signal is fed into the RESIN input of U28.

In either case, if power drops enough to indicate a power failure, the RESET line of the power sensor (U28) will be sent to the Front Panel circuit card, the RESET line of the GPIB controller (U13), and the RESET input of the microprocessor, pin 21:

- The RESET signal sent to the Front Panel circuit card is applied to a PAL (U15) and then to the front panel controller (U12). The low signal on (U12) sets the display to 0.00000.

- The microprocessor RESET sets the system to the power-up state and the relays on the Analog circuit card to a 0.00000 ratio. This is a safety mechanism designed to protect the Model PRT73 and the equipment connected to it from potentially high surge voltages that may be present when power is restored.
- The RESET signal to the GPIB controller (U13) resets the GPIB to a non-remote state.

I/O Monitoring

The I/O monitoring circuitry alerts the microprocessor of changes in the state of the GPIB MENU control button, the GPIB REN and ATN lines, and the OPTION and OV LOAD lines from the Analog circuit card. The I/O monitoring section consists of an eight-bit input latch (U12), an eight-bit output latch (U10), and an eight-bit comparator (U11).

The signal lines being monitored are connected to QA-QH of the comparator (U11). When one of these lines changes state, an interrupt is generated at pin 19 of the comparator and sent to the microprocessor through the PAL (U4). The microprocessor then reads the data by latching it through U10 onto the IBU data bus and then outputs the same data back to the input latch (U12). The data is now analyzed by the microprocessor to discover which lines changed state.

Both PALs (U4 and U7) control the data latched to and from U10 and U12 with the $\overline{\text{GET}}$ and $\overline{\text{PUT}}$ signal lines.

GPIB

The GPIB section is a standard configuration which conforms to IEEE-488. It consists of a GPIB controller (U13) and two GPIB transceivers (U14) and (U15).

Front Panel

The Front Panel circuit card contains all the user interface controls and display. It provides drive control for all the displays and monitors the front panel controls for activity. The Front Panel circuit card communicates with the 8088 CPU W/IEEE circuit card through the IBU bus.

The addressing and control lines are handled by the PAL (U15).

All RATIO decade controls (SW2 – SW9 and SW12 – SW19) are de-bounced and decoded by two PALs (U13 and U14). If a button is pushed, an interrupt is generated by the corresponding PAL. The microprocessor acknowledges the interrupt and checks the data bus to see which RATIO decade control is pressed. As long as the button is pressed down, the decade will increment or decrement provided it is a valid ratio that the Model PRT73 can achieve.

The front panel controller (U12) monitors the remainder of the controls, and displays. All the LEDs and the seven-segment displays are multiplexed using U10 and U11. To conserve power and increase the life of the displays, they are switched on and off at a high frequency. U10 is used to switch power to the display on and off through separate FETs while U11 is used to enable the proper segments A-G in each display. Each display U1-U9 is scanned sequentially along with LEDs DS1, DS2, and DS3.

Analog Circuit Card

General Theory of Transformer Operation

The output voltage at the TAP of the Model PRT73 is produced by the operation of three transformers.

The first transformer divides the input voltage into 10% steps with a tap at each step. This transformer is constructed with a twisted bundle of 12 wires wrapped 100 times through a high permeability core. This creates a 1200 turn auto-transformer with a tap every 100 turns. This type of construction provides excellent linearity. The voltage between adjacent taps (except for the end taps) is switched with relays to drive the next transformer. The input voltage is applied to the second tap from each end of the transformer, which means that end taps provide 110% and -10% of the input. The 110% and -10% taps are brought out to the Front Panel on the 1.1 and -0.1 binding post. These two voltages are provided for the purpose of generating a phase compensation signal. Two taps, the selected ratio and the next higher, are used to drive the next transformer.

The second and third transformers are identical and consist of three decades each. Each decade is wound with a twisted bundle of 13 wires. The first decade has 100 turns, the second decade has 10 turns and the third has 1 turn of a twisted bundle. These transformers use the same high permeability core as the first transformer. The required accuracy of each succeeding lower decade is less because each contributes a factor of 1×10^{-1} to the total error. Each decade on these transformers has an extra winding that is used to drive the succeeding decade. The taps of a decade are switched with relays to the lower end of the succeeding decade which provide a reference for that decade.

Transformer Ratio Switching Method

When changing the ratio, the relays are switched in a way to minimize glitches or steps in the TAP voltage which could be caused by relays switching or the field collapsing around a transformer. The method for changing the ratio (incrementing or decrementing a decade by one) involves three steps.

The first step occurs when the microprocessor receives an interrupt and data from the Front Panel to change the ratio, a “transition” relay is closed on the transformer decade corresponding to the digit being changed on the Front Panel. The transition relay connects the 0.5 tap of the decade being changed through a resistor to the low end of the next lower decade.

The second step opens the relay connecting the tap of the old ratio to the low input of the next decade. The next decade is now referenced to the 0.5 tap. This provides a temporary reference for the next decade until the connection is made to the tap for the new ratio.

The third step closes the relay to the tap for the new ratio. The resistor prevents the 0.5 tap from being connected directly to the old or new ratio tap to prevent shorting out part of the transformer. As a result, the field across the next decade is maintained during this step because the extra drive winding on the decade being changed is never disconnected from the next decade.

When changing the ratio on the Front Panel more than one count, and the display goes into the auto repeat mode, the relays do not try to keep up with the display. The software periodically updates the relays as the display changes.

The ratio displayed on the Front Panel does not always reflect which taps of the seven decades are selected by the relays. A special method for selection of certain ratios is used to provide good incremental linearity. This method centers around the third decade, which can provide a 100% or -10% (1.1 or-0.1) of the third decade as a reference voltage for the fourth decade. The -0.1 tap is used for reducing the ratio at a cardinal point (i.e., 0.00, 0.01, 0.02, 0.03, … 0.98, 0.99, 1.00).

As an example:

> If the ratio = 0.5000000 and the ratio was reduced by 0.1 ppm to 0.4999999, rather than changing the first two decades, which could introduce a change in the linearity by as much as +/-0.9 ppm, the third decade is changed to a -1 and the 4th through 7th decades are set to 9. The selected taps for this new ratio would be 0.5-0.19999. This method allows an incremental linearity of less than +/-0.1 ppm when deviating +/-100 ppm around a cardinal point. The ten position is used when a ratio of 1.0000000 to 1.0009999 is selected. The actual tap selected for the 1.0009999 ratio would be 0.99109999. Using the two extra taps on the third decade will allow the ratio to range from 1.0009999 to 0.9890000 without changing the taps on the first and second decades.

Table 5-2. Ratio Settings that use Over – and Under – windings

Ratio	Actual Digit Setting
1.0000000	0.99▲0000
1.0009999	0.99▲9999
1.0000001	0.99▲0001
0.9999999	0.9999999
0.9000000	0.9000000
0.8999999	0.90▼9999
0.8990000	0.90▼0000
0.8900000	0.8900000
0.8899999	0.89▼9999
0.8890000	0.89▼0000
0.8889999	0.8889999
0.8100000	0.8100000
0.8099999	0.81▼9999
0.8090000	0.81▼0000
0.8000000	0.8000000
0.7999999	0.80▼9999
0.0000001	0.0000001
0.0000000	0.0000000
−0.0000001	0.00▼9999
−0.0010000	0.00▼0000

Legend
▲ = 100% Over-winding on 3rd Decade (1.0 Digit Setting)
▼ = −10% Under-winding on 3rd Decade (−.1 Digit Setting)

Table 5-3. Ratio Setting vs Relay Setting

Notes:

U# PIN # K#

Numbers appearing under this block refer to the U designator of the latch used, the pin number of the latch output pin at a logic high state, and the K designator of the relay that is energized. Refer to the Analog circuit assembly and the 2.5V/Hz Option circuit assembly in the Diagrams and Parts List section for circuit reference.

The Transition Relays are energized only when a digit setting is changed in a particular decade.

	DECADES							
Digit Setting	2.5 V/Hz	1	2	3	4	5	6	7
	U#Pin#K#	U#Pin#K#	U#Pin#K#	U#Pin#K#	U#Pin#K#	U#Pin#K#	U#Pin#K#	U#Pin#K#
1.0				20 11 25				
.9	1 13 72	8 15 12	6 9 18	20 10 24	12 13 32	16 11 39	16 12 46	18 14 53
.8	2 12 71	8 14 11	6 12 17	20 9 23	12 12 31	18 9 38	16 13 45	18 15 52
.7	2 14 70	8 13 10	6 13 16	12 9 22	12 11 30	14 1 37	16 14 44	18 1 51
.6	2 13 69	8 12 9	6 14 15	14 11 21	12 10 29	14 15 36	16 15 43	18 13 50
.5	1 15 68	8 11 8	6 15 14	14 10 56	12 14 28	14 14 35	16 1 42	18 12 49
.4	1 9 67	8 10 7	6 9 18 20 12 20	20 11 25 14 9 27	12 13 32 12 15 34	16 11 39 14 13 41	16 12 46 16 10 48	18 14 53 18 11 55
.3	1 11 66	10 12 6	6 12 17 20 12 20	20 10 24 14 9 27	12 12 31 12 15 34	18 9 38 14 13 41	16 13 45 16 10 48	18 15 52 18 11 55
.2	1 10 65	10 11 5	6 13 16 20 12 20	20 9 23 14 9 27	12 11 30 12 15 34	14 1 37 14 13 41	16 14 44 16 10 48	18 1 51 18 11 55
.1	1 14 64	10 13 4	6 14 15 20 12 20	12 9 22 14 9 27	12 10 29 12 15 34	14 15 36 14 13 41	16 15 43 16 10 48	18 13 50 18 11 55
.0	1 12 63	10 14 3	6 15 14 20 12 20	14 11 21 14 9 27	12 14 28 12 15 34	14 14 35 14 13 41	16 1 42 16 10 48	18 12 49 18 11 55
-.1				14 10 56 14 9 27				
Transition Relays	4 10 73	8 9 13	20 14 19	20 15 26	12 1 33	14 12 40	16 9 47	18 10 54
2.5 or .35 Range		10 1 1 16 15 2						

Table 5-3 shows which latch pin output will be at a logic high state and relays that are energized for a particular ratio setting. The left most column indicates the digit settings for each decade. The top column indicates the individual decades.

To determine which latch pin output and relay are used for a particular ratio setting:

1. Refer to Table 5-2 to determine if there are any over or under windings used for that ratio setting. If the particular ratio setting appears in this table, use the information in the second column next to the ratio setting as your digit settings in Table 5-3.

2. Find the intersection box for each digit set in all decades (your ratio setting). Information contained in each box contains the U designator of the latch, the pin number of the latch output that is at a logic high state, and the K designator of the relay that should be energized. Refer to the Analog circuit assembly and the 2.5 V/Hz Option circuit assembly in the Parts List and Diagrams section for circuit reference.

NOTE: The Transition Relays listed under the Digit Setting column identify the latch pin output and the relay energized when a change is made to a ratio setting within a decade. These latches and relays are energized only during the period of time the ratio is changed.

Analog Status Signals and Transformer Relay Control

Control and status signals flowing between the Analog circuit card and the 8088 CPU circuit card are opto-isolated. Located on the Analog circuit card, the opto-isolators (U1, U2, and U3) convert the TTL signals from the microprocessor to CMOS level signals.

Control data from the 8088 CPU circuit card is used to poll the status of the Analog circuit card and to control the relays used to set the ratio and control the signal on the input binding post. Relays are driven by nine MC14168 relay drivers. Each driver is capable of driving seven relays. Working backwards through the circuit, each relay driver is connected to eight decoder latches. The latch outputs are switched high to switch the relay driver on and energize the selected relay. To switch one of the outputs on the decoder latches high, the latch output must be addressed by the A0 – A2 inputs, data must be present at the data input, and the write input must be enabled.

Control data to enable and disable the Analog circuit card relays is provided serially from the 8088 CPU circuit card to the serial-to-parallel converter (U4). When eight bits of data are entered, four bits of the data are clocked to the input of one sixteen-to-one decoder latch (U5) and the other four bits are clocked to eight three-bit decoder latches (U2, U4…U20). Three of the bits are connected to the address inputs of each three-bit decoder latch (A0, A1, A2) and the fourth bit is connected to the DATA input. The address inputs select which Q output of the latch the DATA will be passed. Data is passed to the Q output when the write enable input is selected by U5.

Status data from the Analog circuit tells the microprocessor which options are present, if an input over-voltage condition exists, and if there has been a power interrupt on the +12 V supply. The status of the option is checked when the Model PRT73 is powered up. Conversely, the over-voltage and power interrupt circuitry are continuously monitored. Any time an over-voltage occurs most of the signal relays are opened and the microprocessor is alerted to this condition. If a power interrupt occurs on the +12 V supply a reset is pulled on the microprocessor and all relays will be set for a ratio of zero. This is done to prevent the relays changing to an unknown state, which could allow the output voltage to go to an undesired or possibly dangerous level.

Over-voltage Circuit Operation

The Over-Voltage Protection circuit (OVP) monitors the voltage applied between the 1.0 and 0.0 binding post. If this voltage exceeds the volts/hertz relationship by approximately 6%, the output of the OVP immediately open the relays that connect the signal on the 1.0 and 0.0 binding post to the first transformer and open most of the other transformer tap relays. Also, the output of the OVP pulls an interrupt on the microprocessor which then commands all transformer relays to open as a further assurance that the over-voltage signal will not damage the transformers.

The basic component of the OVP circuit is an integrated circuit (U32) that has the inverse frequency response as the volts/hertz relationship of the Model PRT73 transformers. The response of the integrator produces an output signal that will have constant amplitude for an input signal set at the maximum volts/hertz relationship.

The standard Model PRT73 has a 0.35 V/Hz relationship, but with the low frequency option this would increase to 2.5 V/Hz. To accommodate these different relationships a relay (K57) is used to change the integrator feedback capacitor value from 0.022 µF (C3) in the 0.35 V/Hz range to 0.158 µF (C3, C4, and C34 in parallel) in the 2.5 V/H range. The AC gain is primarily determined by the impedance of these capacitors divided by the input resistors R11 and R23 (997 kΩ). The DC gain is determined by the input resistors and the feedback resistors, R8, R12, and R13 (effectively 200 MΩ).

The DC gain and the recovery time of the integrator is reduced by turning off Q3. This is under software control and is used momentarily when changing between the 2.5 V/Hz and 0.35 V/Hz range. The output from the integrator is connected to a window comparator (U31). The window comparator has upper and lower limits set to 3.93 volts. If the output from the integrator should exceed one of these limits, the window comparator output will go low and set the over-voltage bi-stable (part of U30). The output of the bi-stable will reset latches U8, U10, U12, U14, U16, U18, and U20. This will open the relays (K1 and K2) connecting the signal on the input binding post to the first transformer and open most of the other transformer tap relays.

Installation

There are two options that can be ordered and installed by the customer: The 2.5V/Hz Option (P/N 70161) and the Rack Mount Option (P/N 70192). The following instructions explain how to install both options.

Model PRT73 Rack Mount Installation Instructions

These instructions explain how to install the Model PRT73 Rack Mount kit (P/N 70192) and (P/N 70192/SP3293). The kit includes all necessary hardware. Figure 6-1 shows an exploded view of the Rack Mount Option.

