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Model 251TL / 351TL
AC Power Source
User and Programming Manual

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Important Safety Instructions

Before applying power to the system, verify that your product is configured properly for your particular application.

 WARNING	**Hazardous voltages may be present when covers are removed. Qualified personnel must use extreme caution when servicing this equipment. Circuit boards, test points, and output voltages also may be floating above (below) chassis ground.**
 WARNING	**The equipment used contains ESD sensitive ports. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.**

Only *qualified personnel* who deal with attendant hazards in power supplies, are allowed to perform installation and servicing.

Ensure that the AC power line ground is connected properly to the Power Rack input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment *must* be grounded properly for both personnel and equipment safety.

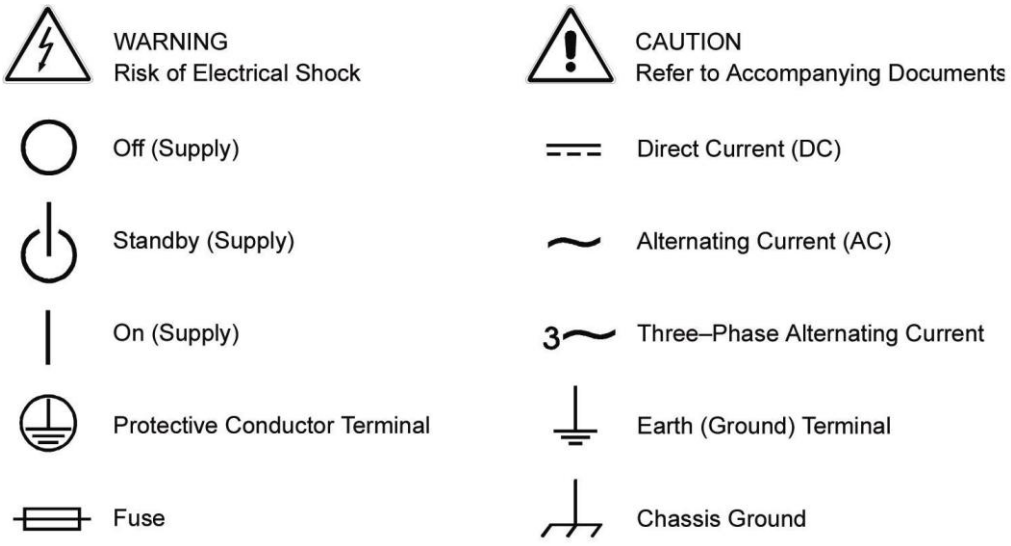
Always ensure that facility AC input power is de-energized prior to connecting or disconnecting any cable.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The customer/user must ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by not touching any portion of the electrical circuits. Even when power is off, capacitors may retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden component failure.

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Warranty Period: One Year

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     Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)
     858-450-0085, ext. 2295 or ext. 2463 (direct)
   - **Outside the United States**, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor or our website, www.programmablepower.com, by clicking Support and going to the Service Centers tab.
2. When requesting an RMA, have the following information ready:
   - Model number
   - Serial number
   - Description of the problem

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense.

NOTE: A returned product found upon inspection by AMETEK, to be in specification is subject to an evaluation fee and applicable freight charges.

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Table of Contents

1 Introduction 1
1.1 General Description 1
1.2 Accessory Equipment/Rack Slides 1

2 Specifications 2
2.1 Electrical 2
2.2 Measurements [Option] 5
2.3 System Specification 6
2.4 Unit Protection 7
2.5 Mechanical 7
2.6 Environmental 8
2.7 Regulatory 8
2.8 Front Panel Controls 9
2.9 Available Options 9

3 Installation and Functional Test 11
3.1 Unpacking 11
3.2 Power Requirements 11
3.3 Input Voltage Range Selection 13
3.4 Mechanical Installation 17
3.5 Input Wiring 17
3.6 Output Connections 17
3.7 Output Voltage Ranges 19
3.8 Functional Test 20
3.9 Current Limit - Modes of Operation 22

4 Front Panel Operation 23
4.1 Functional Controls 23
4.2 How to Examples... 28
4.3 Setting the Power on Initialization Values 31
4.4 Current Limit Modes 32
4.5 Function Strobe [Option] 33
4.6 Remote Inhibit [Option] 33
4.7 External Oscillator Input [Option -EXT] 33

5 Principle of Operation 35
5.1 General 35
5.2 Overall Description 35
5.3 Input Power Supply 35
5.4 Range Relay Board 39
5.5 Amplifier 39
5.6 Controller Module 39
5.7 IEEE 488/ RS232 Interface [Option] 40

6 Calibration 42
6.1 Calibration Equipment 42
6.2 Selecting Calibration Mode 43
6.3 Routine Calibration 44
6.4 Non-Routine Calibration 48

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7 Service 55
7.1 General 55
7.2 Basic Operation 55
7.3 Module Removal 57
7.4 Replaceable Parts 60

8 Remote Control 61
8.1 Introduction 61
8.2 PGUI32 Program Requirements 61
8.3 IEEE Interface 63
8.4 RS232C Interface 64
8.5 PGUI32 Setup and Installation 67
8.6 Trouble Shooting - RS232C 69
8.7 Trouble Shooting - IEEE-488 / GPIB 72
8.8 PGUI32 Distribution Files 73
8.9 Software Registration 74

9 Introduction to SCPI 75
9.1 Conventions Used in This Manual 75
9.2 The SCPI Commands and Messages 75
9.3 Using Queries 78
9.4 Structure of a SCPI Message 78
9.5 SCPI Data Formats 81

10 SCPI Command Reference 82
10.1 Subsystem Commands 82
10.2 Calibration Subsystem 83
10.3 Measurement Subsystem 87
10.4 Source Subsystem 90
10.5 Output Subsystem 94
10.6 Limit Subsystem 97
10.7 Display Subsystem 99
10.8 System Commands 100
10.9 Common Commands 102

11 Programming Examples 109
11.1 Introduction 109
11.2 Programming the Output 109
11.3 Making Measurements 111

12 Status Registers 112
12.1 Power-On Conditions 112
12.2 Standard Event Status Group 113
12.3 Status Byte Register 113
12.4 Examples 114

Appendix A : SCPI Command tree 115

Appendix B : SCPI Conformance Information 116

Appendix C: Error Messages 117

Index 118

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List of Figures

Figure 2-1: Output Power Rating as a Function of Voltage and Load PF 4
Figure 3-1: Model 251TL / 351TL AC Power Source 11
Figure 3-2: Rear Panel View 12
Figure 3-3: Connections to T1 for 105 - 125V Line Input 14
Figure 3-4: Connections to T1 for 210 - 250V Line Input 16
Figure 3-5: Test Setup 351TL 21
Figure 4-1: Front Panel View 23
Figure 4-2: Voltage Auto Range Switch Over Points 25
Figure 4-3: Shuttle Knob 26
Figure 5-1: AC Power System Block Diagram 37
Figure 6-1: Test Equipment Hookup for Routine Output and Voltage Measurement Calibration 44
Figure 6-2: Test Equipment Hook-up for Current and Power Measurement Calibration 45
Figure 6-3: Internal Adjustments 50
Figure 7-1: Assembly Location 58
Figure 8-1: Rear Panel View 62
Figure 8-2: GPIB Address Selection Switch 63
Figure 8-3: RS232C Interface Cable Wiring Diagram 66
Figure 8-4: DB9 to DB25 Adapter Wiring Diagram 66
Figure 8-5: System Properties Dialog Box 70
Figure 8-6: Advanced Port Settings Dialog Box 70
Figure 8-7: COM Port Properties Dialog Box 70
Figure 8-8: NI AT-GPIB/TNT Settings 72
Figure 8-9: NI AT-GPIB/TNT Advanced Settings Dialog 72
Figure 9-1: Partial Command Tree 76
Figure 9-2: Command Message Structure 78
Figure 12-1: AC Source Status System Model 112

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List of Tables

Table 4-1: Factory Default Power on Settings 31
Table 4-2: -EXT Option DIP Settings 34
Table 6-1: Load Resistors and Current 42
Table 6-2: CAL Mode Status LED Indicators 43
Table 7-1: Basic Symptoms 55
Table 7-2: Poor Output Voltage Accuracy 55
Table 7-3: Poor Output Voltage Regulation 55
Table 7-4: Distorted Output 56
Table 7-5: Unit Shuts Down After 3-5 Seconds 56
Table 7-6: No Output and No Lights on Front Panel 56
Table 7-7: No Output But "Display" Is On 56
Table 7-8: Replaceable Parts 60
Table 10-1: Mode Command Encoding 99
Table 10-2: Bit Configuration of Standard Event Status Enable Register 103
Table 10-3: Bit Configuration of Standard Event Status Register 104
Table 10-4: *RST Default Parameter Values 106
Table 10-5: Status Registers - Power on Conditions 106
Table 10-6: Bit Configuration of Status Byte Register 108
Table 12-1: Bus Error Messages 117

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1 Introduction

This instruction manual contains information on the installation, operation, calibration and maintenance of the 351TL and 251TL AC power source.

1.1 General Description

The 351TL AC source is a 350 VA programmable AC power source. The 251TL is a 250 VA version of the power source. In addition to the standard models, several options are available that may change the voltage and frequency ranges of the power source. This user manual covers the following models:

Model	Voltage ranges	Max. Current
351TL	135 V_{RMS} 270 V_{RMS}	2.8 A_{RMS} 1.4 A_{RMS}
251TL	135 V_{RMS} 270 V_{RMS}	2.4 A_{RMS} 1.2 A_{RMS}

The output voltage High and Low terminals are isolated from the chassis, and earth ground. The AC input can be either 105 V_{RMS} to 125 V_{RMS} AC, 210 V_{RMS} to 250 V_{RMS} AC, 91 V_{RMS} to 109 V_{RMS} or 182 V_{RMS} to 217 V_{RMS} at 47 to 67 Hz line frequency.

Simple front panel controls enable the voltage, current limit and frequency to be changed. An optional RS232C and IEEE 488 interface is available for applications that require remote control and measurements.

1.2 Accessory Equipment/Rack Slides

General Devices Company Model C300-120-B308 rack slides (option -RMS) may be attached to the sides of the power source using 10-32 X 3/8 flat head screws.

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2 Specifications

All specifications at 23 ±5°C unless noted otherwise.