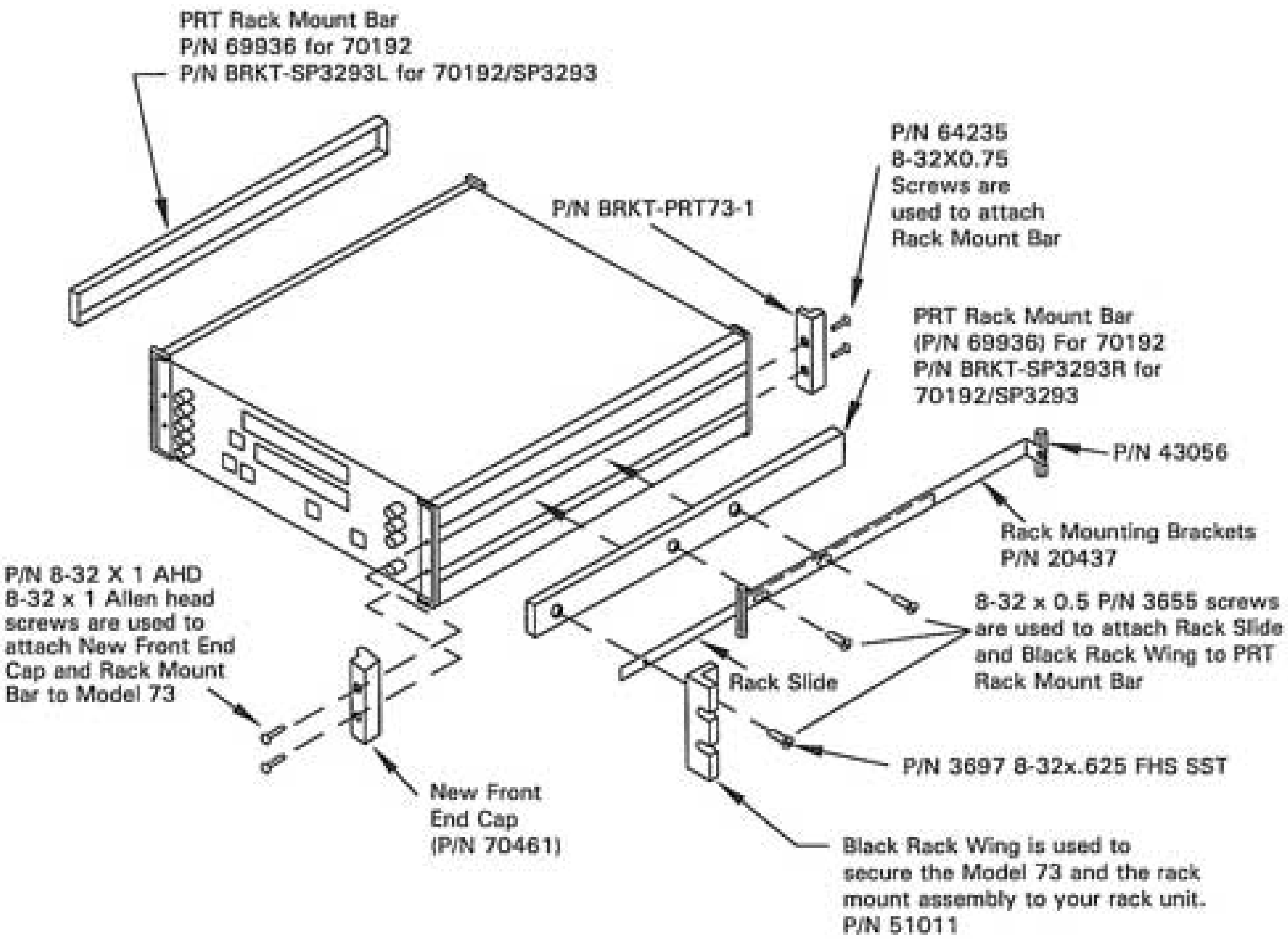


Figure 6-1 Exploded View of Rack Mount Kit

1. Remove the existing front and rear end caps from the Model PRT73 as shown in Figure 6-2.

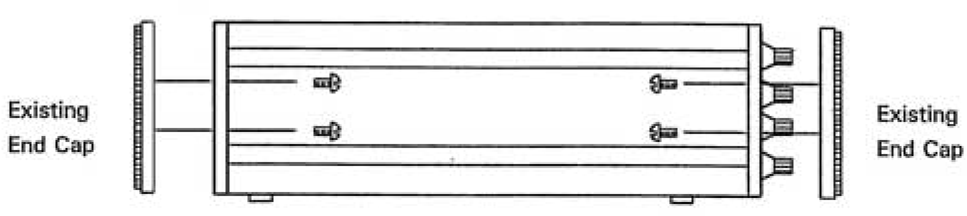


Figure 6-2 Removing End Caps

2. Insert the PRT73 Rack Mount Bar as shown into each side of the Model PRT73 and secure the new back end cap with two 8-32 x .75 Allen head screws at the rear of the Model PRT73. Secure the new Front End Caps and the PRT Rack Mount Bar to the Model PRT73 using two 8-32 x .75 Allen head screws. Refer to Figure 6-3.

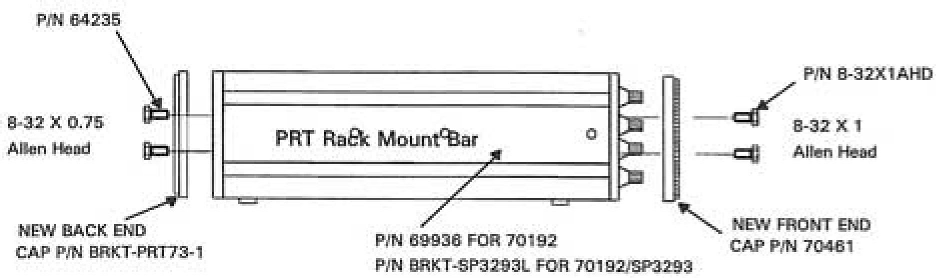


Figure 6-3 Installing PRT73 Rack Mount Bar

3. Remove the Inner Rack Slide from each of the Rack Mounts. Attach the Black Rack Wing and the rack slide to the PRT73 Rack Mount Bar. Refer to figure 6-4.

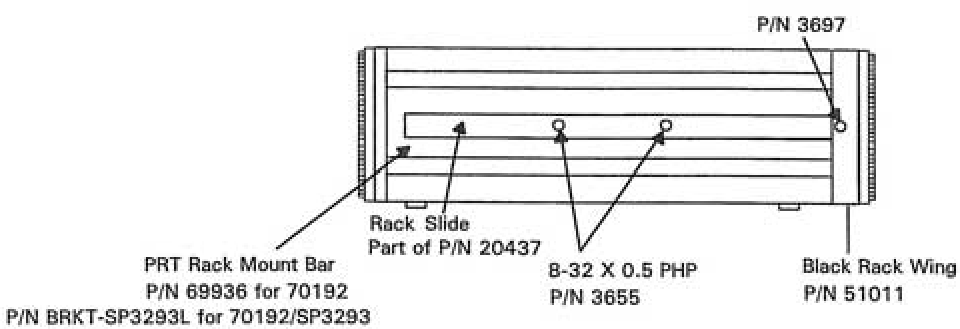


Figure 6-4 Mounting Rack Slide and Black Rack Wing

4. Assemble rack mounts. Attach the rack mount adapters to the mounting ears on the rack mount with 2 – 10 x 3 x .5 screws for each side. Dry fit the two halves of the rack mount in the rack unit to obtain proper hole alignment. Secure the two halves with screws, lockwasher and nuts supplied with P/N 20437.

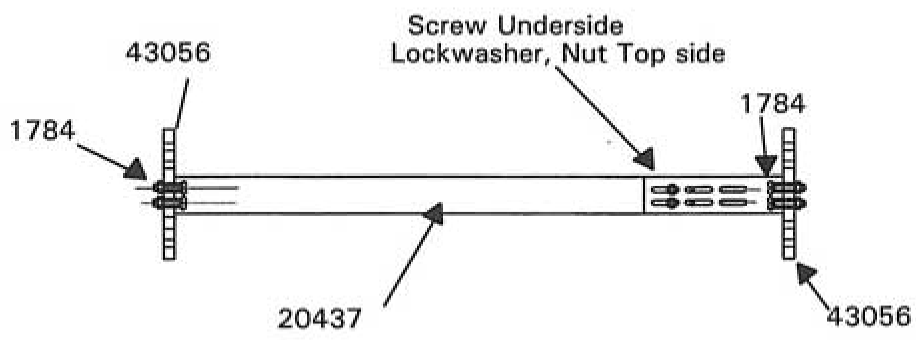


Figure 6-5 Assembly of Rack Mounts

5. Install both Rack Mounts to your Rack Unit using eight 10-32 x 0.5 PHP screws. Then slide the Model PRT73 into the Rack Mounts and secure the Model PRT73 to the Rack Unit with four 10-32 x 0.75 PHP screws. Refer to Figure 6-5.

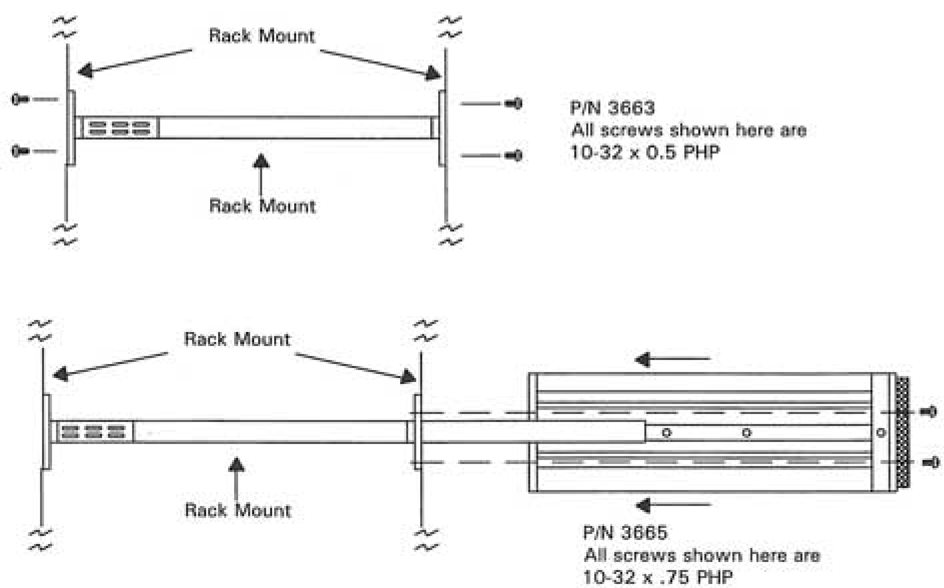


Figure 6-6 Installing Model PRT73 into Rack Unit

2.5 V/Hz Option Installation Instructions

These instructions explain how to install the Model PRT73 2.5V/Hz option kit (P/N 70161). When properly installed the 2.5 V/Hz option will perform to published specifications listed in the Model PRT73 Instructions Manual (P/N 705181). To receive correction values for the 2.5 V/Hz operating range, send the Model PRT73 to TEGAM Inc. for certification or to a standards laboratory that offers this service. Correction values can also be obtained if you own an AC ratio bridge that includes or is calibrated by a certified AC ratio standard.

CAUTION

Components used in the Model PRT73 can be damaged by an electro-static discharge (ESD) when the covers are removed. To prevent ESD damage, the installation of the 2.5 V/Hz Option must be performed on a static-free work surface. The person performing this procedure should also wear a conductive wrist strap connected to the static-free work surface.

WARNING

Electrical Shock Hazard. Disconnect the power cord and other test equipment connected to the Model PRT73 before performing this procedure. Failure to do so can result in severe injury or death from contact with line voltage or high voltage from other test equipment.

1. Switch the instrument POWER OFF and unplug it from its power source.
2. Set the Model PRT73 on a static-free work surface. Remove the top cover by removing four screws from bottom of instrument. Refer to Figure 6-6.
3. Disconnect the CPU-Front Panel Cbl (P/N 68995) from J1 on the CPU Cka (P/N 68700). Refer to Figure 6-7.
4. Remove the four Guard Box shoulder stand-off screws and Guard Box top cover (also four screws). Refer to Figure 6-7.

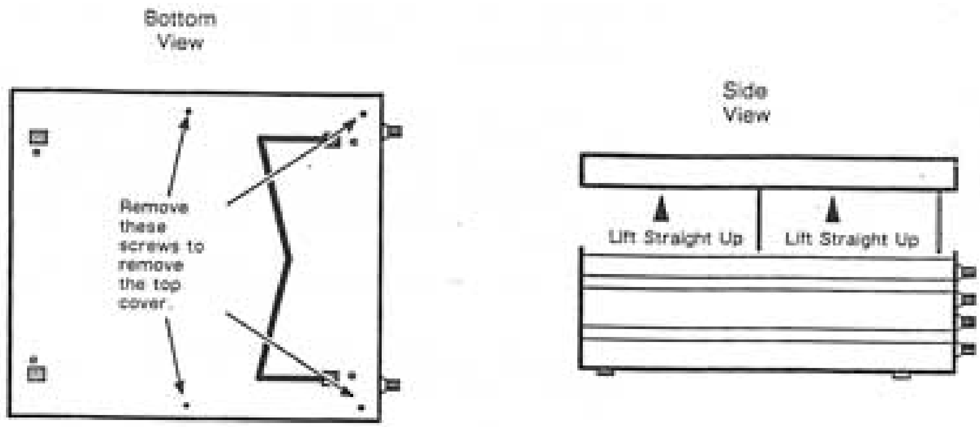


Figure 6-6. Removing Top Cover of Model PRT73.

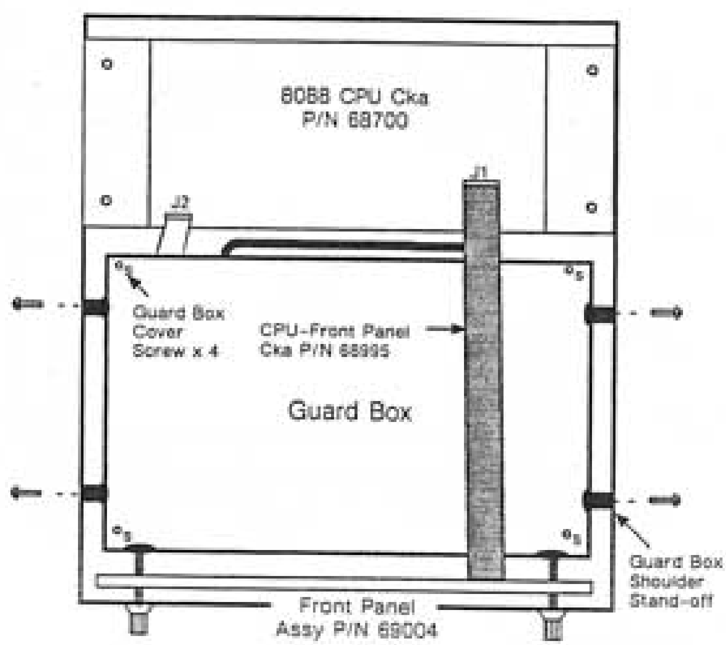


Figure 6-7. Model PRT73 with Top Cover Removed.

5. Refer to Figure 6-8. Remove the following cables from their respective connectors:

- PRT IN Cbl (P/N 68999) from P4 on Analog Cka (P/N 68889)
- PRT OUT Cbl (P/N 69000) from P15 on Analog Cka (P/N 68889)
- +12V-Analog Cbl (P/N 68998) from P17 on Analog Cka (P/N 68889)
- CPU-Analog Cbl (P/N 68996) from J2 on CPU Cka (P/N 68700)

6. Lift the Guard Box straight up from the Model PRT73 chassis and place it on static-free work surface.

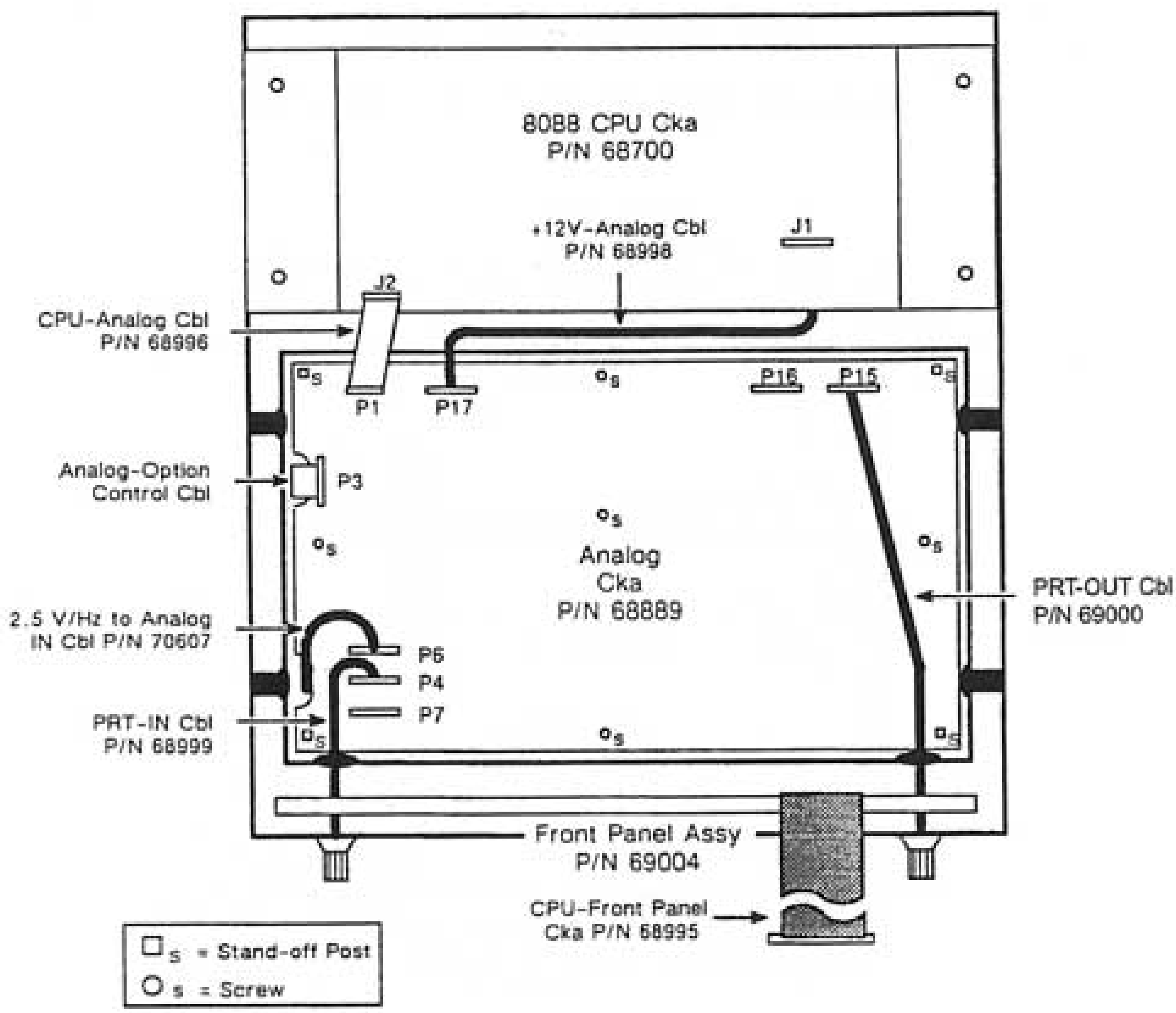


Figure 6-8. Top View with Guard Box Top Removed

7. Remove the four stand-off posts and five screws that secure the Analog Cka to the Guard Box. Refer to Figure 6-8. After the Analog Cka is loose, use a bladed screwdriver to remove all transformer cables from the bottom of the Analog Cka. **DO NOT** pull on the wires to remove the connectors or they may be damaged. Refer to detail A in Figure 6-9.

8. Remove the Analog Cka from the Guard Box.

9. Install the 2.5 V/Hz Cka (P/N 69511) using the six screws supplied in the kit. Refer to figure 6-9.

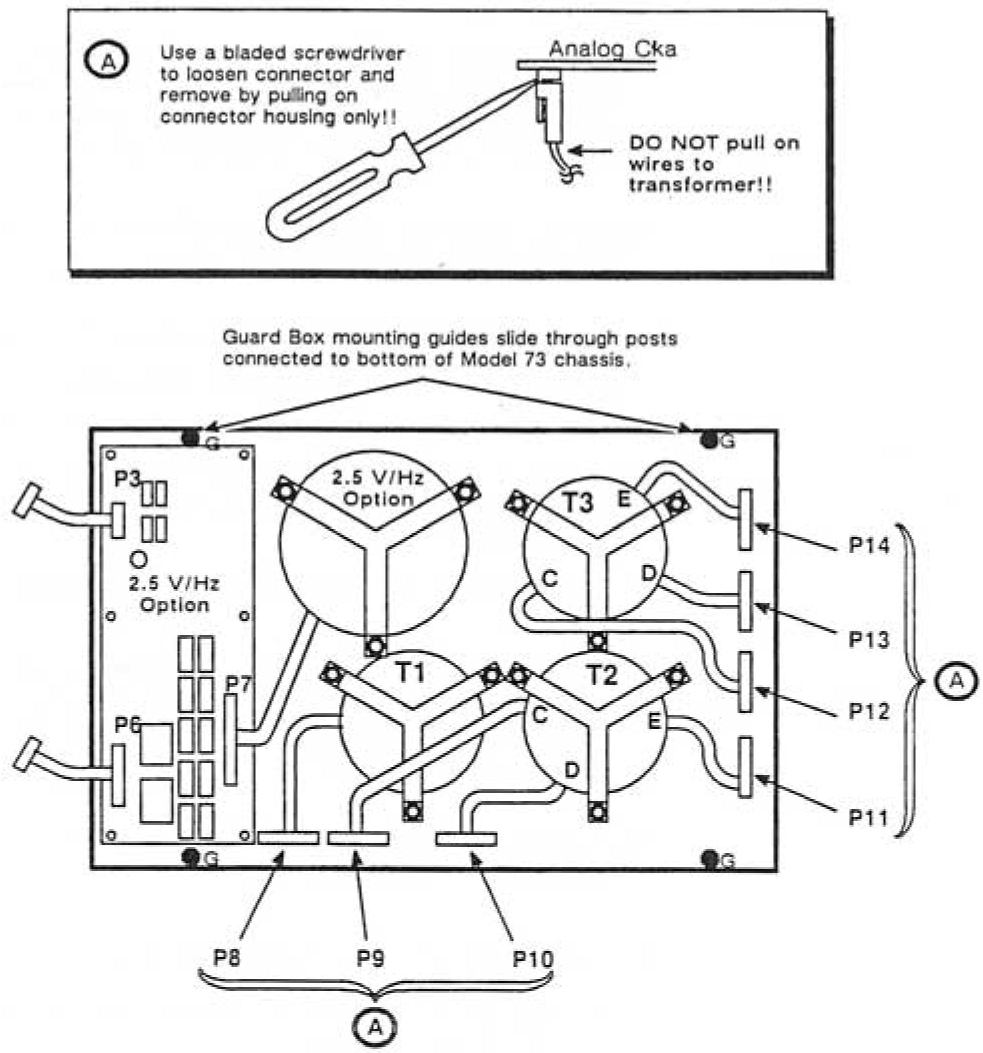


Figure 6-9. Guard Box Removed from Chassis

10. Install the 2.5 V/Hz transformer with the wires coming out of the transformer faced toward the bottom of the Guard Box. Using the other transformer mountings as a guide, secure the large 2.5 V/Hz transformer to the Guard Box with the hardware supplied in the kit. Refer to Figure 6-9.

11. Connect the 2.5 V/Hz transformer cable to P7 on the 2.5 V/Hz Cka. Refer to Figure 6-9.

12. Connect the Analog-Option IN cable supplied in the kit to P6 on the 2.5 V/Hz Cka and dress the cable over the side of the Guard Box as preparation to install the Analog Cka.

13. Install the Analog Cka in position over the transformers and plug the transformer cables to their respective connectors. After all cables are connected, secure the Analog Cka to the Guard Box (four stand-off posts and five screws). Refer to Figure 6-9.

14. Refer to Figure 6-8. Install the Guard Box into the chassis and connect the cables as follows:
    - PRT IN Cbl (P/N 68999) to P4 on Analog Cka (P/N 68889)
    - PRT OUT Cbl (P/N 69000) to P15 on Analog Cka (P/N 68889)
    - +12V-Analog Cbl (P/N 68998) to P17 on Analog Cka (P/N 68889)
    - Option-Analog Control Cbl to P3 on Analog Cka (P/N 68889)
    - 2.5 V/Hz to Analog IN Cbl (P/N 70607) to P6 on Analog Cka (P/N 68889)
    - CPU-Analog Cbl (P/N 68996) to J2 on CPU Cka (P/N 68700)

15. Secure the Guard Box shoulder connectors to the chassis (four screws) and replace the Guard Box top cover (four screws). Connect the CPU-Front Panel Cbl (P/N 68995) to J1 on the CPU Cka (P/N 68700). Refer to Figure 6-7.

16. Connect the top cover and secure with four screws on the bottom of the Model PRT73. See Figure 6-6.

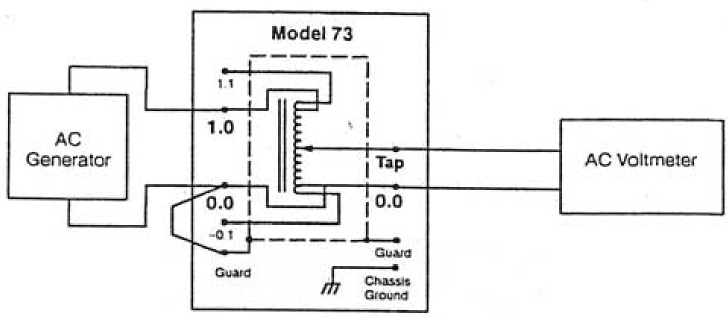
17. Switch power on and verify the option is functioning correctly.

    A. Press the 2.5 V/Hz range button and verify the range LED and the 10^{-8} display lights.

    B. To verify the 2.5 V/Hz decades are switching properly, set up the Model PRT73 with the equipment shown in Figure 6-10.

C. Step through the 2.5V/Hz decade and monitor the TASP OUTPUT with an AC voltmeter for the proper voltage division reading.

D. If you have an AC ratio bridge that is calibrated to a standard AC ratio transformer, you can generate correction values for the 2.5 V/Hz operating range by using the Performance Check Procedure in the Model PRT73 Manual. If you don't have a calibrated AC ratio bridge, you can send the Model PRT73 to TEGAM for certification, to the National Institute of Standards and Technology, or to another standards laboratory that offers this service.



2.5 V/Hz Decade Function Test

1. Set the Model PRT73 to the 2.5 V/Hz operating Range.

2. Set the AC generator to output 10 V at 60 Hz (no DC).

3. Starting with the Model PRT73 set to a RATIO of 1.00000000, decrement the first decade one digit at a time to 0.0. With each change in the ratio setting, the AC voltmeter reading should decrease by 1 VAC (in direct relation to the ratio setting). Example:

Ratio Setting	Voltmeter Reading
1.000	10 VAC
0.900	9 VAC
0.800	8 VAC
0.700	7 VAC
0.600	6 VAC
0.500	5 VAC
0.400	4 VAC
0.300	3 VAC
0.200	2 VAC
0.100	1 VAC
0.000	0 VAC

Figure 6-10. 2.5 V/Hz Decade Function Test Setup

MAINTENANCE

Maintenance performed by a qualified technician on a regular basis will insure the quality of Model PRT73 performance and reduce the possibility of instrument malfunction.

A maintenance procedure that includes cleaning and visual inspection should be performed at 6 month intervals for Model PRT73s installed in temperate and relatively clean environments. In relatively humid or dusty environments, a shorter maintenance interval is recommended.

A maintenance procedure that includes verifying the linearity specifications should be checked every 2 years.

WARNING

Removal of instrument covers may constitute an electrical hazard and should be accomplished by qualified service personnel only. Remove AC power to the Model PRT73 before attempting to clean or perform a visual inspection.

Cleaning

Remove AC power to the Model PRT73 before cleaning.

> **CAUTION**
>
> Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Do not apply any solvent containing ketones, esters, or halogenated hydrocarbons. To clean, use only water soluble detergents, ethyl, methyl, or isopropyl alcohol.

Exterior

DO NOT use abrasive cleaners. Remove loose dust with soft cloth or dry brush. Remove other dirt with a water and mild detergent solution.

Take extra care when cleaning the display window. Using an abrasive rag such as a paper towel will scratch the display window.

Interior

Cleaning the interior is not recommended unless the Model PRT73 is operated in a dirty environment. If you need to clean the interior of the Model PRT73.

- Use an anti-static strap attached to the Model PRT73 and yourself to protect the Model PRT73 components from damage.
- Use low-velocity compressed air with an anti-static tip to blow off the accumulated dust. Hardened dirt can be removed with a cotton-tipped swab, soft, dry cloth, or a cloth dampened with a mild detergent and water solution.

Visual Inspection

Verify the vents located around the Model PRT73 remain clear at all times. Overheating will result if the vents become blocked.

A visual inspection of the interior of the Model PRT73 is not recommended unless the interior needs cleaning or calibration is required.

If you remove the Model PRT73 covers, perform a visual inspection for such defects as broken connections, improperly seated semiconductors, damaged circuit cards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious. If heat damaged components are found, particular care must be taken. Over heating usually indicates other trouble may be present in the Model PRT73. It is important that the cause of overheating be corrected to prevent recurrence of the damage. Call a TEGAM service representative or TEGAM application engineer if heat damaged components are found.

Model PRT73 Performance Check

A Model PRT73 performance test should be performed every 2 years to ensure the quality of your measurements. For more information on how to perform the tests, refer to Section 8 – Performance Check.

PERFORMANCE CHECK AND CALIBRATION

Performance Check and Calibration 8

Procedures in this section are to be performed by qualified personnel only. The performance check procedure is a tool used to verify that the Model PRT73 is performing within its calibration specifications by comparison to a calibrated AC ratio bridge. It is to be performed:

- At scheduled times as part of your maintenance program
- To demagnetize the input if an overload has occurred
- To verify the operation of the over-voltage protection circuit

The Model PRT73 is designed to stay within its published specifications for 5 or more years. However, to guarantee the quality of your measurements, it is recommended to verify the linearity specifications a minimum of every 2 years.

TEGAM offers a 2-year certificate to document the ratio transformer's traceability to the U.S. National Institute of Standards and Technology (NIST).

Table 8-1. Performance Check and Calibration Contents

Performance Check Procedure

The following procedure describes the methods for checking the operation of the over-voltage circuit, degaussing the input transformer(s), and verifying the linearity specifications.

Table 8-2 and Table 8-3 list the equipment necessary to perform the linearity test procedure using a manual or semi-automated test system. To verify the operation of the over-voltage protection circuit or to degauss the transformers you only need an AC generator with no DC component.

Table 8-2. Equipment for Manual System

Equipment	Manufacturer and Model
Standard Ratio Transformer	DT72A or Model PRT73 Must be certified with correction Values at 1 kHz and 100 Hz.
Tuned Detector	GenRad 1238
AC Generator	GenRad 1316
Phase Compensation	PC874
Isolation Transformers	1:1 with primary and secondary shields.
3 1/2 –digit Digital Voltmeter	
Oscilloscope with X-Y mode	

Table 8-3. Equipment for Semi-automated System

Equipment	Manufacturer and Model
Standard Ratio Transformer	Model PRT73 Must be certified with correction Values at 1 kHz and 100 Hz.
Lock-in Amplifier	Standard Research System SR 530
AC Generator	Fluke 5700A or Datron/Wavetek 4200
Phase Compensation	PC874
Isolation Transformers	1:1 with primary and secondary shields
3 ½-digit Digital Voltmeter	
Oscilloscope with X-Y mode	

Over-voltage Circuit Test and Input Transformer Demagnetization

This test is to be performed prior to the performance check and after any input overload. Almost any type of AC generator that is used in your test system can be used to perform this check. If your AC generator coupled, it is recommended that an isolation transformer be used to block any unwanted DC component.

1. Setup the test equipment as shown in Figure 8-1.

2. Set the Model PRT73 to the 0.35 V/Hz operating range and the generator to 60 Hz and 0 V.

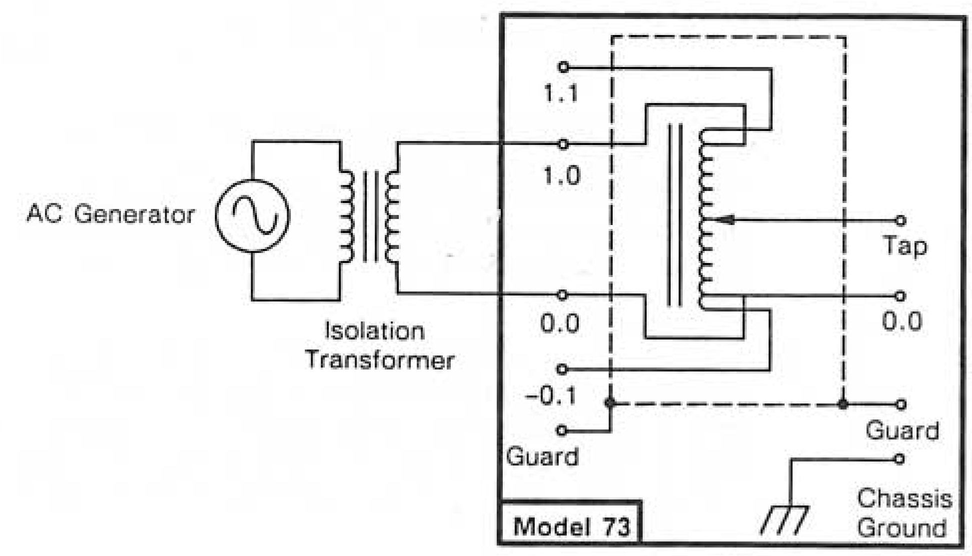


Figure 8-1. Test Equipment Connections for Transformer Demagnetization

3. The trip point for the over-voltage circuit is set to trip at, or 10% above, the 0.35 V/Hz rating. The normal operating range of the over-voltage circuit at 60 Hz is 21 V – 23.1 V. If you are not using 60 Hz to test the over-voltage circuit, calculate your maximum and minimum trip point voltages:

Minimum Trip Point Limit = Operating Range x f
Maximum Trip Point Limit = Operating Range x f x 1.1

4. Slowly increase the generator output to the minimum trip point and continue to increase the voltage to the maximum trip point or until the circuit activates and the Model PRT73 displays “OVERLOAD”.

    - If the circuit is working properly, an “OVERLOAD” message will appear on the Model PRT73’s display between 21 V and 23.1 V. If the 2.5 V/Hz option is installed, the range will change to 2.5 V/Hz (if the voltage does not also exceed the 2.5 V/Hz operating range).
    - If “OVERLOAD” is displayed before the minimum trip point is reached, the over-voltage circuit is too sensitive and indicates a probable failure requiring service. Call TEGAM for instructions.
    - If “OVERLOAD” does not appear on the display, the circuit is not working properly and may need the sensitivity adjusted. Perform the “Over-voltage Circuit Calibration” procedure (p. 8-25) then repeat this procedure from Step 1.

    NOTE: Any frequency and voltage within the operating range of the Model PRT73 can be used to check the over-voltage protection circuit. The trip point of the circuit is nominally 6% above the rated maximum input. It is considered to be working properly if it trips within a range from 0 – 10% above the rated maximum input value.

5. Degauss the input transformer: Set the range of the Model PRT73 to 0.35 v/Hz and decrease the input voltage back to 0 V. Slowly increase the voltage to just below the trip point voltage discussed in step 3, and SLOWLY (a period of several seconds) decrease the voltage back to 0V. The input transformer should now be degaussed.

    NOTE: Slowly decreasing the voltage from near saturation to 0 volts is the process that performs the degassing. It is important that during this process, in steps 4 and 6, the over-voltage circuit not be tripped. If the over-voltage circuit is tripped, reduce the voltage from the generator to 0 volts and repeat the process using a lower maximum voltage value.

6. If the 2.5 V/Hz option is installed you also need to degauss the 2.5 V/Hz transformer. To degauss the 2.5 V/Hz transformer:

    Set the range of the Model PRT73 to 2.5 V/Hz. Slowly increase the voltage again to the maximum input voltage rating. At 60 Hz, this would be 150V. When the maximum voltage is reached, SLOWLY decrease the voltage to 0 V. The 2.5 V/Hz transformer should now be degaussed.

Linearity Test

The linearity test is used to verify that the Model PRT73 is operating within its rated specifications or to calibrate the Model PRT73 or other ratio transformers. When you calibrate a Model PRT73 or other ratio transformer, you actually create a new set of correction values; you do not make any adjustments. The new correction values that will be generated are the same type as appear on the “PRT Calibration Certificate of Test.”

The method explained in this manual is the same method used in the TEGAM manufacturing laboratory. A progressive series of measurements are taken which can be tedious. Before attempting this procedure for generating three-terminal and four-terminal corrections, you should read the rest of this section to understand the process.