2.1 Electrical

Input

Line Voltage:	115 V_{RMS} nominal, 105 V_{RMS} to 125 V_{RMS} AC 230 V_{RMS} nominal, 210 V_{RMS} to 250 V_{RMS} AC 100 V_{RMS} nominal, 91 V_{RMS} to 109 V_{RMS} 200 V_{RMS} nominal, 182 V_{RMS} to 217 V_{RMS} Unit must be configured for correct Line input voltage.
Line Current:	9 A_{RMS} maximum, line voltage = 115 VAC, full-load PF = 0.7
Inrush Current:	150 A_{pk} for 115V line 75 A_{pk} for 230V line
Input power factor:	0.7 at full-load and 115 V_{AC} input
Line Frequency:	47 Hz - 67 Hz
Isolation Voltage:	Input to output = 2300 VAC, input to chassis = 1350 VAC

Output

Parameter		Specification
Voltage		
	Range	0 to 135 V_{RMS} or 270 V_{RMS} (standard ranges)
	Resolution	0.1 volt
	Accuracy	± 0.1 % of calibrated range, 45 Hz - 100 Hz ± 0.2 % of calibrated range, 100 Hz - 5000 Hz ± 0.3 % of calibrated range, 5000 Hz - 8000 Hz
	Load Regulation	0.1 % of FS < 2000 Hz 0.15% of FS 2000 – 5000 Hz 0.25% of FS > 5000 Hz

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Parameter		Specification		
	External Sense	Will compensate for up to 5% of voltage drop up to 2kHz		
	Line Regulation	0.02 % of FS		
	Settling time	From start of voltage change from 5.0 V_{RMS} or higher voltage to within 2% of final value: No load: 16 msec Full load: 300 msec (16 msec to within 15 % of final value)		
	Distortion (THD into linear load)	<0.5 % maximum 45 to 499 Hz <1.0 % above 500 Hz <2.0% 1000 to 8000Hz		
	DC Offset voltage	AC Coupled transformer output		
	Output noise	-73 db typical (20 kHz to 1 MHz at full load)		
	Temperature coefficient:	± 0.02 % of full scale per degree C		
	Stability (24 hours)	± 0.015 % of full scale under constant load, line and temperature		
	Total Power PT = 0.7	351TL: 350 VA from 90 to 100% of V range 251TL: 250 VA from 78 to 100% of V range		
Current (Refer to Figure 2-1 for derating)				
		Output V Range	**Amps rms**	**Amps peak**
	351TL	135	2.8	6
		270	1.4	3
	251TL	135	2.4	6
		270	1.2	3
	Adjustable Limit	0.0 to Maximum available RMS current for selected voltage range.		
	Accuracy	Programmed value + 5, -0 % of maximum RMS current		

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Parameter		Specification
Frequency		
	Range 351TL	16.0 - 8000 Hz Maximum output voltage available from 45 Hz.
	Resolution	0.01 Hz from 16.00 to 80.00 Hz 0.1 Hz from 80.1 Hz to 800.0 Hz 1 Hz from 801 Hz to 8000 Hz
	Accuracy	± 0.02% of programmed value
	Temperature coefficient	± 5 ppm per degree Celsius
	Stability	± 15 ppm per year

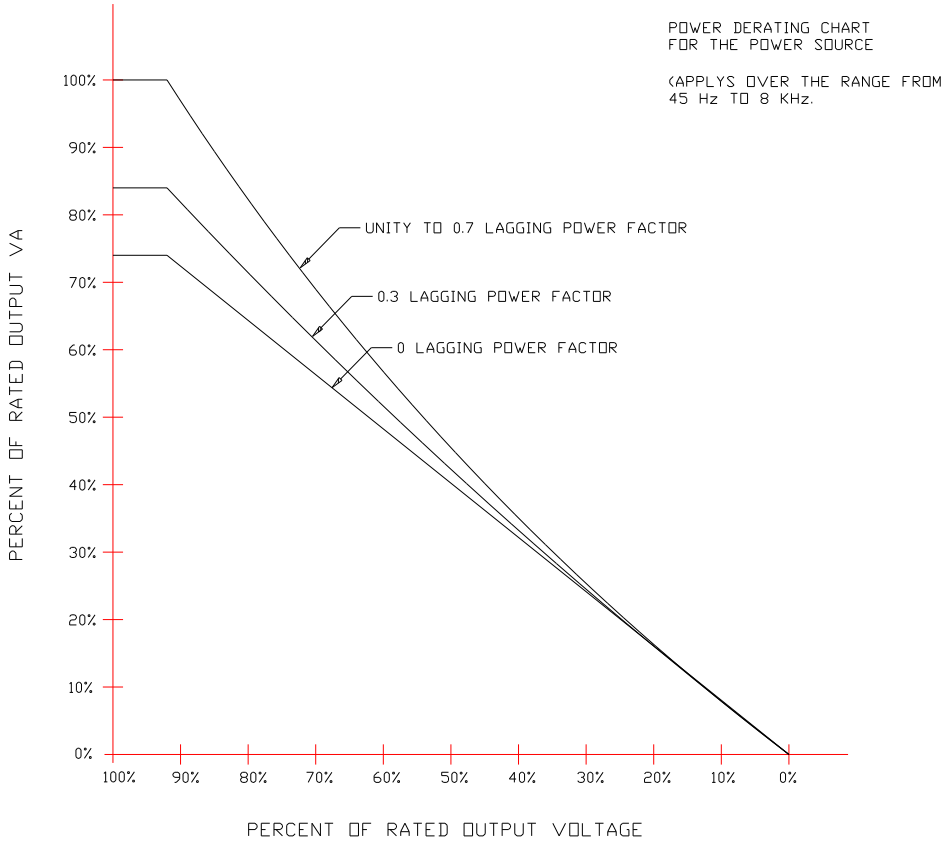


Figure 2-1: Output Power Rating as a Function of Voltage and Load PF

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2.2 Measurements [Option]

Parameter		Specification	Unit
True RMS Current		Available on standard unit.	
	Range	0.000 - 4.000	A_{RMS}
	Accuracy	0.2 % FS + 0.3 % reading	
	Resolution	0.001	A_{RMS}
	Temp Coefficients	0.016	% FS / °C
Peak Current	Requires Option -OP1		
	Range	0.00 – 12.00	A_{PEAK}
	Accuracy	0.5 % FS + 0.5 % reading	
	Resolution	0.01	A_{PEAK}
Crest Factor	Available over bus only. Requires interface Option -OP1		
	Range	0.00 - 4.00	
	Accuracy	0.05	
	Resolution	0.01	
True RMS Voltage	Standard Unit: Available over bus only. -OP1 option: Front Panel and bus.		
	Range	0.0 - 300.0	V_{RMS}
	Accuracy	0.1 % FS + 0.05 % reading	
	Resolution	0.1	V_{RMS}
	Temp Coefficients	0.05	V / °C
Real Power	Requires Option -OP1		
	Range	0 - 400.0	W
	Accuracy	0.2 % FS + 0.5 % reading	
	Resolution	0.2	W
	Temp Coefficients	0.06	% FS /°C
Apparent Power	Available over bus only. Requires -OP1 option		
	Range	(Remote only) 0 - 400.0	VA
	Accuracy	0.3 % FS + 0.8 % reading	
	Resolution	2	VA
Power Factor	Requires -OP1 option		
	Range	0.00 - 1.00	
	Resolution	0..01	

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2.3 System Specification

Parameter	Specification	
Setup storage	Eight non volatile front panel setup registers available through interface. Power on setting register available from front panel.	
Interface	(Option package -OP1 required)	
RS-232C	Bi-directional serial interface	
	Rear panel connector:	9 pin D shell
	Handshake:	CTS, RTS
	Data bits:	8
	Stop bits:	1
	Parity:	None
	Baud rate:	19200
	Command syntax:	IEEE 488.2 commands and SCPI
IEEE-488	GPIB Interface	
	Rear panel connector:	24 pin D-shell
	IEEE address:	set using dip switch on rear panel from 0 to 31
	IEEE functions:	SH1, AH1, T8, L4, RL2, SRQ 0, PP 0, DC 0, DT 0, C0
	Terminators:	LF, CRLF, EOI
	Command syntax:	IEEE 488.2 commands and SCPI
Remote Inhibit	(Option package -OP1 required)	
	Rear panel connector:	BNC
	Input	Contact closure to ground or logic low TTL signal required to turn off output. Automatic recovery when RI signal is removed.
Function Strobe	(Option package -OP1 required)	
	Rear panel connector:	BNC
	Output	Active low TTL signal. Signal driven low for approximately 400 μsec any time output voltage or frequency programmed value changes. Signal level may be changed by removing jumpers to open collector.

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2.4 Unit Protection

Parameter	Specification
Input Overcurrent:	Electronic current limit with circuit breaker.
Transients:	Surge protection to withstand EN50082-1 (IEC 801-4, 5) levels.
Output Overcurrent:	Constant current operation. (Standard) 0.1 Second shutdown (constant voltage mode Option)
Output Short Circuit:	Peak current limit. Shutdown (constant voltage mode Option).
Overtemperature:	Automatic shutdown.

2.5 Mechanical

Parameter	Specification			
Dimensions:	Height	Width	Depth	Unit
	13.26	48.26	56.62	cm
	5.22	19	22.29	inches
Unit Weight:	34 Kg / 75 lbs			
Material:	Steel chassis and panels. Aluminum cover.			
Finish:	Yellow iridite, painted semi-gloss polyurethane			
Cooling:	Fan cooled with air intake on the sides and exhaust to the rear.			
Internal Construction:	Modular sub assemblies.			
Chassis Slides:	P/N 210960 / Option -RMS General Devices Model CTS-1-20-B307-2			
Rear Panel Mounted Connectors:				
	RS232C I/F	DB 9		
	IEEE-488 I/F	D-shell 24 pin		
	Remote Inhibit	BNC (requires -OP1 option package)		
	Function Strobe	BNC (requires -OP1 option package)		
	AC Output	Amp 1-480705-1		
	External Sense	Amp 1-480705-1		
	Line Input	Kulka 9-85-3 Terminal block		

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2.6 Environmental

Parameter	Specification
Operating Temp:	0 degrees to + 40 degrees Celsius.
Storage Temp:	- 40 degrees to + 85 degrees Celsius.
Humidity:	Operating: ≤ 90% RH up to 40° C., non condensing Storage: ≤ 90% RH up to 40° C, ≤75% RH up to 70° C.
Altitude	Operating: 15000 feet / 6000 meters maximum. VA Power: Full VA power output :0 - 6000 feet / 0 - 2000 meters. Derate VA power 5 % per 1000 feet from 6000 to 15000 feet / 2000 to 6000 meters.
Creepage and Clearance:	Rated for Pollution Degree 2.
Insulation:	Rated to Installation Category (Overvoltage Category) II
Vibration:	Designed to meet NSTA 1A transportation levels.
Shock:	Designed to meet NSTA 1A transportation levels.

2.7 Regulatory

Parameter	Specification
Electromagnetic Emissions and Immunity:	Designed to EN50081-1 and EN50082-1 European Emissions and Immunity standards as required for the “CE” marking.
Acoustic Noise:	65 dBA maximum at 0% to 50% load, 75 dBA maximum greater than 50% load to 100% load. Measured at one meter.
Safety:	Designed to EN61010-1 European safety standards as required for the “CE” marking.

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2.8 Front Panel Controls

Parameter	Specification
Controls:	Shuttle knobs: Allows continuous change of Voltage, Frequency and Current limit. Voltage change is inactive on single voltage range configuration units.
	Function keys: Controls Output state, Voltage range and Display mode.
Displays:	Two, 4 digits, 0.5" 7 segment LED display. For viewing programmed voltage, frequency, current limit and for displaying measured current.
Status Indicators:	10 LEDs to indicate: REMOTE, FAULT, OUTPUT (ON/OFF), VOLTAGE RANGE HIGH, VOLTAGE RANGE AUTO FREQUENCY, CURRENT, PEAK CURRENT, POWER, POWER FACTOR DISPLAY MODES (Refer to paragraph 4.1.2).