NOTE: TEGAM offers a calibration service that provides a certificate with correction values for your Model PRT73. The correction values are useful when accuracies approaching 0.9 ppm are required for three-terminal and four-terminal applications. See Section 3 – Operation to determine which correction values to use in your particular application.

Test System Setup

The process, and worksheets, included in this procedure are specific to the test system setup. Using equipment other than defined in Table 8-2 and Table 8-3 may induce errors not accounted for by this procedure.

There are three distinct differences between the test setup presented here and those previously documented by TEGAM.

The first difference is the use of a DVM for measuring the deviation between the AC ratio bridge TAP outputs and the standard ratio transformer or Unit Under Test TAP outputs. Using a DVM connected to the detector to measure deviations has two advantages:

1) Instead of nulling the detector with the AC ratio bridge transformer, deviations are read directly from the DVM and converted to ppm values using a scale factor formula. Nulling a detector using your test system ratio transformer is time consuming.

2) Nulling a detector using the AC ratio bridge transformer requires an additional decade (a Model PRT73 with the 2.5 V/Hz option) to achieve the same resolution as using the DVM.

The second difference is that we will use a standard ratio transformer with corrections at 100Hz and 1kHz to calibrate the AC ratio bridge and obtain system corrections, which means that the ratio transformer used in the test system does not have to be calibrated. The standard ratio transformer should be a certified Model PRT73 or DT72 with a certificate or corrections traceable to NIST.

The third difference is the use of two isolation transformers. The use of the isolation transformer between the AC generator and the rest of the system is necessary if the low output of the generator is connected to chassis ground. The detector isolation transformer, used between the detector and the rest of the system, helps reduce the stray capacitive loading on the system AC ratio transformer and the AC ratio transformer under test. As a result the incremental linearity of the test system is improved.

The test system setup is shown in Figure 8-3. This is a generic representation of the equipment setup. Refer to the specific equipment's documentation for detailed connections. An alternate system setup is shown in Figure 8-2. The alternate setup does not use the detector isolation transformer which may affect the accuracy of your incremental linearity measurements depending on the type of equipment used. When you are making measurements at 5 kHz or greater, you may need to remove the connection between the low input and guard on the certified standard to reduce high and low end offset errors in your measurements.

The same basic setup is used for manual and semi-automated test systems. The only difference is the connection of an IEEE-488 bus between each instrument and a host controller (personal computer). Uses of equipment are as follows:

Scope – Set up in an X-Y mode, you will use the scope to roughly adjust the phase compensation circuitry for a null. This appears as a flat horizontal line on the scope screen. Fine adjustment for phase null is monitored at the detector's quadrature display meter.

Digital Voltmeter – The 3 ½ - digit voltmeter is used to read the DC Meter output of the detector. The voltage from the DC Meter output is proportional to the AC voltage difference (offset voltage) between the two AC ratio transformers.

Generator Isolation Transformer – Isolates the ground-reference output of the generator from the grounded tap of the test system.

Detector Isolation Transformer – Reduces the stray capacitive loading on the system AC ratio transformer and the AC ratio transformer under test. The detector isolation transformer requires the primary and secondary to be shielded.

The primary shield is connected to the Tap of the AC ratio transformer driving the guard voltage which is set to same potential as the Tap output voltages of the system AC ratio transformer and the AC ratio transformer under test. This reduces the capacitive loading on the tap output leads from the system AC ratio transformer and the AC ratio transformer under test.

The secondary shield is connected to chassis ground. This shield reduces the amount of common mode signal that is capacitively coupled to the secondary of the transformer and to the input of the detector.

Guard Voltage Driver – The guard voltage is generated by either a DT72 or Model PRT73. During calibration, the ratio of the guard voltage driver is set to the same ratio as the system AC ratio divider.

Phase Compensation Circuitry – Used to generate a small quadrature signal to compensate for phase errors between the AC ratio bridge and the UUT. The phase angles are roughed-in by monitoring the scope for a horizontal display with the final adjustment made by monitoring the detector's quadrature display meter.

AC Generator – Provides the AC signal source for the ratio transformers, the external sync for the X input to the scope, and Quadrature and In Phase connections to the detector. The Quadrature and In Phase signals are used to detect an in-phase condition of the inputs at the detector.

Detector – Accepts Quadrature and In Phase signals from the AC generator. Provides the Y scope input and the comparator output to the digital voltmeter. The detector compares the input signals from both ratio transformers. Any differential voltage between the two inputs is output to the Digital Voltmeter and to the detector's front panel display meter. Capable to align the real and quadrature vectors with the real and quadrature errors in the system.

Verifying or Generating Three-terminal Corrections (C & C')

This test method will provide you with two sets of correction factors for the Unit Under Test (UUT) which in this procedure can be the Model PRT73 or any other ratio transformer. The corrections are referenced to as "Transfer Ratio Correction – (C)" and "End Adjusted Linearity Correction (C')". The test method uses mathematical linearization to obtain correction values. It also uses a standard certified ratio transformer to calibrate the test system or AC ratio bridge.

Notes are provided throughout this procedure if your test setup or AC ratio bridge uses a mechanical lead balance or if you already know your system corrections.

Sample 1 kHz test data that will be generated by this procedure is shown in Figure 8-4. The chart will be referenced throughout this procedure to illustrate how the values are derived. An empty chart is provided in Figure 8-14 (p. 8-23).

NOTE: The alternate setup shown in Figure 8-2 does not use the detector isolation transformer which may affect the accuracy of your incremental linearity measurements depending on the type of equipment used. When you are making measurements at 5 kHz or greater, you may need to remove the connection between the low input and guard on the certified standard to reduce high and low end offset errors in you measurements.

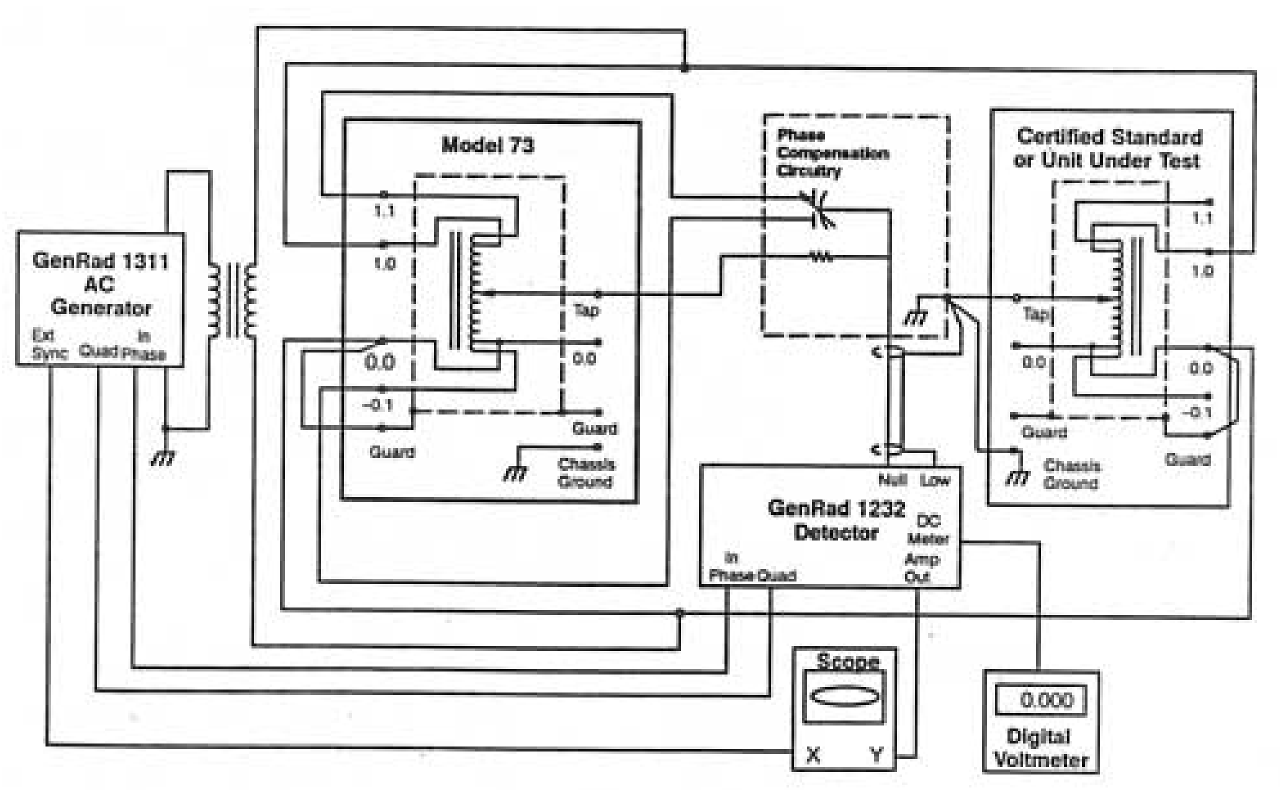


Figure 8-2. Alternate Test Equipment Setup for Testing Linearity.

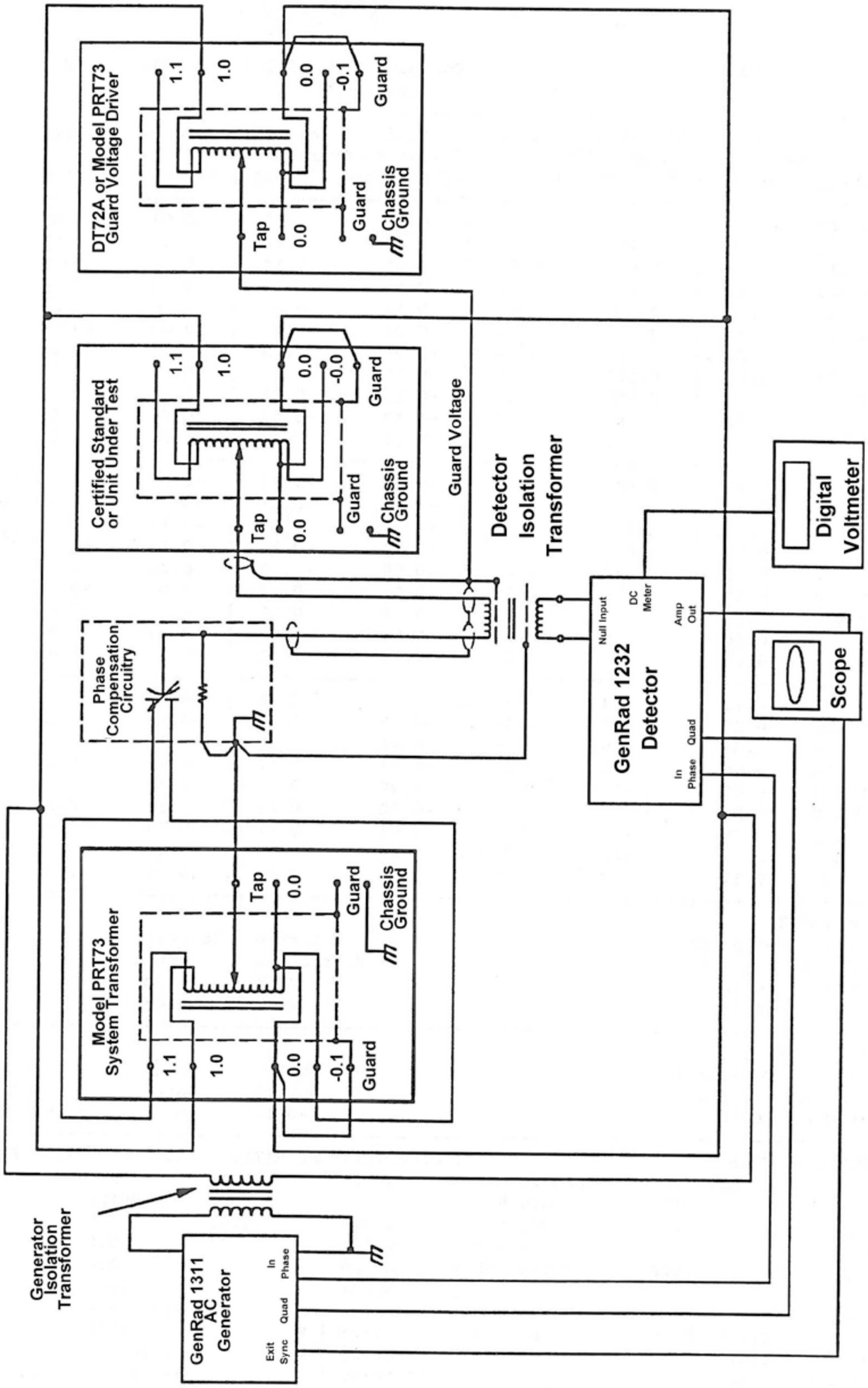


Figure 8-3. Test Equipment Setup for Testing Linearity

PRT73 INSPECTION RECORD

Date: 12/12/90 Inspector: Don Hayes Serial #: 2041190PRT73
Inspection Station #10 1 kHz. 100 VAC Readings

Ratio At tap	UNIT UNDER TEST Detector Voltage	Deviation in ppm	MEASUREMENT SYSTEM Detector Voltage	Deviation in ppm	NIST Deviation Of Standard	System Correction in ppm	Corrected UUT In ppm	Transfer Ratio Corr C	End Adjusted Linearity Corr C'
1.000	-0.133	-0.05	-0.193	-0.07	0.01	0.08	0.03	0.05	0.00
0.900	-0.376	-0.15	-0.257	-0.10	0.09	0.19	0.04	0.05	0.01
0.800	-0.118	-0.05	-0.074	-0.03	0.15	0.18	0.13	0.14	0.10
0.700	0.151	0.08	0.010	0.00	0.15	0.15	0.21	0.21	0.18
0.600	0.383	0.15	0.201	0.08	0.13	0.05	0.20	0.20	0.17
0.500	0.161	0.06	0.237	0.09	0.03	-0.08	0.00	-0.01	-0.03
0.400	0.197	0.08	0.154	0.08	-0.04	-0.10	-0.02	-0.04	-0.05
0.300	0.183	0.07	0.205	0.08	-0.13	-0.21	-0.14	-0.16	-0.17
0.200	0.351	0.14	0.306	0.12	-0.15	-0.27	-0.13	-0.18	-0.16
0.100	0.537	0.21	0.246	0.09	-0.13	-0.22	-0.01	-0.05	-0.04
0.000	0.427	0.17	0.380	0.14	0.00	-0.14	0.03	-0.01	0.00
0.090	0.306	0.12	0.247	0.09	-0.12	-0.21	-0.09	-0.13	-0.12
0.080	0.273	0.11	0.281	0.11	-0.10	-0.21	-0.10	-0.14	-0.13
0.070	0.281	0.11	0.333	0.13	-0.09	-0.22	-0.11	-0.15	-0.14
0.060	0.319	0.12	0.363	0.14	-0.08	-0.22	-0.10	-0.14	-0.13
0.050	0.336	0.13	0.353	0.13	-0.09	-0.22	-0.09	-0.13	-0.12
0.040	0.335	0.13	0.396	0.15	-0.07	-0.22	-0.09	-0.13	-0.12
0.030	0.437	0.17	0.413	0.16	-0.06	-0.22	-0.05	-0.09	-0.08
0.020	0.419	0.16	0.387	0.15	-0.05	-0.20	-0.04	-0.08	-0.07
0.010	0.446	0.17	0.346	0.13	-0.04	-0.17	-0.00	-0.04	-0.03
0.009	0.343	0.13	0.384	0.15	-0.03	-0.18	-0.05	-0.09	-0.08
0.008	0.209	0.08	0.393	0.15	-0.03	-0.18	-0.10	-0.14	-0.13
0.007	0.138	0.05	0.399	0.15	-0.01	-0.16	-0.11	-0.15	-0.14
0.006	0.151	0.06	0.422	0.16	-0.01	-0.17	-0.11	-0.15	-0.14
0.005	0.151	0.06	0.430	0.16	-0.02	-0.18	-0.12	-0.16	-0.15
0.004	0.182	0.07	0.427	0.16	-0.02	-0.18	-0.11	-0.15	-0.14
0.003	0.221	0.09	0.420	0.16	-0.01	-0.17	-0.08	-0.12	-0.11
0.002	0.321	0.12	0.422	0.16	-0.01	-0.17	-0.05	-0.09	-0.08
0.001	0.427	0.17	0.412	0.16	0.00	-0.16	0.01	-0.03	-0.02

DEVIATION OF INPUT

Ratio Input	Detector Voltage	Deviation in ppm	System Correction	Corrected Inputs
1.0	-0.261	-0.10	0.08	-0.02
0.0	0.469	0.18	-0.14	0.04

DEVIATION OF OUTPUT LO

Ratio Input	Detector Voltage	Deviation in ppm	System Correction	Corrected output	w/respect to input LO
0.0	0.425	0.16	-0.14	0.02	-0.02

DETECTOR SCALE FACTORS

	Test Unit	Standard
Voltage at 0 ppm	0.427	0.380 V
Voltage at FS chg	-2.150	-2.268 V
Ppm change	1	1 ppm
Scale factor	2.577	2.648 V/P

FOUR TERMINAL RATIO CORRECTIONS EXAMPLES

Ratio	ppm/	ppm/
1.000	0.07	0.07
0.100	-0.03	-0.29
0.010	-0.02	-2.43
0.001	-0.01	-14.86

REFERENCE DATA	STANDARD SN	NIST#	DATE
1 khz	13816	246944	09/05/90
Measurement System readings			12/10/90

WORST CASE DEVIATIONS	3 Term	Linearized
Maximum Positive	0.21	0.18
Maximum Negative	-0.16	-0.17

Page 1 of 2

Figure 8-4. Sample of Correction Values to be Generated

1. Set up the test system as shown in Figure 8-3 or Figure 8-2 with the certified standard in place of the UUT. All test equipment is setup for measuring the deviation between the test system ratio transformer and the certified standard at 100 V and 1 kHz (or 10V at 100 Hz).