2.9 Available Options[1]

Option	Description	
-OP1	Option package 1 includes: • Measurement Functions • Combined IEEE-488 / RS232C interface. • Remote Inhibit Input • Function Strobe Output Note: Not available with -EXT option.	
-RMS	Rack mount slides P/N 211045 / Option -RMS General Devices Model C300S-120-B308	
-SKT	This option is no longer available.	
-EXT	Removes controller and allows external oscillator input. Note: Not available with -OP1 option. A standard BNC connector on the rear panel is provided to connect the external input signal. This BNC input replaces the Remote Inhibit BNC found on standard TL models.	
	Input range:	0.0 - 5.0 VRMS AC in for 0 - FS Voltage out. Output voltage FS range is factory configured for either 135 V or 270 V. Check type sticker for V range set.

[1] Additional options may have been made available since this manual revision. Installed options are listed on the power source's type sticker. A manual addendum may be issued for new options not covered by this manual.

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Option	Description	
	Impedance:	10 kOhm
	Frequency range:	45 Hz - 8000 Hz
	Output V Range selection:	Internal DIP switch setting. Located on A1 Amp assy. Requires removal of top cover to change output ranges. If changed, amplifier gain must be adjusted (R8) on mother board for 5 V in to FS out.

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3 Installation and Functional Test

3.1 Unpacking

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. ***DO NOT*** return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

3.2 Power Requirements

The AC Power System has been designed to operate from a single phase AC line voltage. The nominal operating voltage is 100V, 115V, 200V or 230V line input. The Power Source line input setting is shown on the type sticker located on the rear panel.



Figure 3-1: Model 251TL / 351TL AC Power Source

WARNING: ***Do not connect the unit to a 400-480 service, as the result will be a severely damaged unit.***

Do not connect the unit to AC line input unless the nominal line input settings match those of the available AC line voltage.

3.2.1 AC Line Voltage

The AC Power Source has been designed to operate from either of the following AC line voltage ranges:

1) 91 to 109 V_{RMS}
2) 82 to 217 V_{RMS}
3) 105 to 125 V_{RMS}
4) 210 to 250 V_{RMS}

CAUTION: The AC Power Source will be damaged if it is operated at an input voltage that is outside its configured input range.

The input voltage range is set at the factory. Section 3.3 gives the procedure to change the input voltage range. The location for connection of the INPUT line is shown in Figure 3-2.

3.2.2 Line Frequency Operating Range

The AC Power Source has been designed to operate with a line frequency from 47Hz to 67 Hz.

3.2.3 Input Power

The input power to the AC Power Source depends upon line and load conditions and may be as high as 1000 watts.

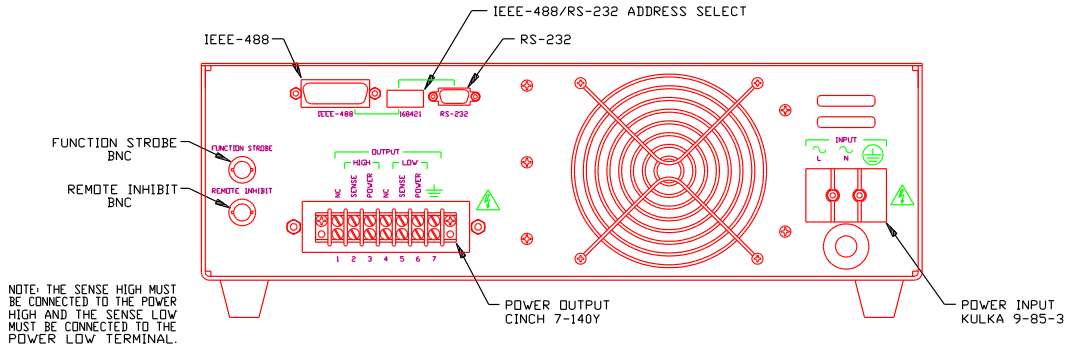


Figure 3-2: Rear Panel View

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3.3 Input Voltage Range Selection

WARNING: ***The line voltage is present in certain sections of this Power Source.***

DEATH: ***On contact may result if personnel fail to observe safety precautions. Do not touch electric circuits when power is applied. Servicing should only be performed by trained personnel.***

The input voltage range is configured by changing the taps on the input transformer. See Figure 3-3 or Figure 3-4 for the location of the jumpers and input wires.

3.3.1 Voltage Range Configuration (105 – 125 V)

In order to change the voltage range configuration:

1. Turn off the input circuit breaker.

2. Disconnect AC input power to the source by unplugging the power cord.

3. Remove the AC Power Source top cover by removing (14) #6-32 x 5/16" FLH screws. There are 7 screws on the sides and 7 screws on the top that hold the cover.



Remove the (2) #6-32 x 1" PHN screws and lock washers that hold the amplifier near the outside panel.



Remove the (2) #6-32 x 3/8" PHN screws and lock washers located near the connector, attaching the red insulator to the center bracket.

The line input voltage range is set by the configuration of the Input Transformer, T1. To configure T1 for the 105-125 volt range, make the following connections to T1 (refer to Figure 3-3) :

Jumper terminals 1 and 4.

Jumper terminals 3 and 6.

Connect the input line from the Circuit Breaker to Terminals 1 and 6.

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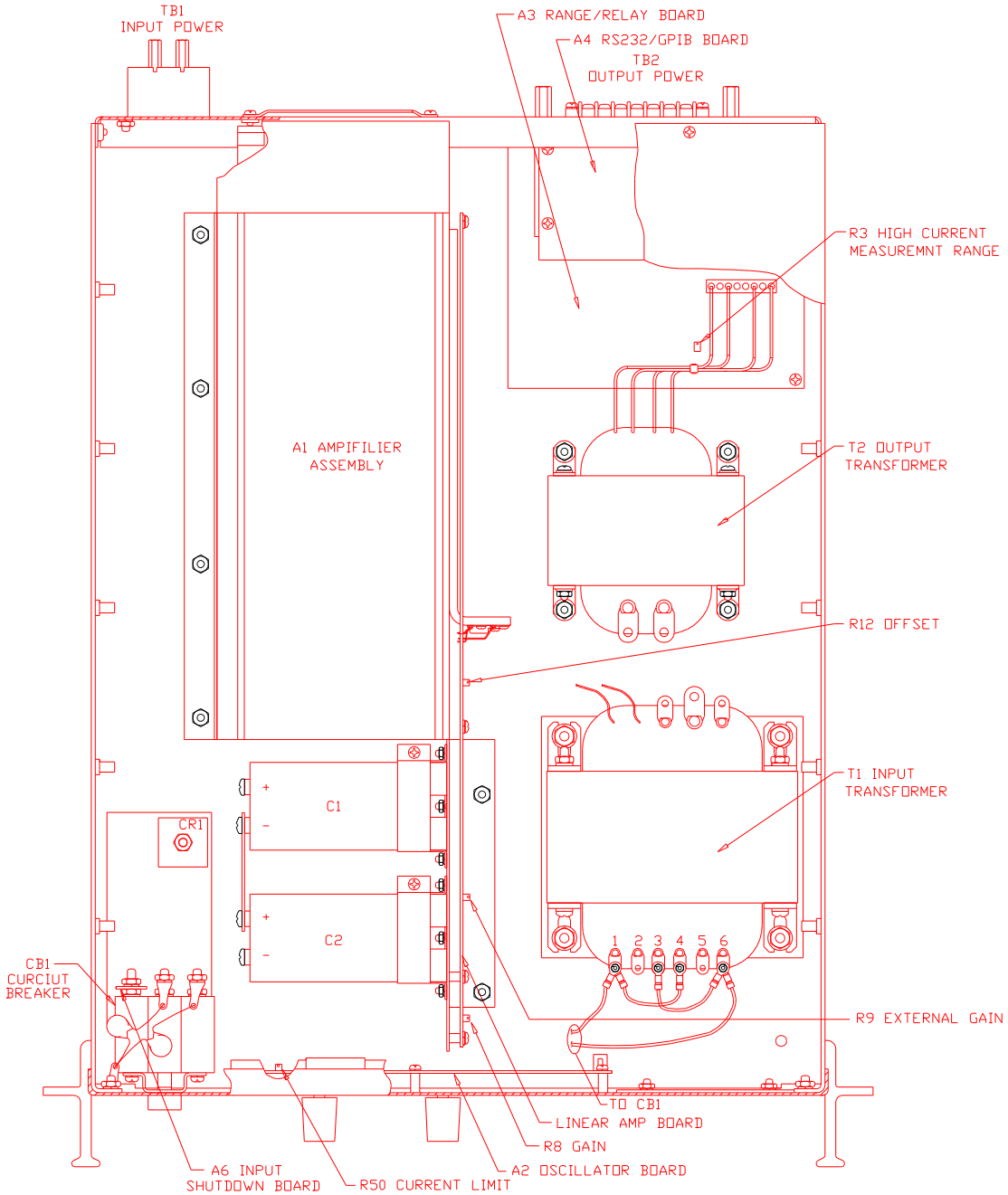


Figure 3-3: Connections to T1 for 105 - 125V Line Input

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3.3.2 High Input Voltage Range Configuration (210 – 250 V)

In order to change the voltage range configuration:

1. Turn off the input circuit breaker.

2. Disconnect AC input power at TB1.

3. Remove the AC Power Source top cover by removing (14) #6-32 x 5/16” FLH screws. There are a total of 7 screws on the sides and another 7 screws on the top that secure the top cover.

The line input voltage range is set by the configuration of the Input Transformer, T1. To configure T1 for the 210-250 volt range, make the following connections to T1 (refer to Figure 3-4).

Jumper terminals 3 and 4.

Connect the input line from the Circuit Breaker to Terminals 1 and 6.

Remove all other connections to Terminals 1 through 6.