   NOTE: If your AC ratio bridge is already calibrated, go to step 5.

2. Determine the scale factor (Detector Scale Factors in the Sample record) for converting the detector voltage readings to ppm values. Figure 8-5 reflects the values appearing on the sample form.

   NOTE: Each time the system setup, generator output, or detector sensitivity is changed, a new scale factor must be generated.

   A. Set the system, guard driver (if applicable), and standard ratio transformers to 0.0.

   B. Make rough corrections for phase differences by adjusting the phase compensation circuitry while monitoring the scope (look for a flat horizontal line). Fine adjust the phase differences by monitoring the Quad meter on the detector (zero or null the meter reading).

      Record the digital voltmeter reading. This is your S_1 value.

   C. Change the AC bridge transformer setting to 1 ppm (0.000001).

   D. Adjust the phase differences as explained in step 2.B. Record this value as your S_2 value.

   E. Calculate the difference between S_1 and S_2. Record this value including sign (+/-) for the Standard Scale Factor.

DEVIATION OF OUTFIT LO

Ratio Input	Detector Voltage	Deviation in ppm	Syst… Corre…	…ct LO
0.0	0.425	0.16	-0.14	…02

DETECTOR SCALE FACTORS	Test Unit	Standard
Voltage at 0 ppm	0.427	0.380 V
Voltage at FS Chg	-2.150	-2.268 V
ppm Change	1	1 ppm
Scale factor	2.577	2.648 V/P

FOUR TERMINAL R… …MPLES

Ratio		
1.000	0.07	0.07
0.100		-0.29
0.01		-2.43
0.000		-14.86

REFERENCE DATA	STANDARD SN	NIST #	DATE
1 kHz	13816	246944	09/05/90
Measurement System readings			12/10/90

WORST CASE DEVIATIONS	3 Term	Linearized
Maximum Positive	0.21	0.18
Maximum Negative	-0.16	-0.17

Step 2B S_1 → 0.380 V

Step 2D S_2 → -2.268 V

Step 2E Scale Factor → 2.648 V/P

Figure 8-5. Measurements Recorded to Calculate Scale Factor Value

3. Comparison measurements are made between the system ratio transformer and the certified standard at each setting of the first three decades. All three AC ratio dividers are set to the same ratio when deviation measurements are performed. Deviation readings are read at the digital voltmeter and recorded as the Measurement System Detector Voltage. The meter readings are then converted to ppm values by dividing them by the scale factor derived in step 2.E. These values are the Measurement System Deviation values in ppm.

   NOTE: During each of the comparison measurements the phase compensation circuitry is adjusted to eliminate any phase differences between the two input signals to the detector.

4. Subtract the Measurement System Deviation in ppm values from the NIST Deviation of Standard in ppm values to obtain System Correction in ppm values. The system is now calibrated and the system's ratio transformer will now be effectively used as a transfer standard using the System Correction in ppm values.

Ratio at tap	UNIT UNDER TEST Detector Deviation Voltage	UNIT UNDER TEST Detector Deviation in ppm	MEASURMENT SYSTEM Detector Deviation Voltage	MEASURMENT SYSTEM Detector Deviation in ppm	NIST Deviation of Standard	SYSTEM Correction in ppm
1.000			-0.193	-0.07	0.01	0.08
0.900			-0.257	-0.10	0.09	0.19
0.800			-0.074	-0.03	0.15	0.18
0.700			0.010	0.00	0.15	0.15
0.600			0.201	0.08	0.13	0.05
0.500			0.237	0.09	0.03	-0.06
0.400			0.154	0.06	-0.04	-0.10
0.300			0.205	0.08	-0.04	-0.21
0.200			0.306	0.12	-0.04	-0.27
0.100			0.246	0.09	-0.13	-0.22
0.000			0.380	0.14	0.00	-0.14
0.090			0.247	0.09	-0.12	-0.21
0.080			0.281	0.11	-0.10	-0.21
0.070			0.333	0.13	-0.09	-0.22
0.060			0.363	0.14	-0.08	-0.22
0.050			0.353	0.13	-0.09	-0.22
0.040			0.396	0.15	-0.07	-0.22
0.030			0.413	0.16	-0.06	-0.22
0.020			0.387	0.15	-0.05	-0.20
0.010			0.346	0.13	-0.04	-0.17
0.009			0.384	0.15	-0.03	-0.18
0.008			0.393	0.15	-0.03	-0.18
0.007			0.399	0.15	-0.01	-0.16
0.006			0.422	0.16	-0.01	-0.17
0.005			0.430	0.16	-0.02	-0.18
0.003			0.427	0.16	-0.02	-0.18
0.003			0.420	0.16	-0.01	-0.17
0.002			0.422	0.16	-0.01	-0.17
0.001			0.412	0.16	0.00	-0.16

Step 3. Deviation readings of voltmeter recorded at each tap setting.

Step 3. Convert voltmeter readings to ppm values by dividing the voltage reading by the scale factor derived in step 2:

$$\frac{\text{Voltage}}{\text{Scale Factor}} = \text{Deviation in ppm}$$

Step 4. kHz correction values of standard ratio transformer from NIST.

Step 4. Subtract Measurement System Deviation in ppm values from NIST Deviation of Standard values to obtain System Correction in ppm values

Figure 8-6. Measurements Recorded to Calculate System Correction Values

5. Set up the test system as shown in Figure 8-3 or Figure 8-2 with the UUT in place of the certified standard. All test equipment is setup for measuring the deviation between the AC bridge transformer and the UUT at 100 V and 1 kHz (or 10V at 100 Hz).

6. A second scale factor is calculated and recorded for a 1 ppm difference between the UUT and the system ratio transformers for converting the digital voltmeter readings to ppm values. Figure 8-7 identifies the values appearing on the sample form.

NOTE: Each time the system setup, generator output, or detector sensitivity is changed, a new scale factor must be generated.

A. Set the system, guard driver (if applicable), and unknown ratio transformers to 0.0.

B. Make a rough corrections for phase differences by adjusting the phase compensation circuitry while monitoring the scope (look for a flat horizontal line). Fine adjust the phase differences by monitoring the Quad meter on the detector (zero or null the meter reading).

Record the digital voltmeter reading as you S_1 value.

C. Change the AC bridge transformer setting to 1 ppm (0.000001).

D. Adjust for phase differences as explained in step 2.B. Record the digital voltmeter reading as you S_2 value.

E. Calculate the <u>difference</u> between S_1 and S_2. Record this value including sign (+/-) for the Test Unit Scale Factor.

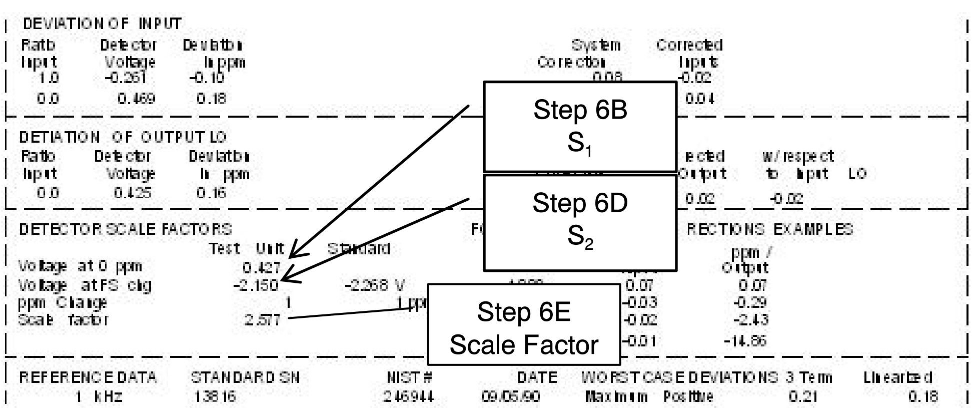


Figure 8-7. Measurements Recorded to Calculate Scale Factor Value for UUT

7. Comparison measurements are made between the system transformer and the UUT at each setting of the first three decades. All three AC ratio dividers are set to the same ratio when deviation measurements are performed. Deviation readings are read at the digital voltmeter and recorded as the UUT Detector Voltage. The meter readings are then converted to ppm values by dividing them by the scale factor derived in step 6.E. These values are the UUT Deviation values in ppm. See Figure 8-9 for where these measurements are recorded on the sample chart.

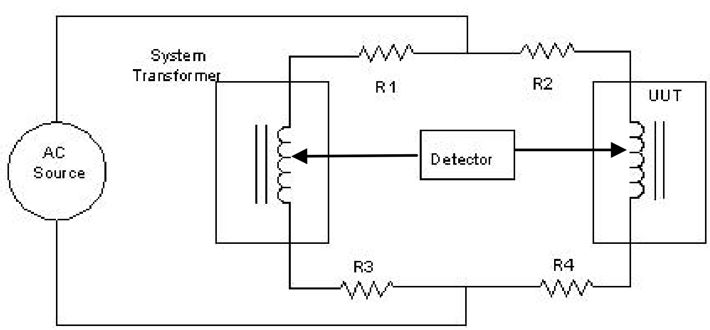
   NOTE: During each of the comparison measurements the phase compensation circuitry is adjusted to eliminate any phase differences between the two signals to the detector.

8. Corrected UUT values are calculated by adding the UUT Deviation values and the System Correction values. See Figure 8-9 for where these calculations are recorded on the sample chart.

   NOTE: For AC ratio bridges like the one described here, the Corrected UUT values are correction values that include offset and gain errors induced by factors that include:

   - Unbalanced resistance in the test leads between the ratio bridges and the AC source. See Figure 8-8.
   - Offset and gain errors in the detector.

For AC ratio bridges that use mechanical lead balancing, the values obtained at this point of the procedure are the End Adjusted Linearity Corrections (C'). If you use mechanical lead balancing, stop at this point and repeat this procedure at an AC generator frequency of 100 Hz at 10 volts.



Unbalanced test lead resistance will cause gain and offset error in your corrections	R1 ≠ R2 R3 ≠ R4

Figure 8-8. System Offset and Gain Errors Due to Unbalanced Lead Resistance.

Step 7. Deviation readings of voltmeter recorded at each tap setting.

Step 8. Convert voltmeter to ppm values by dividing the voltage reading by the scale factor derived in step 6:

$$\frac{\text{Voltage}}{\text{Scale Factor}} = \text{deviationinppm}$$

Step 8 System Correction Values calculated in Step 4.

Ratio at tap	UNIT UNDER TEST Detector Deviation Voltage	UNIT UNDER TEST Detector Deviation in ppm	MEASURMENT SYSTEM Detector Deviation Voltage	MEASURMENT SYSTEM Detector Deviation in ppm	NIST Deviation of Standard	SYSTEM Correction in ppm	
1.000	-0.133	-0.05	-0.193	-0.07	0.01	0.08	0.03
0.900	-0.376	-0.15	-0.257	-0.10	0.09	0.19	0.04
0.800	-0.118	-0.05	-0.074	-0.03	0.15	0.18	0.13
0.700	0.151	0.06	0.010	0.00	0.15	0.15	0.21
0.600	0.383	0.15	0.201	0.08	0.13	0.05	0.20
0.500	0.161	0.06	0.237	0.09	0.03	-0.06	0.00
0.400	0.197	0.08	0.154	0.06	-0.04	-0.10	-0.02
0.300	0.183	0.07	0.205	0.08	-0.04	-0.21	-0.14
0.200	0.351	0.14	0.306	0.12	-0.04	-0.27	-0.13
0.100	0.537	0.21	0.246	0.09	-0.13	-0.22	-0.01
0.000	0.427	0.17	0.380	0.14	0.00	-0.14	-0.03
0.090	0.306	0.12	0.247	0.09	-0.12	-0.21	-0.09
0.080	0.273	0.11	0.281	0.11	-0.10	-0.21	-0.10
0.070	0.281	0.11	0.333	0.13	-0.09	-0.22	-0.11
0.060	0.329	0.12	0.363	0.14	-0.08	-0.22	-0.10
0.050	0.336	0.13	0.353	0.13	-0.09	-0.22	-0.09
0.040	0.335	0.13	0.396	0.15	-0.07	-0.22	-0.09
0.030	0.437	0.17	0.413	0.16	-0.06	-0.22	-0.05
0.020	0.419	0.16	0.387	0.15	-0.05	-0.20	-0.04
0.010	0.446	0.17	0.346	0.13	-0.04	-0.17	-0.00
0.009	0.343	0.13	0.384	0.15	-0.03	-0.18	-0.05
0.008	0.209	0.08	0.393	0.15	-0.03	-0.18	-0.10
0.007	0.138	0.05	0.399	0.15	-0.01	-0.16	-0.11
0.006	0.151	0.06	0.422	0.16	-0.01	-0.17	-0.11
0.005	0.151	0.06	0.430	0.16	-0.02	-0.18	-0.12
0.003	0.182	0.07	0.427	0.16	-0.02	-0.18	-0.11
0.003	0.221	0.09	0.420	0.16	-0.01	-0.17	-0.08
0.002	0.321	0.12	0.422	0.16	-0.01	-0.17	-0.05
0.001	0.427	0.17	0.412	0.16	0.00	-0.16	-0.01

\+ =

Step 8. Add the UUT Deviation in ppm values to the System Correction in ppm values to obtain Corrected UUT in ppm values.

Figure 8-9. Calculating Corrected UUT Values

9. Correct for setup offset and gain errors by measuring the deviation between the UUT's 1.0 and 0.0 INPUTs and the AC ratio bridge TAP OUTPUT at settings of 1.0 and 0.0, then mathematically linearize the data.

   A. Move the test lead from the UUT TAP output to the 1.0 INPUT terminal. Set the ratio of the system and guard driver AC ratio bridges to 1.0 and record the digital voltmeter reading.

   B. Divide the reading by the scale factor to obtain a ppm value.

   C. Add the System Correction for a 1.0 setting to the deviation and record this value under Corrected Inputs. This is your $Dev_{1.0}$ value that is used in the 1st linearization calculations.

   D. Move the UUT test lead to the 0.0 INPUT terminal. Set the ratio of the system and guard driver AC ratio bridges to 0.0 and record the digital voltmeter reading.

   E. Divide the reading by the scale factor to obtain a ppm value.

   F. Add the System Correction for a 0.0 setting to the deviation and record this value under Corrected Inputs. This is your $Dev_{0.0}$ value that is used in the 1st linearization calculations.

   G. Linearize the Corrected UUT data at each ratio setting to obtain the Transfer Ratio Correction (C) values. Use the formula in Figure 8-11.

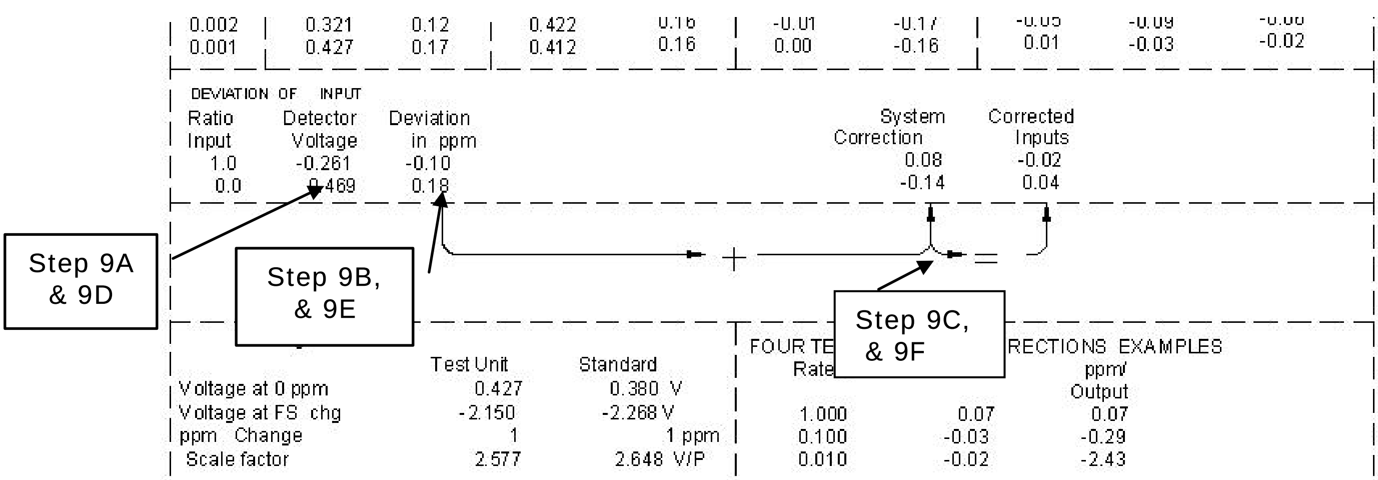
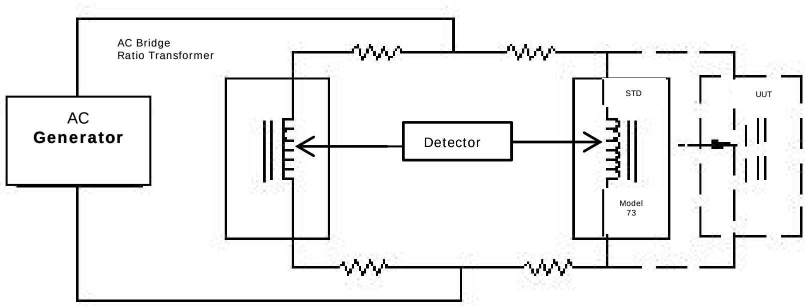
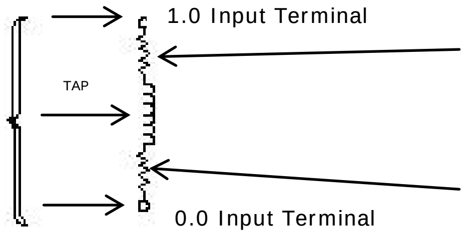


Figure 8-10. Measurements at UUT 1.0 and 0.0 INPUT Terminals with Corrections



Unbalanced test lead resistance will cause gain and offset error in your measurements.