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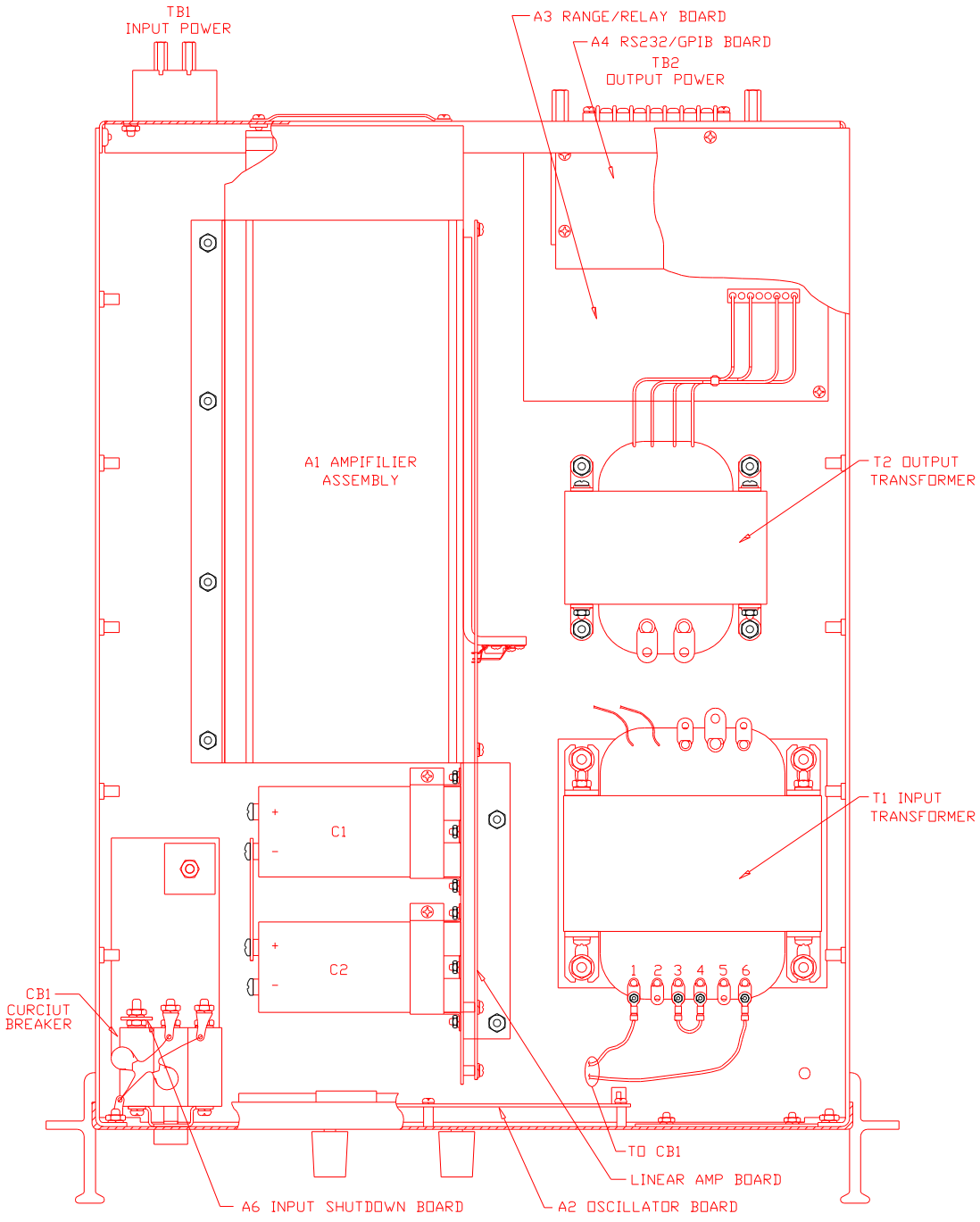


Figure 3-4: Connections to T1 for 210 - 250V Line Input

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3.4 Mechanical Installation

The power source has been designed for rack mounting in a standard 19 inch rack. The unit must be supported from the sides with optional rack slides. See Accessory Equipment/Rack Slides in Section 1.2. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch (6.35cm) clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Keep in mind that adequate ventilation of the mounting cabinet must be maintained for sufficient cooling of the power source. Use louvered side panels, and/or perforated rear panels to assure adequate airflow. Also, the air intake holes on the sides of the power source must not be obstructed when mounted inside cabinet. See Figure 3-1.

3.5 Input Wiring

The AC Power Source must be operated from a three-wire single-phase service. The mains source must have a current rating greater than or equal to 10 A for the low input range. Use the supplied safety cover/strain relief when connecting the input wires to the power source. Refer to

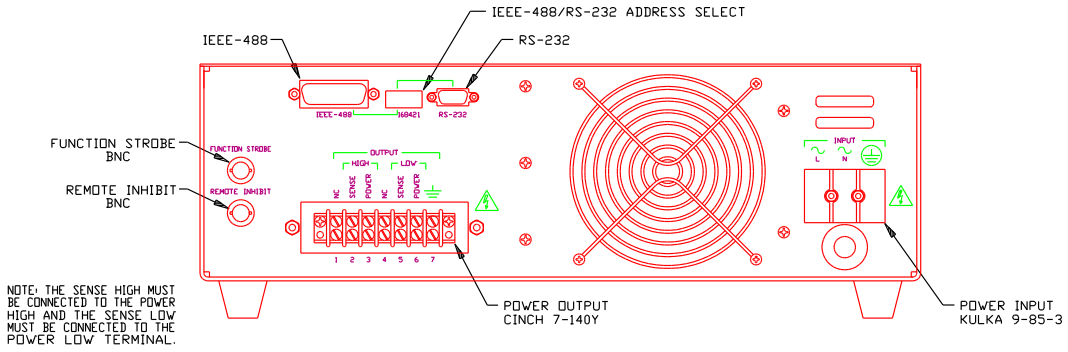


Figure 3-2 for the input power connections. When connecting the input wires to input terminal block, make sure the safety grounding wire from the strain relief grommet is longer than the Line and Neutral wire so that the ground wire will be the last one to take any strain. For low-range input operation (115V) we recommend #12 AWG input wires as a minimum. For high-range input operation (230V) #14AWG is recommended. For European applications (230V), the following input cordset may also be used:

Panel Components # 86518030 Rated 16A, 250V, 70° C, 3x 1.5mm² conductor size. VDE approved. Install as described above for discreet wiring.

3.6 Output Connections

The output terminal block is located at the rear of the power source. All load connections must be made on the rear panel terminal block. The remote sense inputs are normally jumpered directly to the adjacent power output pins on the output connector. If the sense terminals are not connected to the power output pins, the output voltage may rise significantly above the programmed value. When connecting the output wires, use the supplied safety cover/strain relief and mount over the output connector. Also mount the supplied snap-on

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ferrite filter around the output wiring between the output terminals and the strain relief grommet. Enclose ferrite filter with the safety cover.

If the load is a significant distance from the output terminal strip it may be desirable to sense the output voltage directly at the load. If remote sensing is to be used, then the size of the output power wiring must be heavy enough to prevent a voltage difference greater than 7% of the programmed value from the power output pins to the sense input pins.

The Remote Sense inputs must be connected or an output voltage 7% higher than the programmed output will be generated. If the Power Source is configured for constant voltage, a fault will be generated.

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3.7 Output Voltage Ranges

The standard 351TL AC power source has two output voltage ranges 0-135 V_{AC} and 0-270 V_{AC}. The operator may switch from one range to the other at will with no special precautions except to remember that the output voltage will go to zero voltage whenever a range change takes place.

Certain options available on the 351TL series may result in different voltage range values or a single voltage range only. Certain models may be ordered with a single voltage range only. On single voltage range units, the Range change button has no function and the LED indicator is not used.

351TL AC power source models with dual voltage ranges offer an auto voltage range change mode. In this mode, the voltage range is automatically changed when the user sets a voltage above 135 or below 131 V_{RMS}.

The AUTO mode can be selected by pressing the range change button until the AUTO mode LED illuminates. To take the AC power source out of the AUTO voltage range mode, press the Voltage range button briefly. This will put the unit in the present range but takes it out of auto mode.

Note:	**Even in AUTO mode, the output temporarily goes to zero volts when a voltage range change occurs. If this is not acceptable, the AC source should be operated in the high voltage range only and not in AUTO mode.**

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3.8 Functional Test

CAUTION: ***Work carefully when performing these tests - hazardous voltages are present on the input and output during this test.***

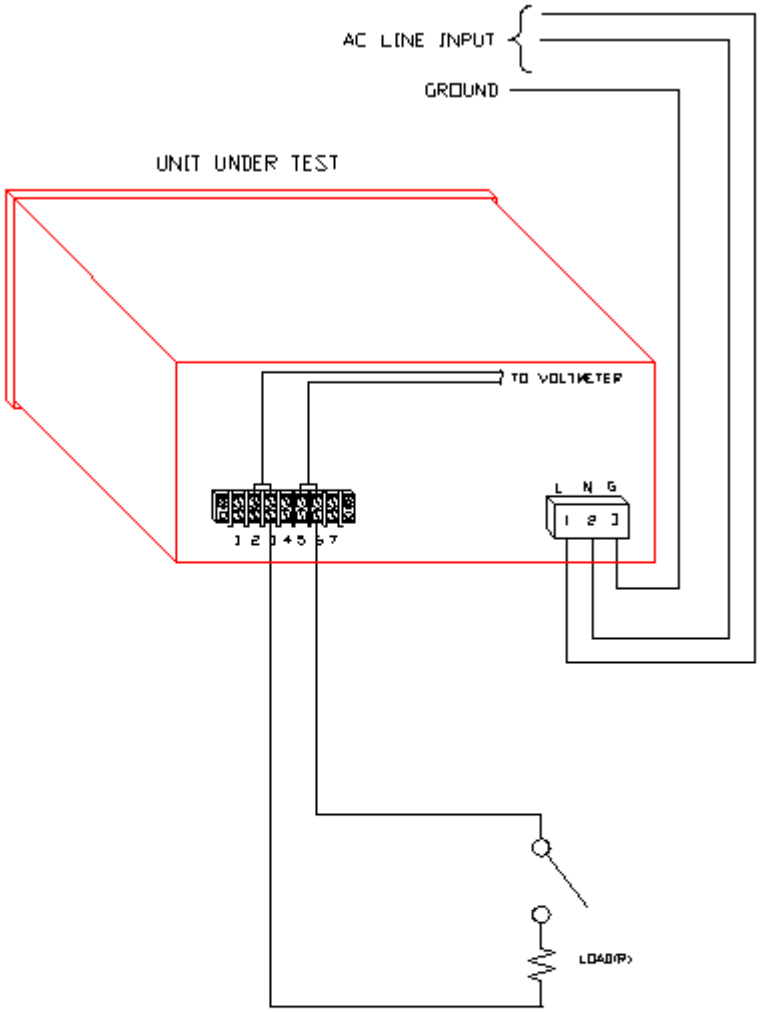
Refer to Figure 3-5 for the test set up. Use the following load resistor values:

Model	Voltage Range	Resistor	Current (A_{RMS})
351TL	135	52 Ω	2.60
	270	208 Ω	1.30
251TL	135	72.9 Ω	1.85
	270	292 Ω	.92

1. Connect an oscilloscope, voltmeter and/or distortion analyzer to the AC source output at the rear panel output terminal.
2. Connect the AC power input voltage connections to the AC source input terminals. Connect the sense input to the adjacent power pin on the rear panel connector. Turn on the power switch located at the rear panel.
3. Verify that the front panel 7 segment LED displays read out the initial start up voltage and frequency.
4. Select the low voltage range. Set the frequency to 60 Hz with the right shuttle. Select the current function with the Frequency/Current selector. Set the current limit to the maximum value using the right shuttle. Set the output voltage to 135V with the left shuttle.
5. Enable the output by pressing the output “on/off” button in the top right of the front panel. The green LED above the button will illuminate when the output is on. The output should be a clean 135V AC sinewave having less than 0.5 % distortion.
6. Apply full load (refer to table on Figure 3-5) to the output of the source and verify the output remains within 0.05 % of the initial 135V . The output should still be clean and the distortion should still be less than 0.5 % at 60 Hz.
7. Using the right shuttle set the output current limit value to 2 amps (1 amp for the 251TL). If the unit is configured for Constant Current mode, the system should go into current limit and reduce the output voltage. This may create additional distortion on the output voltage. If the unit is configured for Constant Voltage mode (factory default), an error message will appear on the display (err. -300) that indicates an output fault condition and the output will go off. Return the current value to the maximum current and disconnect the load.
8. Repeat steps 4 through 7 but set the output for the following: Hi voltage range and the current limit to maximum value. Refer to the table above for the relevant resistor values. For units that are factory configured with a single voltage range, these steps do not have to be repeated.

In the event the power source does not pass the functional test, refer to the calibration procedure in Section 6 or call California Instrument’s customer satisfaction department for further assistance.

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MODEL	RANGE	LOAD(R)	CURRENT
351TL	135	52 OHM	2.60A
251TL	135	72.9 OHM	1.85A

Figure 3-5: Test Setup 351TL

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3.9 Current Limit - Modes of Operation

When the Power Source is shipped from the factory, it is configured for the Constant Current Mode of operation. This mode means if the load current exceeds the programmed Current Limit value, the output current will continue at the programmed value.

The Power Source can be configured to operate in the Constant Voltage mode. In this mode of operation, if the load current exceeds the Current Limit value, the output voltage will default with the output relay open. The Constant Voltage mode is only usable if the default voltage is set for 5.0 volts. If the default is any other voltage, the power source may display a fault at power up.

To configure the Power Source, remove the input line voltage connection from the rear panel. Remove the top cover. Install jumpers W1 and W2 on the front panel controller. Reinstall the top cover.

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4 Front Panel Operation

4.1 Functional Controls

The front panel can be divided in a small number of functional areas:

- Output Sockets
- Status Indicator lights
- Shuttle knobs
- LED display[1]
- Button controls



Figure 4-1: Front Panel View

Note:	**This chapter does not apply if the -EXT option is installed. The -EXT option allows an external user provided oscillator signal to be used. In this case, the front panel has no controls.**

4.1.1 Dual Outlet Socket (Option -SKT)

This option has been discontinued and is no longer available on the 251TL or 351TL.

1 Note: Units shipped prior to October 2005 used LCD displays. No functional differences exist between unit with LCD or LED display types.

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4.1.2 Status Indicator Lights

Ten LED status indicators are located directly above the LED display. These LED's correspond to the following conditions:

REMOTE	The REMOTE LED indicates that the unit is in remote control mode. If the RS232C interface is used, the REMOTE state can be enabled by the controller using the SYST:REM command. Any time the REMOTE LED is lit, the front panel of the RP Series unit is disabled. There is no LOCAL button that allows the user to regain control of the front panel. The SYST:LOC command will enable the front panel controls. When using IEEE, the remote /local state is controlled by the REN (Remote Enable) interface line.
FAULT	The FAULT LED indicates an overtemperature condition. Overtemperature is usually caused by poor air flow. Check the air flow exhaust at the rear of the unit to make sure it is not obstructed. If the power source is configured for constant voltage, the indicator will illuminate for loss of sense lines or an overload condition.
OUTPUT	The Output LED indicates the status of the OUTPUT relay. The output relay is controlled by the OUTPUT ON/OFF button located directly below the LED. When the Output LED is not lit, the output voltage is not present at the output socket regardless of the voltage setting.
RANGE - HIGH	The Range High LED indicates the selected output voltage range. When it is illuminated it indicates the high voltage range has been programmed. Any time the user switches voltage ranges, the output is programmed to zero volt. The output relay state is not changed however.
RANGE - AUTO	The Range AUTO LED indicates the Power Source is in auto ranging mode and will switch voltage range automatically if the selected output voltage increments or decrements through the low range voltage limit. (135 V_{RMS} on standard units). During a range change, the output voltage will be programmed to zero momentarily. Some hysteresis is provided. See Figure 4-2.
FREQ	Illuminates when the LED display shows the programmed frequency. In the calibration mode this indicator is not illuminated for calibrating the output voltage. When it is illuminated in the calibration mode the voltage measurement can be calibrated.
I RMS	Illuminates when the LED displays shows the programmed current limit, measured current values, or current measurement calibration.
I PK	Illuminates when the LED displays shows the measured peak current or peak current calibration. See Note.
PWR	Illuminates when the LED displays shows the measured power or power calibration. See Note.

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PF	Illuminates when the LED displays shows the measured power factor. It also illuminates in the calibration mode of operation. In calibration mode, the PF LED is always lit in combination with the measurement or output junction being calibrated. In normal mode of operation, only one LED in this group is on at a time. See Note.

Note: For peak current, power and power factor measurements, Option -OP1 is required. If this option is not installed, these functions are not available and the SELECT button will only toggle between FREQ and CURR modes.

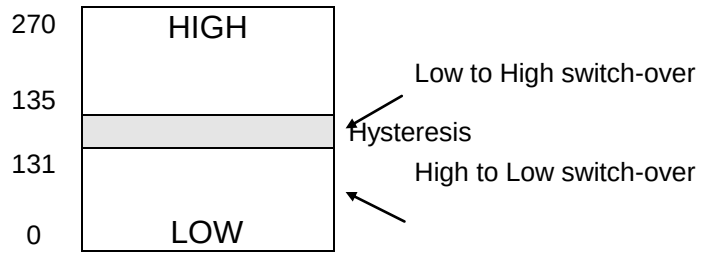


Figure 4-2: Voltage Auto Range Switch Over Points

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4.1.3 Shuttle knobs

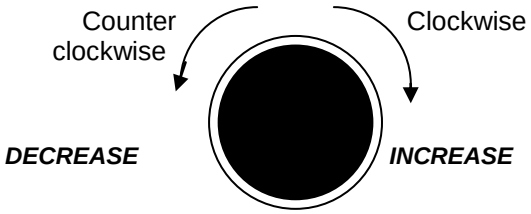


Figure 4-3: Shuttle Knob

There are two shuttle knobs located below the LED display which are used to change setup parameters for voltage, frequency and current limit. The SELECT button selects the function of the right shuttle. The right shuttle will control either the frequency or the current limit as indicated by the indicator above the right LED. The left shuttle always controls the voltage.

4.1.4 Buttons

There are three function buttons for the Output Voltage Range, Output State and Shuttle Mode. The following is a description of these buttons:

KEY	DESCRIPTION
RANGE	The RANGE button is used to change the voltage range between the low range (0 to 135 volts) and high range (0 to 300, 270 or 230 volts). The LED above the switch will light to indicate the high voltage range selection. The output voltage will be reset to zero voltage after a range change. ***If the Power Source is configured for a single voltage range, this button is disabled.*** The same button may be used to put the Power Source in the AUTO voltage range change mode. This button toggles from Lo, Auto, Hi and back to Lo. The AUTO LED will illuminate when the AUTO range mode is enabled. While in AUTO mode, the Power Source will switch to the high range whenever a value larger than the low range limit is programmed. Whenever a value below the low range limit is programmed, the unit will switch to the low voltage range. The output is momentarily interrupted when a range change occurs. To take the unit out of AUTO mode, press the RANGE button again.
OUTPUT	The OUTPUT button will toggle the output relay to connect or disconnect the output. The LED above the button will light when the output relay is closed. No output voltage will be present when the OUTPUT button is off despite the level of voltage programmed.

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SELECT

The SELECT button selects the function of the right Shuttle knob and the LED display. The Shuttle will control the output frequency and the display will show the program frequency value when the mode selection is frequency. The Shuttle knob will program the current limit and the display will show its value in the current mode. The display will revert back to showing the measured current after 3 seconds from the last movement of the shuttle.
The SELECT button also allows selection of the desired measurement function readout. Available selections are:

- Current (Also puts the shuttle in Current Limit set mode)
- Peak Current
- Power
- Power Factor

Measurements are updated 4 times per second. The display mode is indicated by the LED's above the LED display. Note that voltage measurements are available through the Voltage LED.

(CAL)

There is a switch behind this hole in the front panel. When the switch is depressed with the proper tool, the PF indicator will illuminate to indicate the calibration mode has been selected. The table below shows the calibration mode LED indications after the (CAL) button is depressed.

CALIBRATE	INDICATORS ILLUMINATED
Output voltage	PF only
Voltage measurement	PF and FREQ
Current measurement	PF and IRMS
Peak current measurement	PF and IPK
Power measurement	PF and PWR

4.1.5 LED Segment Displays

Settings and measurements are shown on two 4 digit, 7 segment displays[1]. The voltage display shows the programmed voltage as the user turns the left knob. After releasing the knob for about 3 seconds, this display reverts back to displaying the measured output voltage. The right hand LED display is a multi purpose display. For setup purposes, it displays either Frequency or Current limit settings. After about 3 seconds on inactivity, this display switches to the selected measurement parameter. The SELECT button will define the operating mode or the selected measurement parameter for the right hand display.

[1] Note: Units shipped prior to October 2005 used LCD displays. No functional differences exist between unit with LCD or LED display types.

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4.2 How to Examples...

This section covers some common tasks that are often performed with an AC power source. These examples are written in a How to... format and provide step by step instructions on how to set up the AC Source for a specific task.

4.2.1 Set the Output

Output parameters are Voltage, Frequency and Current Limit.

1. Disable the output by pressing the OUTPUT button. The LED above the button will turn off.

2. Use the left shuttle to set the output voltage. Clockwise will increase the output, counter clockwise will reduce the output. The display above the shuttle will show the voltage setting.

3. Use the right shuttle to set the frequency and current limit. The SELECT button will define the function of the shuttle and the display above it. The Frequency or Current LED will turn on to indicate the function controlled by the right shuttle.

4. Enable the output by pressing the OUTPUT button.

4.2.2 Slew Output Values

The output parameters can be slewed using the shuttles.

1. Enable the output by pressing the OUTPUT button. The LED above it will turn on.

2. Use the left shuttle to set the output voltage. Clockwise will increase the output, counter clockwise will reduce the output. The display above the shuttle will show the voltage setting.

3. Use the right shuttle to set the frequency and current limit. The SELECT button will define the function of the shuttle as indicated by the display above it. The LED's located above the display will indicate the selected function.

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4.2.3 Display Measurement Data

Measurements can be called up as follows:

1. For voltage, the left display always displays the measured output voltage unless the knob is turned. As the knob is turned, the programmed voltage will be displayed instead. After releasing the knob for about 3 seconds, the display reverts back to the measured voltage.

2. All other measurements can be displayed by using the SELECT button to toggle through the available measurements. The individual LED's above the 7 segment LED display indicate the current selection. The knob only affects programmed frequency and current limit.

3. Moving the right shuttle knob will interrupt the select measurement and put the display back in Current Limit adjust mode.

Note: For peak current, power and power factor measurements, Option -OP1 is required.

4.2.4 Change the Voltage

The voltage range can be changed as follows (If the Power Source is configured for a single voltage range, this does not apply):

1. Press the RANGE button located in the upper left corner. The output voltage will reset to 0 volts.

2. Use the left shuttle knob to set the output voltage.

The AUTO voltage range can be selected as follows:

3. Press the RANGE button located in the upper left corner. The AUTO LED will illuminate. The AC source is now in Auto range mode. Turn the left shuttle knob to a value above 135 V. The unit will switch to high range and the HIGH LED will illuminate.

4. Turn the left shuttle knob to reduce the voltage to a value below 135 V. The AC source will switch to the low voltage range and the HIGH LED will turn off.

To turn off the AUTO voltage range, proceed as follows:

5. Press the RANGE button. This puts the AC source back in normal mode. The voltage range that was in effect does not change. The AUTO LED will turn off.