With the 1st linearization calculation you look at the linearity of the UUT tap settings in reference to the 1.0 and 0.0 INPUTs.



Errors internal to the ratio transformer between the 1.0 and 0.0 INPUTs and the 1.0 and 0.0 tap settings. These errors are removed in the 2nd linearization calculation to achieve the End Adjusted Linearity

The 1st linearization removes the gain and offset errors of your test setup. The formula shown below will produce the Transfer Ratio Corrections (C).

Formula: $\text{CorrUUT} - \text{Dev0.0} - S(\text{Dev}_{1.0} - \text{Dev}_{0.0}) = C$

CorrUUT = System Corrected UUT values at each tap setting

$\text{Dev}_{0.0}$ = Deviation of UUT 0.0 INPUT to AC Bridge transformer 0.0 TAP OUTPUT

$\text{Dev}_{1.0}$ = Deviation of UUT 1.0 INPUT to AC Bridge transformer 1.0 TAP OUTPUT

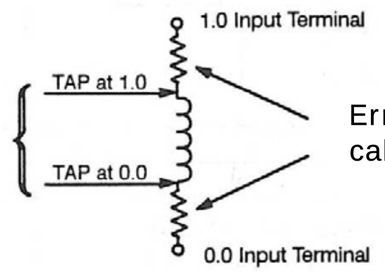
S = Ratio at tap setting

C = Transfer Ratio Correction

Figure 8-11. Linearization formula for Transfer Ratio Corrections (C)

10. Linearize the Transfer Ratio Correction (C) data to derive the End Adjusted UUT Linearity Correction (C') values. Use the formula as shown in Figure 8-12.

With the 2nd linearization calculation you look at the linearity of the UUT tap settings in reference to the 1.0 and 0.0 TAP OUTPUT ratio settings.



Errors removed by 2nd linearization calculation

The 2nd linearization removes the errors internal to the ratio transformer between the 1.0 and 0.0 INPUT terminals and the 1.0 and the 0.0 TAP OUTPUT ratio settings. The corrections that result from the second linearization are called End Adjusted Linearity Corrections (C').

Formula: $C_T - C_{0.0} - S(C_{1.0} - C_{0.0}) = C'$

C_T = Transfer Ratio Correction (C) values at each tap setting

$C_{0.0}$ = Transfer Ratio Correction (C) 0.0 value

$C_{1.0}$ = Transfer Ratio Correction (C) 1.0 value

S = Ratio at tap setting

C' = End Adjusted Linearity Correction value

Figure 8-12. Linearization formula for End Adjusted Linearity Correction (C')

NOTE: When comparing corrections to other sources:

The corrections (C) are of the same type generated by NIST standard ratio transformer measurements.

The corrections (C') are similar in type to those TEGAM has historically supplied on calibration certificates for the DT72.

11. Set the AC generator to output 10V at 100 Hz. Repeat this entire procedure to obtain 100 Hz correction values.

Verifying or Generating Four-terminal Corrections

This procedure will generate two sets of four-terminal correction values for use when the Model PRT73 is configured as an attenuator or four-terminal device. These corrections take into account the small error between the 0.0 INPUT terminal and the 0.0 OUTPUT terminal. The two correction values are referred to as Four-terminal Ratio Correction ppm/Input (D) and Four-terminal Ratio Correction Values ppm/Output (D')

Samples of the test chart shown in Figure 8-4 (p. 8-11) are referenced in this procedure to illustrate how the values are derived. An empty chart is provided in Figure 8-15 (p. 8-24) for recording your measurements and calculated correction values.

1. Using the same test setup you used for generating the three-terminal correction values (reference Figure 8-3, p. 8-10), set the AC ratio bridge transformer to output 1 kHz, at 100V (or 100 Hz, at 10V).

2. Measure the deviation between the 0.0 INPUT and the 0.0 OUTPUT terminal. Refer to Figure to 8-13.

   A. Move the test lead from the UUT TAP output to its 0.0 OUTPUT terminal. Set the ratio of the system and guard driver AC ratio bridges to 0.0 and record the digital voltmeter reading under DEVIATION OF OUTPUT LO Detector Voltage.

   B. Divide the reading by the scale factor (scale factor must be the one derived for the particular frequency and voltage setting) to obtain a ppm value (DEVIATION OF OUTPUT LO Deviation in ppm).

   C. Calculate the Corrected Output by adding the DEVIATION OF OUTPUT LO Deviation in ppm value to the Three-terminal System Correction value at the 0.0 ratio setting.

   D. Calculate the deviation between the 0.0 INPUT and the 0.0 OUTPUT terminals by subtracting the DEVIATION OF INPUT 0.0 Corrected Input value from the DEVIATION OF OUTPUT LO Corrected Output value. Enter this value under w/respect to input LO.

Ratio at tap	UNIT UNDER TEST Detector Deviation Voltage	UNIT UNDER TEST Detector Deviation in ppm	MEASURMENT SYSTEM Detector Deviation Voltage	MEASURMENT SYSTEM Detector Deviation in ppm	NIST Deviation of Standard	SYSTEM Correction in ppm	Corrected UUT in ppm	Transfer Ratio Corr C	End Adjusted Linearity Corr C'
1.000	-0.133	-0.05	-0.193	-0.07	0.01	0.08	0.03	0.05	0.00
0.900	-0.376	-0.15	-0.257	-0.10	0.09	0.19	0.04	0.05	0.01
0.800	-0.118	-0.05	-0.074	-0.03	0.15	0.18	0.13	0.14	0.10
0.700	0.151	0.06	0.010	0.00	0.15	0.15	0.21	0.21	0.18
0.600	0.383	0.15	0.201	0.08	0.13	0.05	0.20	0.20	0.17
0.500	0.161	0.06	0.237	0.09	0.03	-0.06	0.00	-0.01	-0.03
0.400	0.197	0.08	0.154	0.06	-0.04	-0.10	-0.02	-0.04	-0.05
0.300	0.183	0.07	0.205	0.08	-0.04	-0.21	-0.14	-0.16	-0.17
0.200	0.351	0.14	0.306	0.12	-0.04	-0.27	-0.13	-0.16	-0.16
0.100	0.537	0.21	0.246	0.09	-0.13	-0.22	-0.01	-0.05	-0.04
0.000	0.427	0.17	0.380	0.14	0.00	-0.14	-0.03	-0.01	0.00
0.090	0.306	0.12	0.247	0.09	-0.12	-0.21	-0.09	-0.13	-0.12
0.080	0.273	0.11	0.281	0.11	-0.10	-0.21	-0.10	-0.14	-0.13
0.070	0.281	0.11	0.333	0.13	-0.09	-0.22	-0.11	-0.15	-0.14
0.060	0.329	0.12	0.363	0.14	-0.08	-0.22	-0.10	-0.14	-0.13
0.050	0.336	0.13	0.353	0.13	-0.09	-0.22	-0.09	-0.13	-0.12
0.040	0.335	0.13	0.396	0.15	-0.07	-0.22	-0.09	-0.13	-0.12
0.030	0.437	0.17	0.413	0.16	-0.06	-0.22	-0.05	-0.09	-0.08
0.020	0.419	0.16	0.387	0.15	-0.05	-0.20	-0.04	-0.08	-0.07
0.010	0.446	0.17	0.346	0.13	-0.04	-0.17	-0.00	-0.04	-0.03
0.009	0.343	0.13	0.384	0.15	-0.03	-0.18	-0.05	-0.09	-0.08
0.008	0.209	0.08	0.393	0.15	-0.03	-0.18	-0.10	-0.14	-0.13
0.007	0.138	0.05	0.399	0.15	-0.01	-0.16	-0.11	-0.15	-0.14
0.006	0.151	0.06	0.422	0.16	-0.01	-0.17	-0.11	-0.14	-0.14
0.005	0.151	0.06	0.430	0.16	-0.02	-0.18	-0.12	-0.16	-0.15
0.003	0.182	0.07	0.427	0.16	-0.02	-0.18	-0.11	-0.15	-0.14
0.003	0.221	0.09	0.420	0.16	-0.01	-0.17	-0.08	-0.12	-0.11
0.002	0.321	0.12	0.422	0.16	-0.01	-0.17	-0.05	-0.09	-0.08
0.001	0.427	0.17	0.412	0.16	0.00	-0.16	-0.01	-0.03	-0.02

DEVIATION OF INPUT

Ratio Input	Detector Voltage	Deviation in ppm	System Correction	Corrected Inputs
1.0	-0.261	-0.10	0.08	-0.02
0.0	0.469	0.18	-0.14	0.04

Step 2D

DEVIATION OF INPUT

Ratio Input	Detector Voltage	Deviation in ppm	System Correction	Correction output	w / respect to input LO
0.0	0.425	0.16	-0.14	0.02	-0.02

Step 2A

Step 2B

Step 2C

+ =

DETECTOR SCALE FACTORS

	Test Unit	Standard
Voltage at 0 ppm	0.427	0.380 V
Voltage at FS chg	-.150	-2.268 V
ppm Change	1	1 ppm
Scale factor	2.577	2.648 V/P

FOUR TERMINAL RATIO CORRECTIONS EXAMPLES

Ratio	ppm / Input	ppm / Output
1.000	0.07	0.07
0.100	-0.03	-0.29
0.010	-0.02	-2.43
0.001	-0.01	-14.86

Figure 8-13. Calculating DEVIATION OF OUTPUT LO Values

3. Calculate the Four-terminal Ratio Correction ppm/Input (D) values for each ratio tap setting of the first three decades by subtracting the w/respect to input LO value from each of the Transfer Ratio Correction (C) values:

Formula: C_T – w/respect to input LO = D
C_T = Transfer Ratio Correction (C) values at each tap setting
D = Four-terminal Ratio Correction ppm/Input

4. Calculate the Four-terminal Ratio Correction ppm/Output (D') values for each ratio tap setting of the first three decades by dividing the Four-terminal Ratio Correction ppm/Input (D) values by the ratio setting:

Formula: D/r = D'
r = Ratio tap setting
D = Four-terminal Ratio Correction ppm/input
D = Four-terminal Ratio Correction ppm/output

Model PRT73 Calibration Record
Three-terminal Corrections

Serial Number:___________ Reading: *f* =_______ V=________ Date:________

Inspection Station:________ Inspector: _________________________

Ratio at TAP	UNIT UNDER TEST Detector Voltage	Deviation in ppm	MEASUREMENT SYSTEM Detector Voltage	Deviation in ppm	NIST Deviation of Standard	System Correction in ppm	Corrected UUT in ppm	Transfer Ratio Corr C	End Adjusted Linearity Corr C'
1.000									
0.900									
0.800									
0.700									
0.600									
0.500									
0.400									
0.300									
0.200									
0.100									
0.000									
0.090									
0.080									
0.070									
0.060									
0.050									
0.040									
0.030									
0.020									
0.010									
0.009									
0.008									
0.007									
0.006									
0.005									
0.004									
0.003									
0.002									
0.001									

DEVIATION OF INPUT

Ratio Input	Detector Voltage	Deviation in ppm	System Correction in ppm	Corrected INPUTS in ppm
1.0	__________	________	________	________
0.0	___________	________	________	________

DEVIATION OF OUTPUT LO

Ratio Input	Detector Voltage	Deviation in ppm	System Correction in ppm	Corrected OUTPUT in ppm	w/respect to 0.0 INPUT
0.0	__________	________	________	________	__________

DETECTOR SCALE FACTORS

	UUT	Standard
Voltage at 0.0	_____	________
Voltage at FS Change	______	________
Scale Factor	______	________

REFERENCE DATA

Standard S/N ___________

Calibration Date ___________

NOTES:

Model PRT73 Calibration Record
Four-terminal Corrections

Serial Number: _________ Date: ____________

Inspection Station: ______ Inspector: ________

Ratio at TAP	TRANSFER Ratio Corr C	1kHz Ratio Corrections ppm Input D	ppm Output D'	100 Hz Corrections ppm Input D	ppm Output D'
1.000					
0.900					
0.800					
0.700					
0.600					
0.500					
0.400					
0.300					
0.200					
0.100					
0.000					
0.090					
0.080					
0.070					
0.060					
0.050					
0.040					
0.030					
0.020					
0.010					
0.009					
0.008					
0.007					
0.006					
0.005					
0.004					
0.003					
0.002					
0.001					

DEVIATION OF INPUT

Ratio Input	Detector Voltage	Deviation in ppm	System Correction in ppm	Corrected INPUTS in ppm
0.0	______	________	________	_______

DEVIATION OF OUTPUT LO

Ratio Input	Dector Voltage	Deviation in ppm	System Correction in ppm	Corrected OUTPUT in ppm	w/respect to 0.0 INPUT
0.0	________	________	_______	_______	_________

DETECTOR SCALE FACTORS

	UUT
Voltage at 0.0	_____
Voltage at FS Change	______
Scale Factor	______

REFERENCE DATA

Standard S/N ___________
Calibraton Date ___________
NOTES:

Figure 8-15. Four-terminal Correction Record

Over-voltage Circuit Calibration

WARNING

Electrical Shock Hazard. Disconnect the power cord and other test equipment connected to the Model PRT73 before performing this procedure. Failure to do so may result in severe injury or death from contact with line voltage or high voltage from other test equipment.

1. Switch the instrument POWER OFF and unplug it from its power source.

2. Set the Model PRT73 on a static-free work surface. Remove the top cover by removing four screws from bottom of instrument. See Figure 8-16.

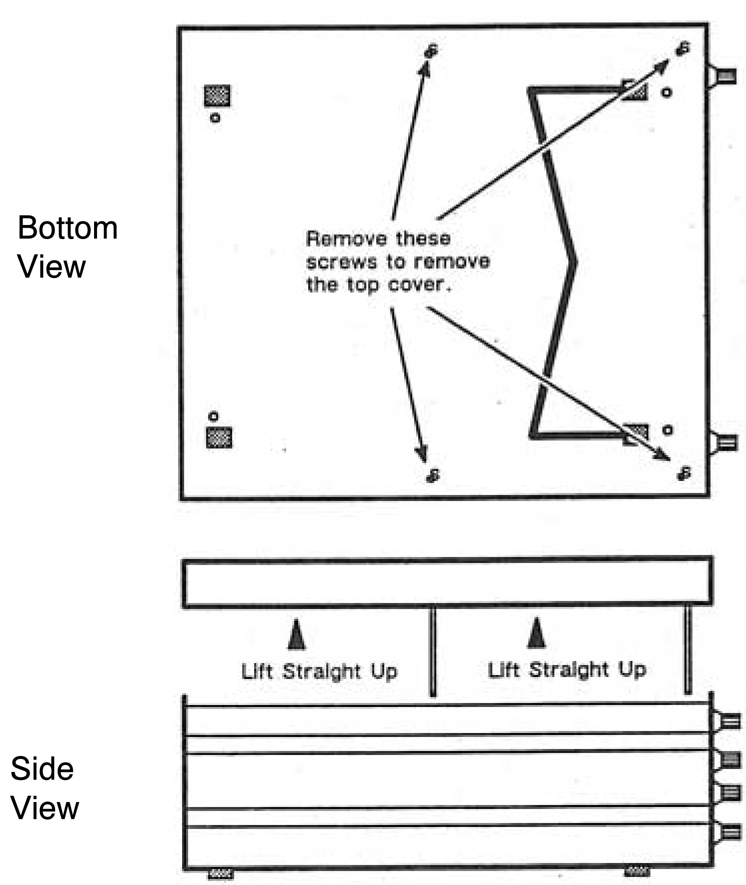


Figure 8-16. Removing the Model PRT73 Top Cover

3. Connect the 0.0 INPUT and 1.0 INPUT together with a piece of wire.

4. Remove the Guard Box cover by disconnecting J1 on the 8088 CPU Cka and the four screws at each corner of the cover. Refer to Figure 8-17.

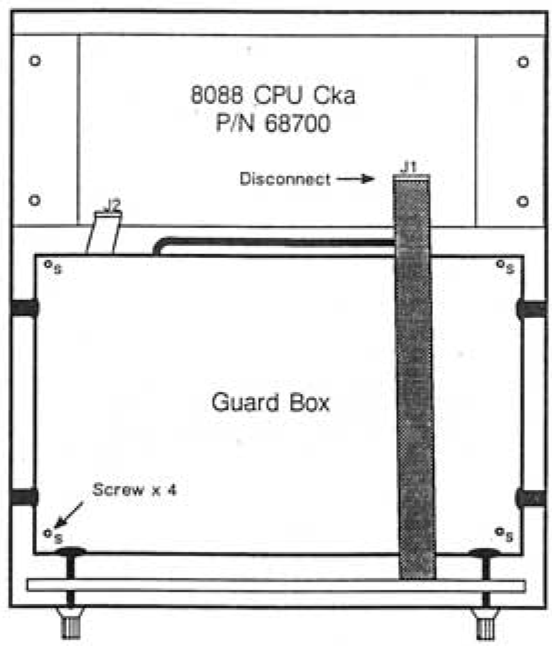


Figure 8-17. Accessing the Analog Cka

5. Refer to the Analog circuit assembly part location illustration on page 11-14. Monitor TP8 (Test Point 8) with a voltmeter and adjust R6 for a reading of 0 V (±2 mV).