6. Press the RANGE button again to toggle voltage ranges.

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4.2.5 Control the Output

The Output can be disabled or enabled using the ON/OFF button as follows:

1. Pressing the OUTPUT button when the output LED is on will open the AC source output relay. The programmed voltage setting will remain at the last program value.

2. Pressing the OUTPUT button again will close the output relay and the output will revert to the last programmed value.

4.2.6 Measure Peak Inrush Current (Requires -OP1 Option)

The peak current measurement function of the Power Source uses a sample and hold circuit to track the highest peak current found until reset. The peak current sample and hold circuit is reset any time the user toggles away from the peak current display mode to a different measurement.

The peak inrush current for a unit under test can be measured using this function as follows:

1. Program the output to zero volts and open the output relay using the ON/OFF button.

2. Use the SELECT button to display the present peak current value.

3. Use the SELECT button again to toggle to any other measurement readout. This will effectively reset the peak current sample and hold circuit to zero amps.

4. Use the left shuttle knob to set the voltage to the nominal supply voltage of the unit under test.

5. Use the ON/OFF button to apply the programmed voltage to the unit under test.

6. Use the SELECT button to display the measured peak current value.

Note:	**The 351TL output is turned on at random phase angle. It may be necessary to repeat this test to find the highest possible peak inrush current demanded by the unit under test.** **Phase angle control is available over the bus if the –OP1 option package with IEEE-488/RS232C interface is installed.**

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4.3 Setting the Power on Initialization Values

The Power Source is supplied with default factory settings when the unit is powered up. The factory settings are:

Parameter	Factory default setting
Voltage range	Low
Auto Voltage Range	OFF
Voltage	5.0 Volt
Frequency	60 Hz
Current limit	2.8 amps
Display mode	Frequency
Output Relay state	OFF
Output start state	OFF
Output start phase	0 degrees
Local / Remote State	Local. Front panel unlocked.

Table 4-1: Factory Default Power on Settings

It is possible to change the power on initialization values in one of two ways:

1. Using the optional RS232 or IEEE-488 interface and the supplied PGUI32 program.

2. Using the front panel.

To change the power on initialization values from the front panel, proceed as follows:

1. Set the unit up in the desired way from the front. (Range, voltage, frequency, current limit, output relay state, display mode).

2. Press and hold the SELECT key (normally toggles LED display mode). Make sure the correct indicator LED is illuminated, e.g., FREQ to display voltage and frequency.

3. While holding the SELECT key, press the OUTPUT ON/OFF key. This will save the present front panel settings in non volatile memory register (NVM) no 7 and assign this register as the power on register.

4. Release both keys. Note that as step 2 is executed, the display mode will toggle . This means the display mode after power up is different from how the unit was set up. To avoid this, just toggle the display till one position before the desired power on mode first and then execute steps 2-4.

5. This procedure can be repeated as often as needed by the user.

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4.4 Current Limit Modes

The Power Source supports two modes of current limiting. In either mode, the end user can set the RMS current level at which the current limit function will kick in. The available current limit modes are:

Constant Current (CC) mode	This is the default mode as supplied from the factory. In this mode of operation, the output voltage is automatically reduced by the AC power source to maintain the set current. Once the current drawn drops below the set limit value, the voltage is increased again. No error message is generated in this mode of operation. This mode is suitable for starting up loads that require high inrush currents but don't need full nominal voltage to run. (example AC motors).
Constant Voltage (CV) mode	In this mode of operation, the output of the AC source is turned off and the programmed voltage is set to 0 volt as soon as the load current exceeds the set current limit value. (Trip current).

The selected current limit mode may be changed by moving a jumper on the AC power source controller board. This requires that the AC source is disconnected from the AC line and the top cover is removed. The current mode jumper is located at the top of the controller board which is directly behind the front panel.

MODE	JUMPERS
CC	W1 and W2 Removed
CV	W1 and W2 Installed

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4.5 Function Strobe [Option]

The Function Strobe (FS) is a TTL logic level signal provided at the rear panel of the Power Source. This signal is synchronized to any voltage and frequency output changes of the AC source and may be used to trigger external test equipment such as oscilloscopes.

Default mode of operation

The function strobe is an active low TTL output signal. Each sync pulse lasts approximately 400 μsec . The output changes on the falling edge of the function strobe output.

Alternative mode of operation

The function strobe output logic uses the GPIB interface DC supply to provide the required logic levels. If the GPIB interface is connected to the user's PC, excessive ground noise may prevent the function strobe from operating correctly. If this is the case, the output mode of the function strobe may be changed to provide an open collector output instead. In this case, the end user has to provide an external DC power supply and pull-up. A 9 Volt DC battery may be used for this purpose. Contact California Instruments' service department for details on changing the operation of the FS output.

4.6 Remote Inhibit [Option]

A Remote Inhibit BNC input is located on the rear panel of the Power Source if the -OP1 option was specified at the time of purchase. This input may be used to kill the AC source output using an external control signal.

Default mode of operation

If the Remote Inhibit input is left unconnected, the output of the AC source can be turned on using the ON/OFF button on the front panel or the appropriate bus command. To disable the output relay, a logic low level or a contact closure needs to be present across the terminals of the BNC (RI) connector.

Typical use of the RI input is in rack and stack systems where the RI input is wired to a switch that detects removal of the rear panel. This input may also be used to simultaneously shut down multiple AC power sources.

Note that the RI input has an internal pull up resistor to TTL logic high. When the RI input cable is disconnected, the output will recover and the output relay will be closed automatically.

4.7 External Oscillator Input [Option -EXT]

An external oscillator input may be used in lieu of the built in controller if the TL is order with the -EXT option. Installing this option implies that the internal controller is removed and a blank front panel is used instead. In this configuration, there are no front panel controls and or measurements.

When turned on, the Fan will run but no other indication of power on is provided other than the position of the AC line switch.

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External Input signal

The output range with the -EXT option will be fixed at either 135V or 270V. This is determined by the S3 Dip switch on the mother board. **The desired output voltage range must be specified at the time of order.** It is noted on the model type sticker (serial tag). To change this setting, the top cover must be removed. Contact customer service (support@calinst.com) before attempting to change these settings.

Default settings are shown in BOLD.

S3	Position	ON	OFF
	1	270V Range	135V Range
	2	**-EXT input**	Internal Oscillator
	3	Output relay Open	**Output relay Closed**
	4	Internal Oscillator	**-EXT input**

Table 4-2: -EXT Option DIP Settings

The external input signal must be an AC voltage waveform with an RMS value as follows:

0.0 to 5.0 VRMS for 0.0 to Full Scale VRMS output.

Note: Do not apply more than 5.0 Vrms to the EXT input as the output transformer will saturate.

An External input BNC connector is located on the rear panel. This BNC input replaced the Remote Inhibit BNC normally found on the 251/351TL without the –EXT option.

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5 Principle of Operation

5.1 General

An explanation of the circuits in the AC Source is given in this section. Refer to block diagram in Figure 5-1.

5.2 Overall Description

Input power at the rear panel is routed through the circuit breaker to the input transformer. The DC supply outputs then go to the Amplifier, A1, then are directed to other modules.

The output of the transformer, T1, goes to a bridge rectifier and filter caps for a + and -28 supply.

The Programmable Controller Assembly, A2, generates the oscillator waveforms, power source controls and measurement signals. The oscillator assembly is connected to the rest of the power source through the Amplifier Board, A1.

The Amplifier Module, A1, takes its DC supply voltages directly from the DC supply. It gets it's input signal from the Controller Board, A2. It produces the high power output for the primary of the output transformer, T2. The output from the output transformer is connected to the Range Relay Board, A3.

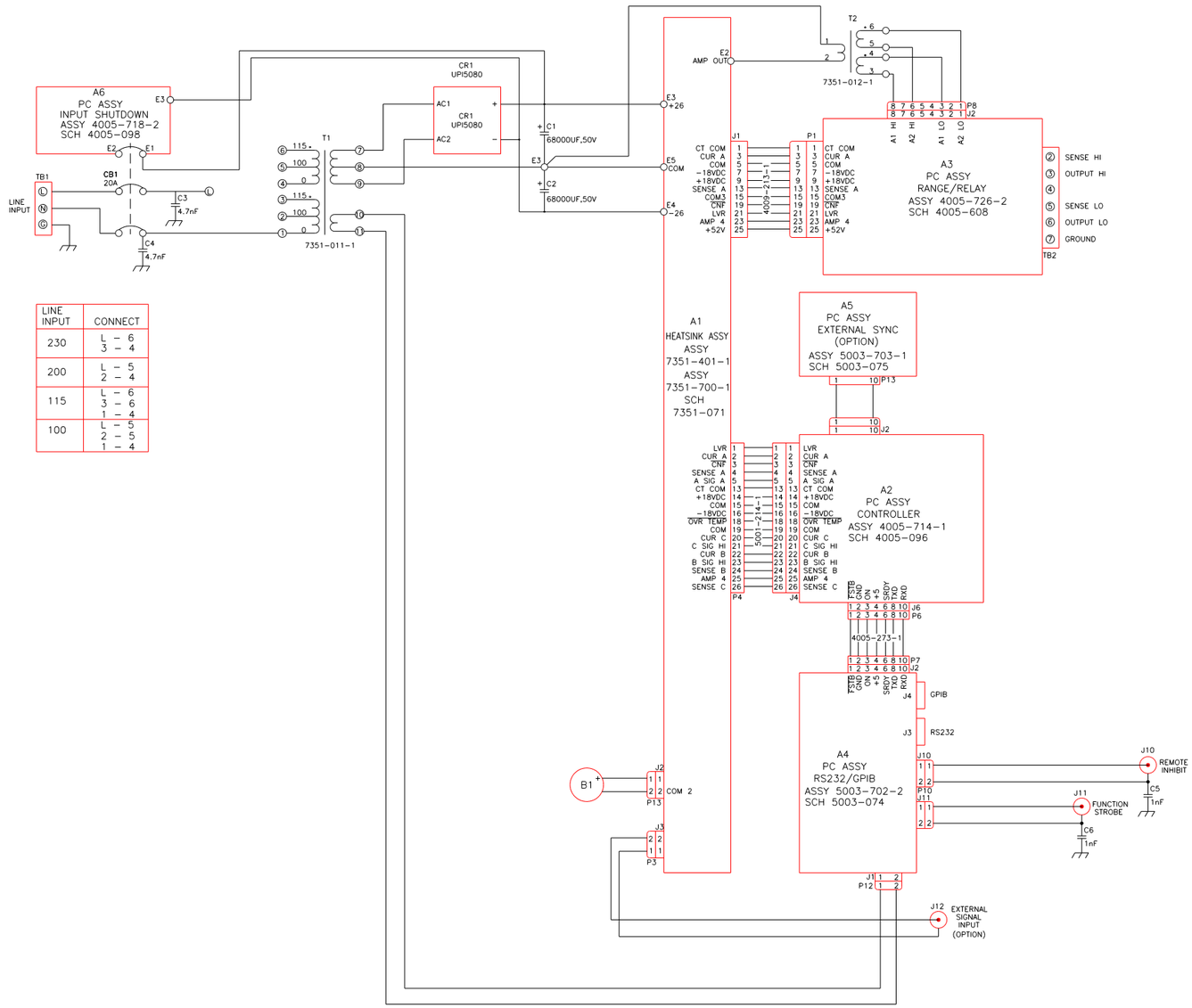
The Range Relay Board assembly configures the secondaries of the output transformers for the correct output voltage range. The output from the AC Power Source is taken from the Range Relay Board.

5.3 Input Power Supply

The Input Power Supply consists of transformer, T1, Bridge Rectifier OR1 and capacitors C1 and C2. The DC output from the supply connects to the Amplifier. The +28 VDC supply connect to the Amplifier terminal E2. The -28 VDC supply connect to E3 and the common to E4. The transformer also supplies the RS232/GPIB assembly with an isolated AC supply.

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Figure 5-1: AC Power System Block Diagram



LINE INPUT	CONNECT
230	L – 6 3 – 4
200	L – 5 2 – 4
115	L – 6 3 – 6 1 – 4
100	L – 5 2 – 5 1 – 4

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5.4 Range Relay Board

The Range Relay Board, Module Assembly A3, has all of the AC Power Source relays. These relays are operated from +28 VDC. The output relay is controlled by the CNF Logic Line. The range relay is controlled by the LVR line.

There is a current transformer on the Range Relay Board. This transformer generates an AC voltage that is proportional to the output current. The current transformer burden resistor has two different values for the two current measurement ranges. The relay for the measurement ranges is controlled by the AMP 4 line.

The Range Relay Board also has an instrumentation amplifier. This amplifier is used to remotely sense the output voltage. The signal from the instrumentation amplifier is SENSE A.

5.5 Amplifier

The AC Power Source uses a linear amplifier for a low-noise, low distortion output. The amplifier module is designated A1. The Amplifier assembly also acts as an interconnect between the other board assemblies.

The Amplifier obtains its input signal from the Controller. A 5.0V RMS input signal will generate a full-scale output voltage at the output of the AC Power Source and 11.5V RMS on the primary of the output transformer.

The Amplifier requires $\pm$ 28 VDC. The $\pm$ 28 VDC supply comes from the DC input power supply.

The Amplifier has a thermo-switch mounted on its heat sink. If the heat sink temperature exceeds 80 degrees C, the amplifier shuts down and sends an OVT signal to the oscillator module. Logic low on the OVT control line will cause the front panel FAULT indicator to be illuminated. When the heatsink exceeds 45 degrees C, the fan speed will increase.

5.6 Controller Module

The Controller Module is designated A2. The module consists of one printed circuit assembly. This assembly is interconnected to the Amplifier Board.

The Oscillator Module has the circuits to perform the following operations:

1. Generates the output voltage sinewave.
2. Interprets the Voltage, Frequency and Current limit commands from the front panel and RS232/GRIB Board.
3. Attenuates the oscillator drive signal to operate in a constant current mode.
4. Measures the output voltage, current, peak current and power.
5. Performs voltage dropouts at a designated phase angle.

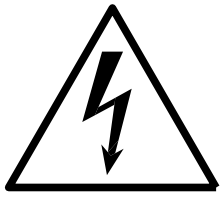
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5.7 IEEE 488/ RS232 Interface [Option]

The 351TL can optionally be outfitted with a combined RS232C and IEEE 488 interface board. This board assembly has opto-couplers for interface isolation.

The GPIB address for the AC source is selected by a DIP switch on the rear panel. Only one interface can be active at any given time and must be selected using DIP switch position 6. (Refer to Figure 8-2).

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CAUTION

THE INPUT LINE VOLTAGE IS PRESENT IN CERTAIN SECTIONS OF THIS POWER SOURCE. THIS EQUIPMENT GENERATES POTENTIALLY LETHAL VOLTAGES.



DEATH

ON CONTACT MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. DO NOT TOUCH ELECTRONIC CIRCUITS WHEN POWER IS APPLIED.

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6 Calibration

Routine calibration should be performed every 12 months. Non-routine calibration is only required if a related assembly is replaced or if the periodic calibration is unsuccessful.

Calibration can be performed through the front panel by putting the Power Source in Calibration mode (CAL mode) or over the RS232C or IEEE-488 bus if the interface option is installed. For bus calibration, the PGUI32 program may be used. Refer to the PGUI32 help file supplied with the program for instructions on calibration over the remote control bus.

All routine calibrations can be performed without removing the top cover (Closed case calibration).

6.1 Calibration Equipment

Digital Multimeter (DMM):	Two (2) HP 34401A
100 milliohm Current Shunt:	Isotek Model RUG-Z-R100-0.1 or equivalent
Load Bank:	Various power load resistors will be needed

Model	Range	Current max.	Load
351TL	135 V	2.8 A	48.2 Ω
	270 V	1.4 A	192.9 Ω
251TL	135 V	2.4 A	56.3 Ω
	270 V	1.2 A	112.5 Ω

Table 6-1: Load Resistors and Current

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6.2 Selecting Calibration Mode

The Power Source can be placed in calibration mode (CAL mode) by depressing the recessed CAL button located on the front panel using a pen or similar pointed object. Depressing this button for a brief moment will place the Power Source in CAL mode, indicated by the illumination of the PF LED. While in CAL mode, the front panel controls are used to adjust the various calibration parameters. Both controls and status indicators take on different functions while the unit is in CAL mode. The SELECT button is used to select the various measurement parameters that can be calibrated in this mode. The following status indications are in effect while in CAL mode:

Status LED	CAL mode * (PF LED illuminated)	Normal operating mode *
FREQ	Indicates voltage measurement calibration is selected. If this LED is not lit while in CAL mode, the Output Voltage calibration mode is selected.	Indicates frequency setting or measurement is displayed on right 7 segment LED display.
I RMS	Indicates current measurement calibration is selected.	Indicates current limit setting or current measurement is displayed on right 7 segment LED display.
I PK	Indicates peak current measurement calibration is selected.	Indicates peak current measurement is displayed on right 7 segment LED display.
PWR	Indicates power measurement calibration is selected.	Indicates power measurement is displayed on right 7 segment LED display.
PF	Indicates 351RP unit is in calibration mode.	Indicates power factor measurement is displayed on right 7 segment LED display.

Table 6-2: CAL Mode Status LED Indicators

* Some measurement functions are optional and may not be available. The calibration mode will only select measurement calibration for measurement functions that are installed.

Note that in normal mode of operation, at no time more than one of the measurement mode selection LED's are lit at the same time. In CAL mode however, the PF LED is always on, in addition to one of the other four measurement selection LED's or no other LED for output voltage calibration.

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6.3 Routine Calibration

Setup:

Connect the test equipment to the power source as shown in Figure 6-1. The DMM can be connected to the common output terminal at the rear of the unit.

Never connect the load wire to the SENSE terminal at the Rear Panel terminal strip. The load must be connected to the POWER output terminal and a jumper between the POWER and SENSE terminal. Always connect the external DVM to the SENSE terminal.

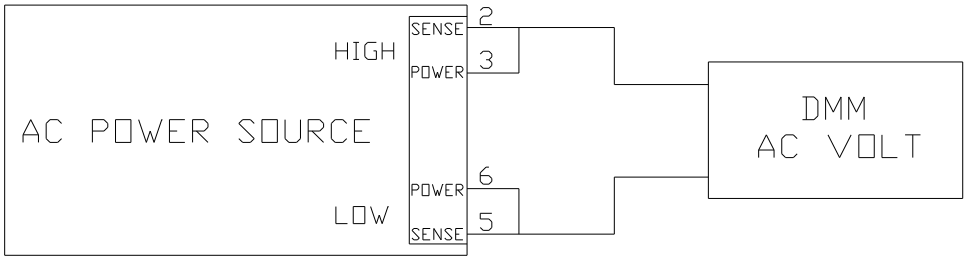


Figure 6-1: Test Equipment Hookup for Routine Output and Voltage Measurement Calibration

6.3.1 Output Voltage Calibration

1. Select the high voltage range. Set the output frequency to 400 Hz . Set the output voltage to 240 volts.

2. Remove the load and enable the output voltage with the Output ON/OFF button.

3. Put the Power Source in CAL mode by pressing the recessed CAL button.

4. Use the SELECT key to toggle to the output voltage calibration mode. In this mode, all LED's excepts the PF LED are off.

5. Use the Left control knob to adjust the output voltage displayed on the external reference DMM until it reads as close as possible to 240 V_{AC}.

6. Press the CAL button to leave the calibration mode.

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6.3.2 Measurement Calibration - Low Scale

Note:	**Measurement calibration can be done at any output frequency setting as only one set of calibration coefficients is used for measurement calibration. However, for best results, calibrate the measurements at the frequency which is used in most applications, e.g. 50 Hz, 60 Hz, or 400 Hz.** **Refer to Table 6-1 for correct load resistors based on model number.**

Low Scale Voltage Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-2. **Do not** connect any load during this step. Voltage calibration must be done under no load conditions.

2. Select the Low Voltage Range and program the output voltage to 10 volt AC.

3. Put the Power Source in CAL mode by pressing the recessed CAL button.

4. Use the SELECT key to select the Voltage Measurement calibration mode. This mode is indicated by the FREQ LED.

5. Use the left control knob to adjust the voltage reading shown on the right hand 7 segment LED display until it reads as close as possible to the reference reading as displayed on the external DMM.

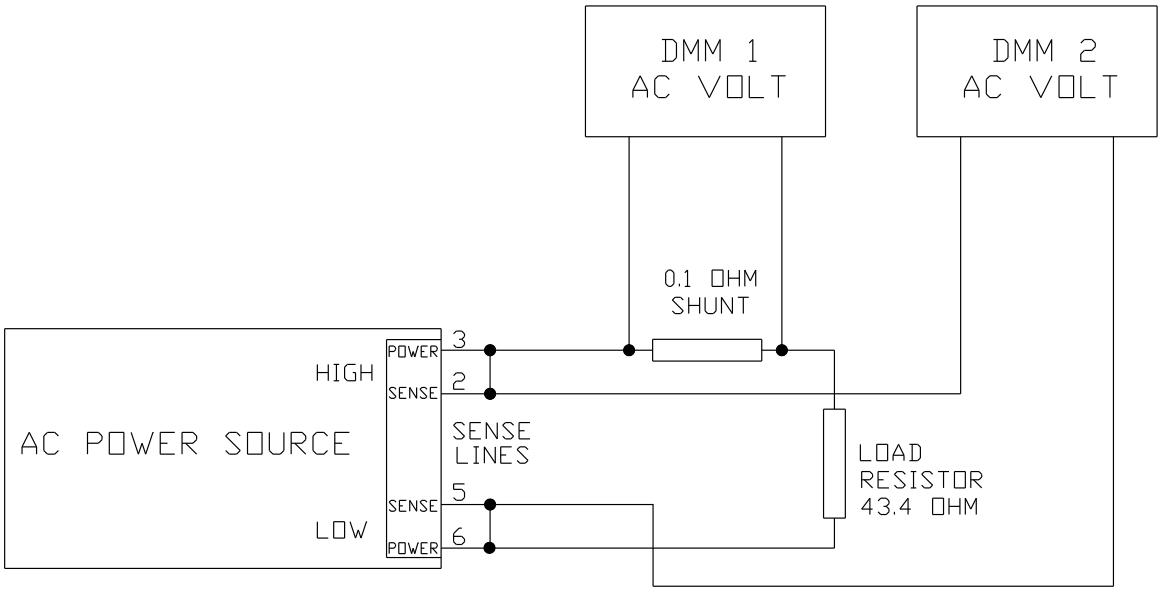


Figure 6-2: Test Equipment Hook-up for Current and Power Measurement Calibration

Low Scale Current Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-1.