6. Refer to the Analog circuit assembly part location illustration on page 11-14. Monitor TP3 on the Analog circuit assembly with a voltmeter and adjust R_on the +12 V Power Supply for a reading of +12 V (±50 mV).

7. Proceed to the “Over-voltage Circuit Test and Input Transformer Demagnetization” (p. 8-4) and complete the procedure to verify the operation of the over-voltage circuit.

Troubleshooting

Troubleshooting 9

WARNING

Troubleshooting and repair of the Model PRT73 should be done only by qualified TEGAM service representatives or by qualified service technicians.

For assistance from TEGAM service representative:

Phone: (440) 466-6100
ask for Instrument Customer Support

Routine Checks

1. Check the voltage select switch to ensure it matches the line voltage and that the proper fuse is installed.

2. Make sure the Model PRT73's front panel switches are set properly and are functioning and that all equipment connected to the Model PRT73 is functioning properly.

3. Visual Check. Visually check the portion of the Model PRT73 where the trouble is suspected. Many problems can be located by visual indications such as bad connections, broken wires, damaged circuit cards, damaged components, or components bent over and touching.

4. Check Voltages. A circuit stage may not be operating due to incorrect supply voltages. Typical supply voltages are given on the diagrams; however,these are not absolute and may vary slightly between instruments.

Problem Isolation

Problem isolation is divided in two major parts. The first part is used as a guide to determine what procedures to perform in the second part. Table 9-1 contains a column listing symptoms the Model PRT73 can display when one or more of the components from the recommended replacement parts list fails. Another column for action provides specific tasks to complete and directs you to procedures following the table.

CAUTION

Components used in the Model PRT73 can be damaged by an electrostatic discharge (ESD) when the covers are removed. To prevent ESD damage, all work must be performed on a static-free work surface. The person performing this procedure should also wear a conductive wrist strap connected to the static-free work surface.

Table 9-1. Problem Symptoms

Symptom	Possible Cause and Action
No display present when power is applied.	Power Source or Power Supply Problem-Go to Voltage Entry, Voltage Select, and Power Supplies Check Procedure (p. 9-6).
A. There is no output voltage or the output voltage is grossly inaccurate for all ratio settings. B. There is no output voltage or the output voltage is grossly inaccurate for some ratio settings. C. The output voltage is out of specification by a few ppm at one ratio setting or several ratio, settings with a common digit on one decade. D. The Generator can't drive the Model PRT73 INPUT. E. After power is applied, "ANALOG" is displayed. F. The Input voltage exceeds the V/Hz range by more than 10% and "OVERLOAD" message does not appear on the display. G. "OVERLOAD" is continuously displayed.	Symptom A-G-ESD (electro-static discharge) has set the relays to an unknown state.-Switch POWER off for 5 seconds, then switch POWER on. If the problem disappears, stop. If the problem repeats intermittently, check your working environment for potential ESD problem areas. If none exist and the Model PRT73 is operated in a relatively static-free environment, return the Model PRT73 for repair. Symptom A - [1] Output or input cable problem – check cable connections and continuity. Also check test lead connections. [2] Analog Problem – Go to Analog Cka Check Procedure (p. 9-8) Symptom A, D - [1] Output or input cable problem – check cable connections and continuity. [2] Analog Problem – Go to Analog Cka Check Procedure. (p. 9-8). Symptom B – Analog Problem - Go to Analog Cka Check Procedure (p. 9-8). Symptom C - [1] Relay contact resistance is greater than 100 mΩ - Go to Analog Cka Check Procedure (p. 9-8). Symptom E, F, G - [1] Digital to Analog cable problem – check cable connections and continuity. [2] Analog Problem – Go to Analog Cka Check Procedure (p. 9-8).

Symptom	Possible Cause and Action
Front Panel display is scrambled	1 Front Panel Cka – Swap the Front Panel Cka with a known good circuit card. This can be done by disconnecting the front panel control cable from J2 on the 8088 CPU Cka and connecting the other Front Panel Cka (or the Model PRT73) in for repair. 2 Clock circuit on 8088 CPU Cka – Monitor U1, pin 1 on the 8088 CPU for a 1200 Hz signal. Replace the 8088 CPU Cka or send the Model PRT73 in for repair if no signal is present. If the signal is present and the problem does not go away when the Front Panel Cka is swapped, return the Model PRT73 for repair.
No response from any front panel control	1 Model PRT73 is in a remote operating mode – release IEEE-488 control. 2 Front Panel Cka – Swap the Front Panel Cka with a known good circuit card. This can be done by disconnecting the front panel control cable from J2 on the 8088 CPU Cka and connecting the other Front Panel Cka without installing it. If this corrects the problem, replace the Front Panel Cka or sent the Model PRT73 in for repair. 3 Processor malfunction on the 8088 CPU Cka – After verifying the Front Panel Cka was not the problem, monitor U6, pin 18 on the 8088 CPU Cka for a low interrupt signal when a button on the front panel is pressed. If an interrupt signal is seen, replace the 8088 CPU Cka or send the Model PRT73 in for repair.
Display does not change when a ratio control button is pressed.	1 Defective ratio control button – On the front Panel Cka, monitor pin 2 of the suspect button for a low when pressed. Replace the button if a low signal is not detected. If a low signal is detected, continue. 2 Front Panel Cka – Swap the Front Panel Cka with a known good circuit card. This can be done by disconnecting the front panel control cable from J2 on the 8088 CPU Cka and connecting the other Front Panel Cka without installing it. If another Front Panel is not available, check the operation of the suspect front panel as described above. If the front panel button is functioning, monitor the associated PAL U13 or U14, pin 14 for a low when a button is pressed. If no low signal is detected replace the Front Panel Cka or send the Model PRT73 in for repair.

Symptom	Possible Cause and Action
No action when 0.0, 1.0, 2.5 V/Hz, 0.35 V/Hz, or LOCAL button is pressed.	1 Defective control button – Using an oscilloscope, monitor the pin of U12 on the Front Panel Cka that the button connects to for a low strobe pulse when the button is pressed. If a strobe pulse is not detected, check the input of the associated control button. Replace the button if the strobe signal is not being passed. If the signal is passed, continue. 2 Front Panel Cka – Swap the Front Panel Cka with a known good circuit card. This can be done by disconnecting the front panel control cable from J2 on the 8088 CPU Cka and connecting the other Front Panel Cka without installing it. If you don't have a spare Front Panel Cka, check that U10 and U12 are generating a strobe pulse. Monitor U10 at pins 8 or 17. If a strobe signal is not present either U10 or U12 is not functioning properly. In either case, replace the Front Panel Cka or send the Model PRT73 in for repair.
One segment of one LED display does not light or LED does not light properly.	1 Faulty LED or LED display – Replace the LED display. **NOTE:** If you replace an LED or a FET, the intensity of the LED display may be different than the existing LED displays, TEGAM matches batch numbers of the LEDs and tightly specifies the FET characteristics.
The same segment on all LED displays do not light.	Front Panel Cka – Replace the Front Panel Cka or send the Model PRT73 in for repair.
One display does not have any segments lit.	Faulty FET, LED display, or Front Panel Cka – Check pins 3 and 8 of the suspect display for +5V. If +5V is present, replace the LED display. If +5V is not present, check that the gate of the FET is being switched. If gate of the FET is not being switched replace the Front Panel Cka or send the Model PRT73 in for repair.

Voltage Entry, Voltage Select, and Power Supply Check

1. Check the voltage source and the Model PRT73 Voltage Select Switch for correct line voltage.

   - The Model PRT73 will not work if the line voltage does not fall within the requirements listed in Section 2 – Specifications.
   - If the line voltage is correct, continue.

2. Switch system power off and unplug the main AC power cord from the Model PRT73. Check the Model PRT73. Check the Model PRT73's fuse for the proper voltage and load rating.

   - If the fuse is blown, replace the fuse and switch power on. If the fuse blows again, proceed to step 3. If the fuse does not blow and the Model PRT73 display appears to be working, stop here.
   - If the fuse is not blown, proceed to step 3.

3. Set the Model PRT73 on a static-free work surface. Remove the top cover by removing four screws from bottom of the instrument. See Figure 9-1.

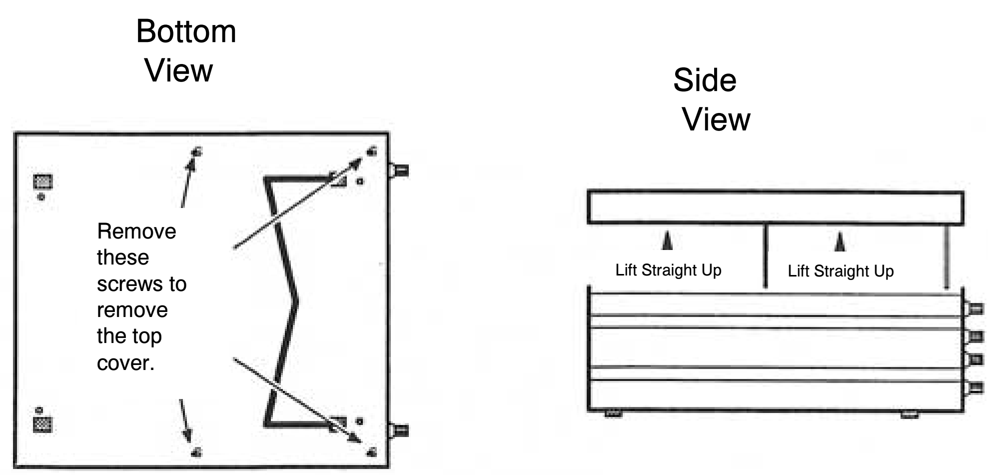


Figure 9-1. Removing the Top Cover

4. Remove the Guard Box cover by disconnecting J1 on the 8088 CPU Cka and the four screws at each corner of the cover. After the cover is removed, reconnect J1. Refer to Figure 9-2.

   - If the fuse was blown and/or continued to blow in step 2, go to step 5.
   - If the fuse was not blown after checking it in step 2, check each power supply for the proper voltage output at j6 on the 8088 CPU Cka and J17 on the Analog Cka. If a supply is not functioning or does not output the proper voltage, continue to step 5.

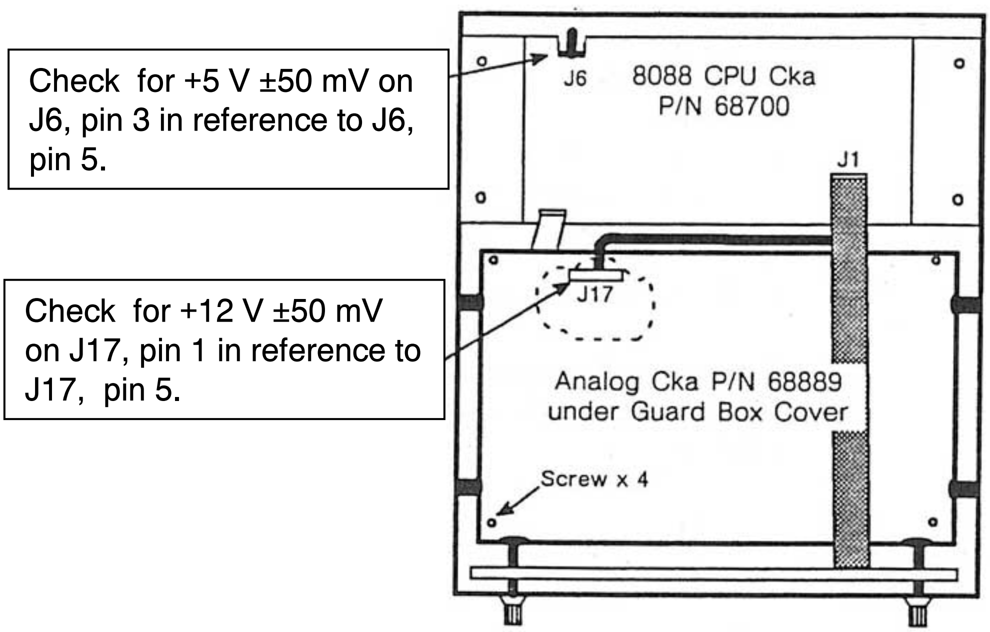


Figure 9-2. Power Connectors on 8088 CPU Cka and Analog Cka

5. Disconnect J6 and J17 shown in Figure 9-3. Apply power and check for the proper voltage on as shown in Figure 9-2.

   - If proper voltage is present, one of the circuit assemblies can be pulling too much current. To isolate the circuit assembly first disconnecting J1 which supplies power to the Front Panel Cka from the 8088 CPU Cka. Then sequentially reconnect each connector J6, J17, J1 to their respective circuit assemblies until the problem reappears. The Cka that is causing the short should be sent back to TEGAM for repair.
   - If the voltage is present, but out of specification, go to step 6.
   - If the fuse blows, go to step 6.

6. Access the power supplies by moving the tray that holds the 8088 CPU Cka as shown in Figure 9-4. To move the tray, remove the four screws that secure the tray to the

chassis and disconnect the cables connected to J1 and J2.

- If a power supply output is low, try to adjust VR2 on the +12 V supply or VR2 on the +5 V supply for the proper voltage as shown in Figure 9-2. Replace the supply if you can't adjust it to the proper level. If the power supply does adjust, reconnect J6, J17, and J1 then adjust the supplies again for the proper voltage when under load.
- If the fuse continues to blow with no load; one of the power supplies is shorted or there is a problem between the Power Entry module and the power supplies. Isolate the problem by systematically disconnecting each module until the problem is found.

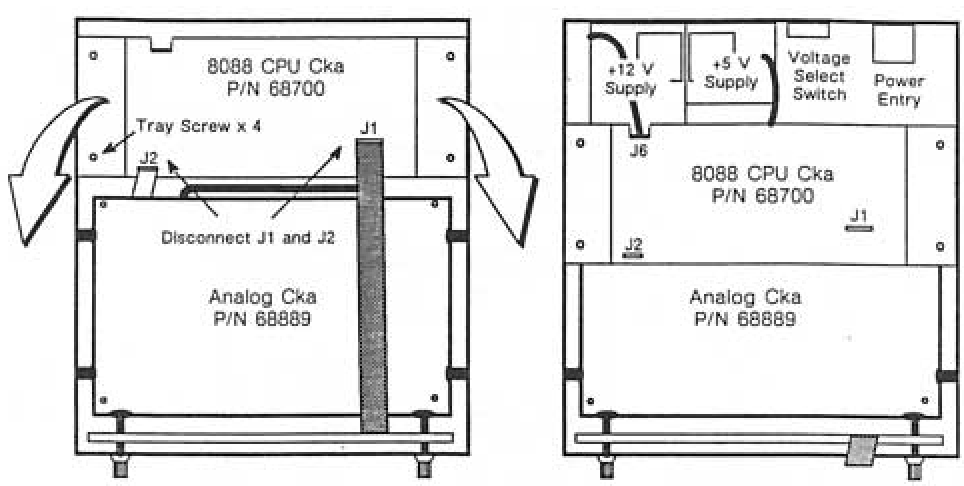


Figure 9-4. Accessing the Power Supplies

Analog Cka Check Procedure

1. Set the Model PRT73 on a static-free work surface. Remove the top cover by removing four screws from bottom of the instrument. See Figure 9-1.

2. Remove the Guard Box cover by disconnecting J1 on the 8088 CPU Cka and the four screws at each corner of the cover. After the cover is removed, reconnect J1. Refer to Figure 9-2.

3. Check that all cables connected to the top of the Analog Cka are secure and appear to be making good contact.

4. Check the voltages as shown in Figure 9-5.
   - If the +12 V is not at the proper level, try to adjust it to the proper level as described in Step 5.
   - If the +5 V at TP6 is not at the proper level, and the +12 V at tP3 is at the proper level, replace the +5V regulator (U24) or the Analog Cka.
   - If the -5 V at TP6 is not at the proper level, and the +12 V at TP3 is at the proper level, replace the -5 V regulator (U34) or the Analog Cka.

5. Access the power supplies by moving the tray that holds the 8088 CPU Cka as shown in Figure 9-4. To move the tray, remove the four screws that secure the tray to the chassis and disconnect the cable connected to J1.
   - Try to adjust VR2 on the +12 V supply for +12 V ±50 mV. Replace the supply if you can't adjust it to the proper level. If the power supply does adjust, check to see if your original problem is corrected. If the problem is still there, continue.

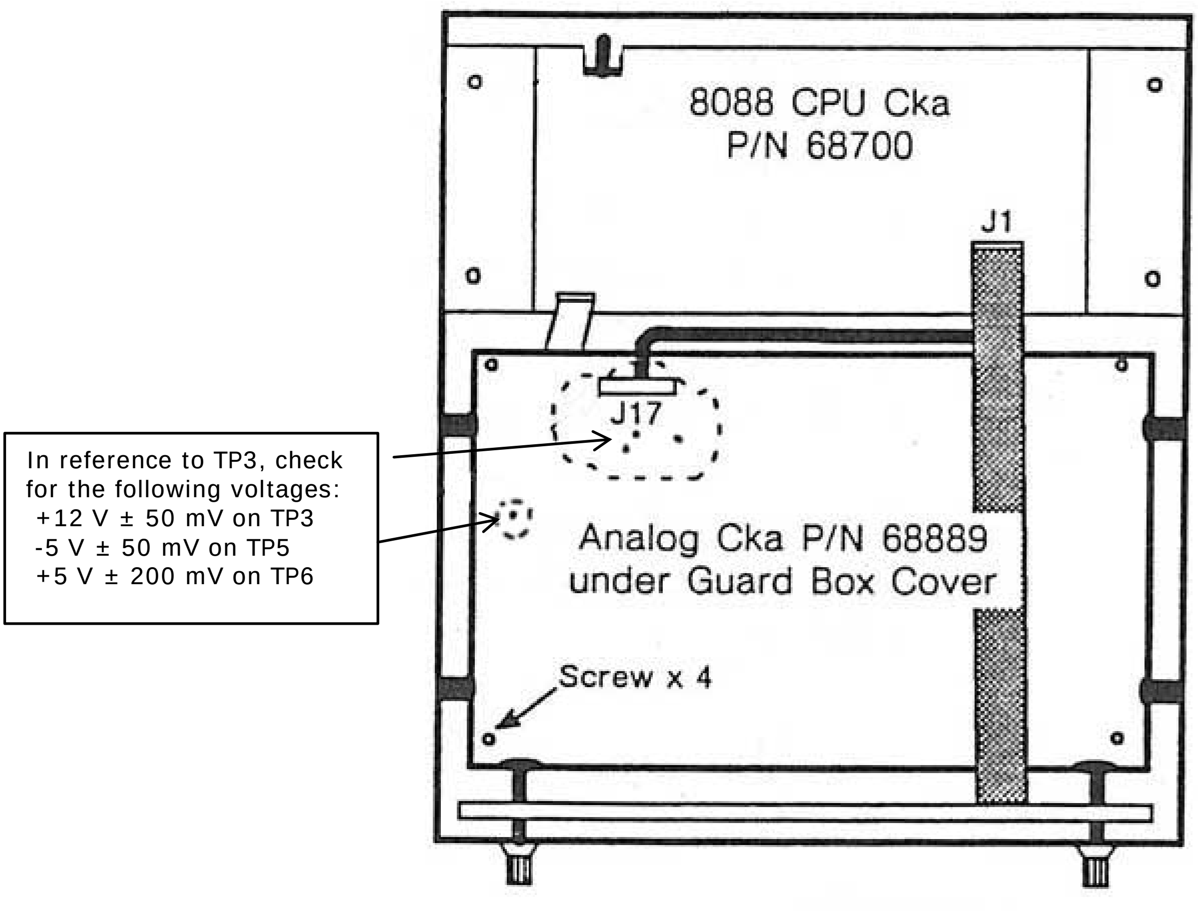
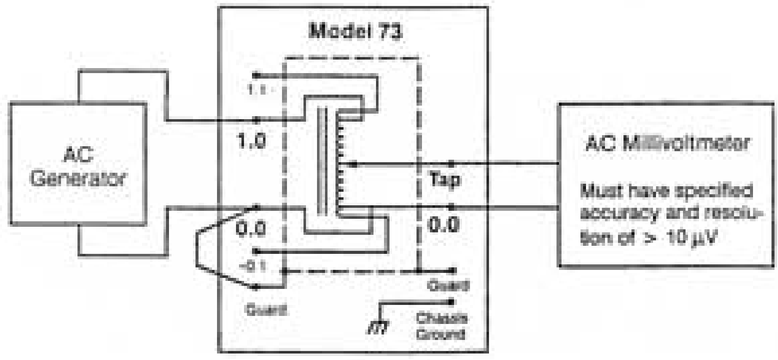


Figure 9-5. Power Connectors on Analog Cka

6. Perform a rough linearity test of the Model PRT73 for each digit on all decades. A linearity test can be performed by comparing each setting of the Model PRT73 against another ratio transformer or by inputting a known value and measuring the output with a millivoltmeter. Refer to Figure 9-6.

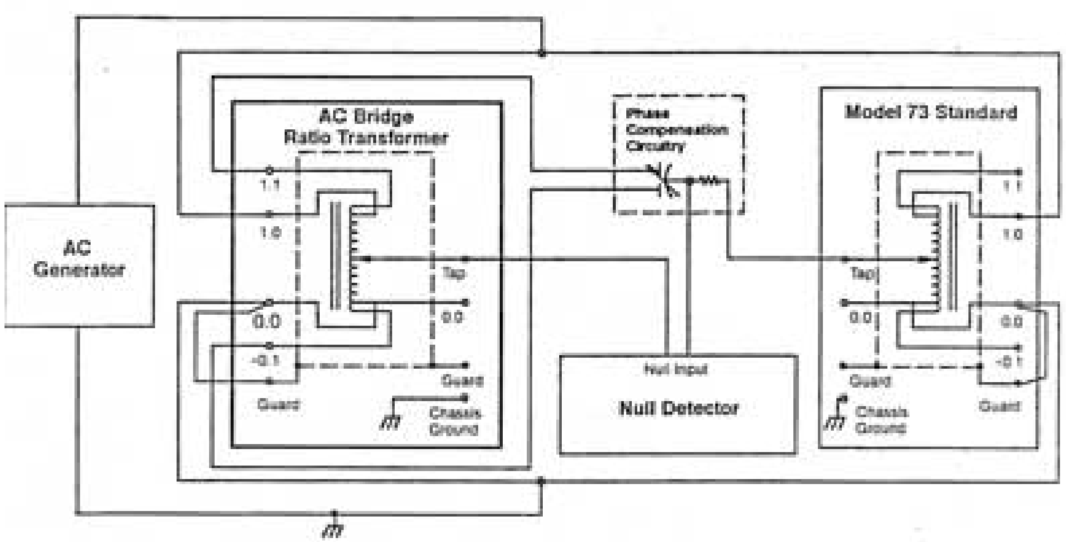
   If a discrepancy is found in the linearity, it is recommended that the unit be sent back to TEGAM for repair due to the amount of time that can be consumed in troubleshooting. However, the following information can help diagnose the problem to a relay or transformer if you wish to go further:

   - record any settings that do not produce the proper output, a pattern may appear that will help you solve the problem. If a discrepancy is found, a problem can exist within the logic that drives the relays or it can be a problem with the relays or transformers.
   - If a problem exists in the logic driving the relays, it can be traced to a latch or relay driver on the Analog Cka by using the information in Table 5-2 (p. 5-11) and Table 5-3 (p. 5-12) to see what relay is suppose to be enabled for any one setting. If the logic appears to be functioning properly but, the information being clocked into the latches appears to be incorrect, you will need to perform a board swap with a spare 8088 CPU Cka, Front Panel Cka, or Analog Cka to find which circuit assembly is causing the problem.
   - If the logic is functioning properly, a problem may exist either in a relay or in the transformers. Check the continuity of the relay contacts in question. The maximum contact resistance is 100 mΩ. A relay with higher contact resistance must be replaced. If the contact resistance of the relay(s) in question is < 100 mΩ, the only component left that can cause a problem is the transformer.
     Before replacing the transformer, visually inspect all the transformer connections. If no connector problems can be found then double check logic levels and the linearity to confirm your results. If the problem appears to be with transformer T2 or T3, they can be swapped to see if the problem moves with the transformer. To access the transformer connections you must remove the Guard Box from the chassis. Refer to Figure 9-7.
     NOTE: If any relay or transformer is replaced, perform the Performance Check procedure to verify the unit linearity specifications. <u>Additionally, correction factors must be regenerated when a relay or transformer is replaced.</u>



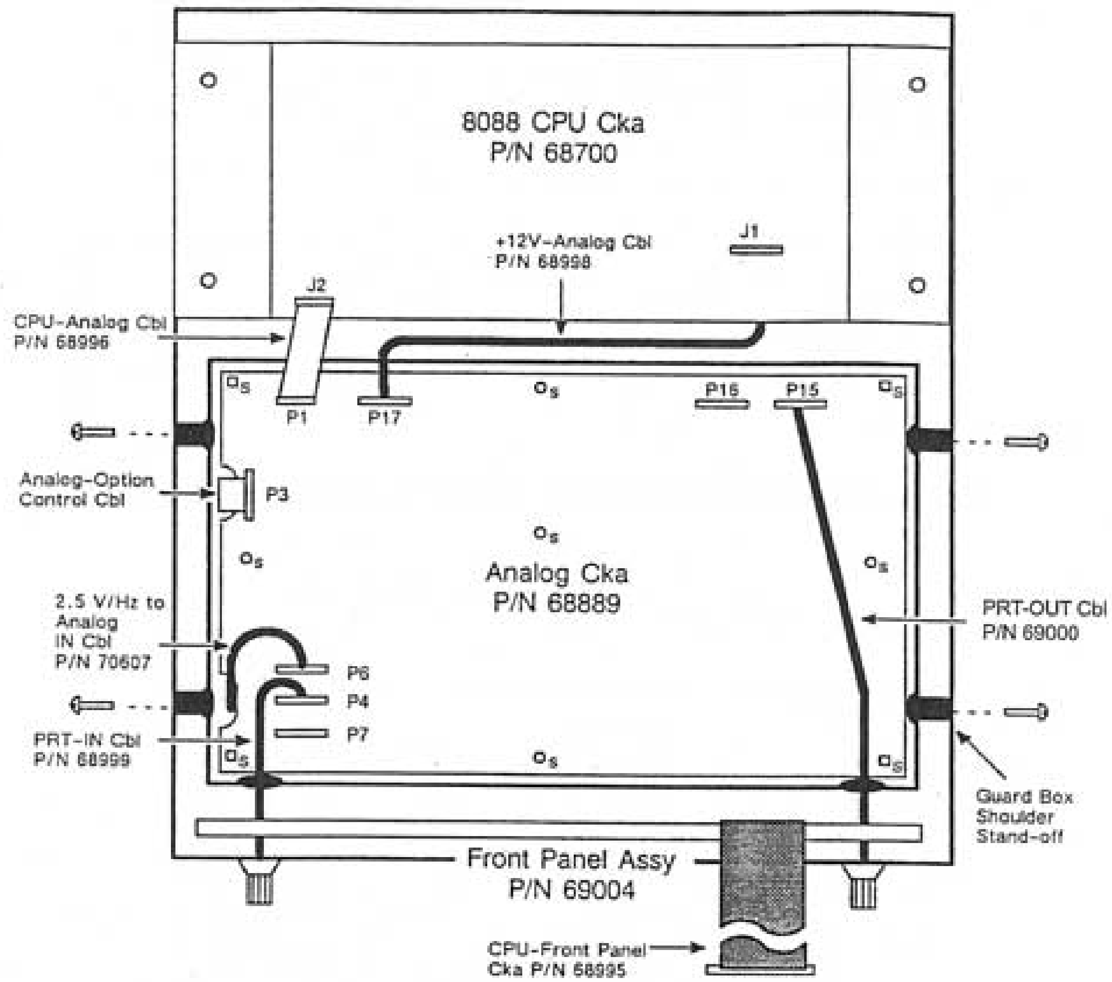
This type of setup is good enough for a rough linearity check. An example of how to check the linearity using this setup:

- Set the AC generator to a known voltage 1 kHz at 100 V.
- Starting with a ratio of 0.000000, increment the 10^{-7} decade to 1. The output voltage of the Model PRT73 should increase by approximately 10 µV. Each change in the 10^{-7} decade should now show an equal increase in voltage. This process is performed for each settings of the remaining decades.



If you use a calibrated test station to check the linearity , you should see no more than 0.5 ppm difference when comparing the two ratio transformers at each setting.

Figure 9-6. Linearity Test Setups



To remove the Guard Box from the chassis, remove the four screws that secure shoulder stand-offs, disconnect all the cables from the Analog Cka, then lift the Gurard Box straight up from the chassis and place it on a static-free work surface.

Figure 9-7. Removing the Analog Guard Box

CAUTION

Use a bladed tool to remove transformer cables from the bottom of the Analog Cka. DO NOT pull on the wires to remove the connectors or they may be damaged. Refer to detail A in Figure 9-8.

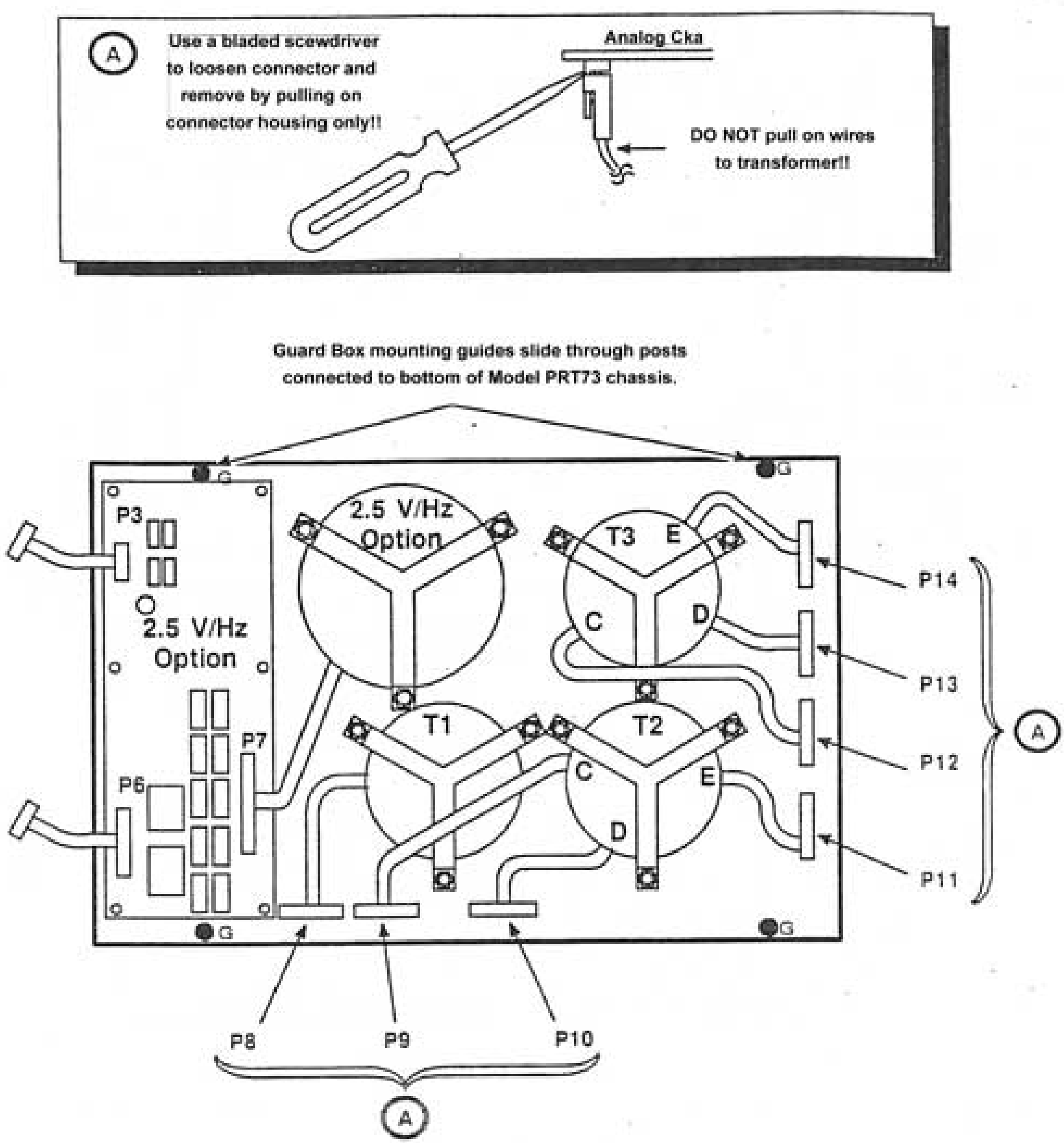


Figure 9-8. Removing Transformer Connectors

Preparation for Calibration or Repair Service

Once you have verified that the cause for 1830A malfunction cannot be solved in the field and the need for repair and calibration service arises, contact TEGAM customer service to obtain an RMA, (Returned Material Authorization), number. You can contact TEGAM customer service via the TEGAM website, www.tegam.com or by calling 440.466.6100 (*All Locations*) OR 800.666.1010 (*United States Only*).

The RMA number is unique to your instrument and will help us identify you instrument and to address the particular service request by you which is assigned to that RMA number.

Of even importance, a detailed written description of the problem should be attached to the instrument. Many times repair turnaround is unnecessarily delayed due to a lack of repair instructions or of a detailed description of the problem.

This description should include information such as measurement range, and other instrument settings, type of components being tested, are the symptoms intermittent, conditions that may cause the symptoms, has anything changed since the last time the instrument was used, etc. Any detailed information provided to our technicians will assist them in identifying and correcting the problem in the quickest possible manner. Use a copy of the Repair and Calibration Service form provided on the next page.

Once this information is prepared and sent with the instrument to our service department, we will do our part in making sure that you receive the best possible customer service and turnaround time possible.

Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. The Completion of this form and including it with your instrument will expedite the processing and repair process.

RMA#:		Instrument Model #:	
Serial Number:		Company:	
Technical Contact:		Phone Number:	
Additional Contact Info:			

Repair Instructions:

☐ Evaluation ☐ Calibration Only ☐ Repair Only ☐ Repair & Calibration ☐ Z540 (Extra Charge)

Detailed Symptoms:

Include information such as measurement range, instrument settings, type of components being tested, is the problem intermittent? When is the problem most frequent? Has anything changed with the application since the last time the instrument was used?, etc.

Warranty Information

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of three years from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of one year from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by TEGAM Inc. The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment, which is calibrated at planned intervals by comparison to certified standards maintained in the laboratories of TEGAM Inc.

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Document publishing dates may lag product changes.
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