2. **Do not** apply a load to the output terminals. Make sure the external DMM used for voltage measurement is across the same terminals.

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3. The output voltage must be programmed to 10.0 volts.

4. Use the SELECT key to select the Current Measurement calibration mode. This mode is indicated by the I RMS LED.

5. Use the left control knob to adjust the current reading shown on the right hand 7 segment LED display until it reads as close as possible to 0.0. Do not go past a reading of zero.

Low Scale Peak Current Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-1. Do not connect the load.

2. Program the output voltage to 10.0 volts.

3. Use the SELECT key to select the Peak Current Measurement calibration mode. This mode is indicated by the I PK LED.

4. Use the left control knob to adjust the peak current reading shown on the right hand 7 segment LED display until it reads as close as possible to 0.0. Do not go past a reading of zero.

Low Scale Power Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-1. Do not connect the load.

2. Program the output voltage to 10.0 volts.

3. Use the SELECT key to select the Power Measurement calibration mode. This mode is indicated by the PWR LED.

4. Use the left control knob to adjust the power measurement reading shown on the right hand 7 segment LED display until it reads as close as possible to 0.0. Do not go past a reading of zero.

Note:	**The method of adjusting the low scale values for voltage, current and power insure that the measured value is correct for small values. Under a no-load condition, however, the measured value may not be 0**

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6.3.3 Measurement Calibration - Full Scale

Note:	**Measurement calibration can be done at any output frequency setting as only one set of calibration coefficients is used for measurement calibration. However, for best results, calibrate the measurements at the frequency which is used in most applications, e.g. 50 Hz, 60 Hz. Refer to Table 6-1 for correct load resistors based on model number.**

Full Scale Voltage Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-1. **Do not** connect any load during this step. Voltage calibration must be done under no load conditions.

2. Select the High Voltage Range and program the output voltage to 240.0 volts AC or the maximum voltage available if less than 240 Volts.

3. Put the Power Source in CAL mode by pressing the recessed CAL button.

4. Use the SELECT key to select the Voltage Measurement calibration mode. This mode is indicated by the FREQ LED.

5. Use the left control knob to adjust the voltage reading shown on the right hand 7 segment LED display until it reads as close as possible to the reference reading as displayed on the external DMM.

Full Scale Current Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-2.

2. Apply the 43.4 Ω resistive load to the output terminals. Make sure the external DMM used for voltage measurement is across the sense terminals.

3. Program the output voltage to a value that produces the maximum output current. Refer to the following for the maximum current:

POWER SOURCE	MAX CURRENT
351TL	2.8 A
251TL	2.4 A

4. Use the SELECT key to select the Current Measurement calibration mode. This mode is indicated by the I RMS LED.

5. Use the left control knob to adjust the current reading shown on the right hand 7 segment LED display until it reads as close as possible to the reference reading indicated by the DMM measuring the current shunt voltage (DMM 1). Note that .28 V reading represents 2.8 Amps if the recommended 100 mΩ shunt is used.

Full Scale Peak Current Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-2.

2. Select the low voltage range and program the output voltage to 135 volts. Apply the load for the maximum current allowed.

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3. Use the SELECT key to select the Peak Current Measurement calibration mode. This mode is indicated by the I PK LED.

4. Use the left control knob to adjust the peak current reading shown on the right hand 7 segment LED display until it reads as close as possible to the reference reading derived from the external DMM (DMM 1). Remember the peak current value is equal to 1.414 times the value shown on the external DMM.

Full Scale Power Measurement Calibration

1. Connect the test equipment to the power source as shown in Figure 6-2.

2. Program the output voltage to 135 volts and apply the maximum load.

3. Use the SELECT key to select the Power Measurement calibration mode. This mode is indicated by the PWR LED.

4. Calculate the power by multiplying the external reference current reading (DMM 1) with the external reference voltage reading (DMM 2).

5. Use the left control knob to adjust the power measurement reading shown on the right hand 7 segment LED display until it reads as close as possible to the calculated power reading.

6.4 Non-Routine Calibration

The following calibrations are not required on a routine basis:

- Current Transformer Adjustment (Section 6.4.1). If either the current or power measurements cannot be adjusted, this adjustment must be performed.

- Current Limit Adjustment (Section 6.4.2). This calibration is only required if the output current, while operating in the constant voltage or current mode, is not equal to or more than the programmed value.

- Open Sense Adjustment (Section 6.4.3). This adjustment must be made if the output voltage can't be calibrated while operating in the constant current mode. If the output faults, with no-load, while operating in the Constant Voltage mode, this adjustment must also be made.

- Amplifier Offset Adjustment (Section 6.4.4).

All of the non-routine calibration adjustments must be made with the top cover removed. Refer to Figure 6-3 for the location of the internal adjustments.

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6.4.1 Current Transformer Adjustment

Note:	**The Current Transformer must be adjusted before the Current Limit and Current Measurement Adjustments.**

1. Connect the test equipment as shown in Figure 6-2. Use the 43.4 ohm load.

2. Program the output voltage to 135V on the low voltage range and 60 Hz.

3. Use the **SELECT** key to select the Current Measurement display. Note that this is not the Current Measurement calibration mode. Only the I RMS **LED** should be illuminated.

4. Observe the actual output current as shown on the external DMM and current shunt. Adjust R3 on the Range/Relay Board for a measurement display equal to the actual output current.

CAUTION:	**The amplifier wind tunnel must be covered for proper cooling if the adjustment takes more than 1 minute.**

6.4.2 Current Limit Adjustment

Note:	**If the Current Limit and High Current Measurement Range Adjustments are both adjusted, the High Current Measurement Range must be adjusted first.**

1. Connect the test equipment as shown in Figure 6-2. Use the 43.4 ohm load.

2. Program the current to 2.0 A. Program the output to the low voltage range, 60 Hz. Adjust the output voltage for an output current of 2.1 amps. If the output faults before 2.1 A is reached, adjust R50 several turns clockwise and readjust the output for 2.1 A.

CAUTION:	**The amplifier wind tunnel must be covered for proper cooling if the adjustment takes more than 1 minute.**

1. Slowly adjust R50 on the Oscillator Board counterclockwise just until the output faults.

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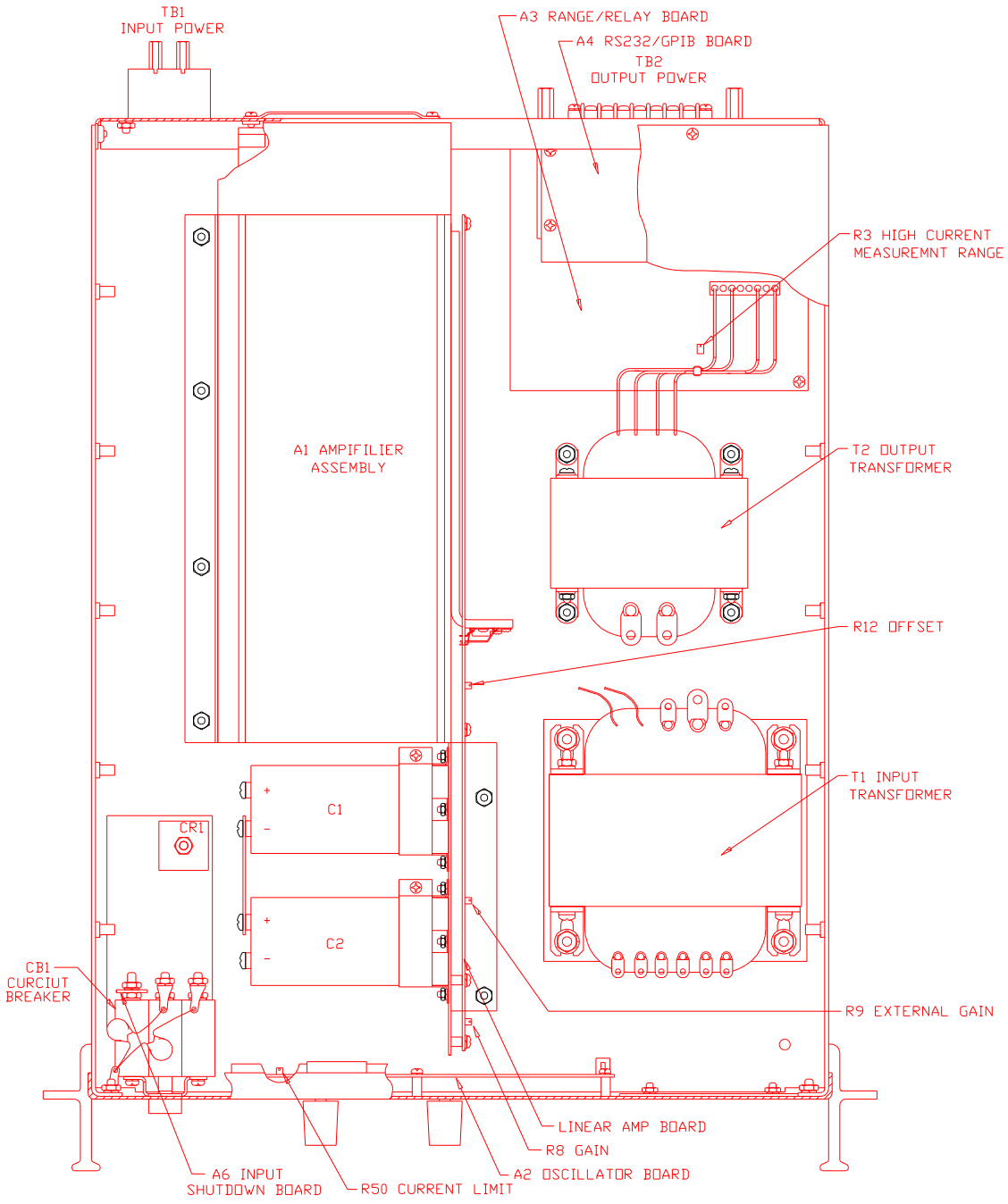


Figure 6-3: Internal Adjustments

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6.4.3 Open Sense Adjustment

Connect the test equipment as shown in Figure 6-1.

NOTE:	**The 351TL must be configured for the Constant Current Mode of operation for this procedure. For this mode jumpers W1 and W2 on the controller must be removed.**

Disconnect the SENSE HIGH terminal on the rear panel terminal strip. Connect the external AC DMM between the two output POWER terminals on the rear panel.

Program the output to 100.0 volts and adjust R8 on the Amplifier Board for an output voltage of 115 volts.

Turn off the front panel circuit breaker and reinstall the top cover. Also reconnect the external SENSE terminals at the rear panel.

Reinstall jumper W1.

6.4.4 Amplifier Offset Adjustment

Turn off the Front Panel circuit breaker.

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Connect the DMM to the primary of the output transformer, T2. The transformer primary terminals are the two wire lugs. Refer to

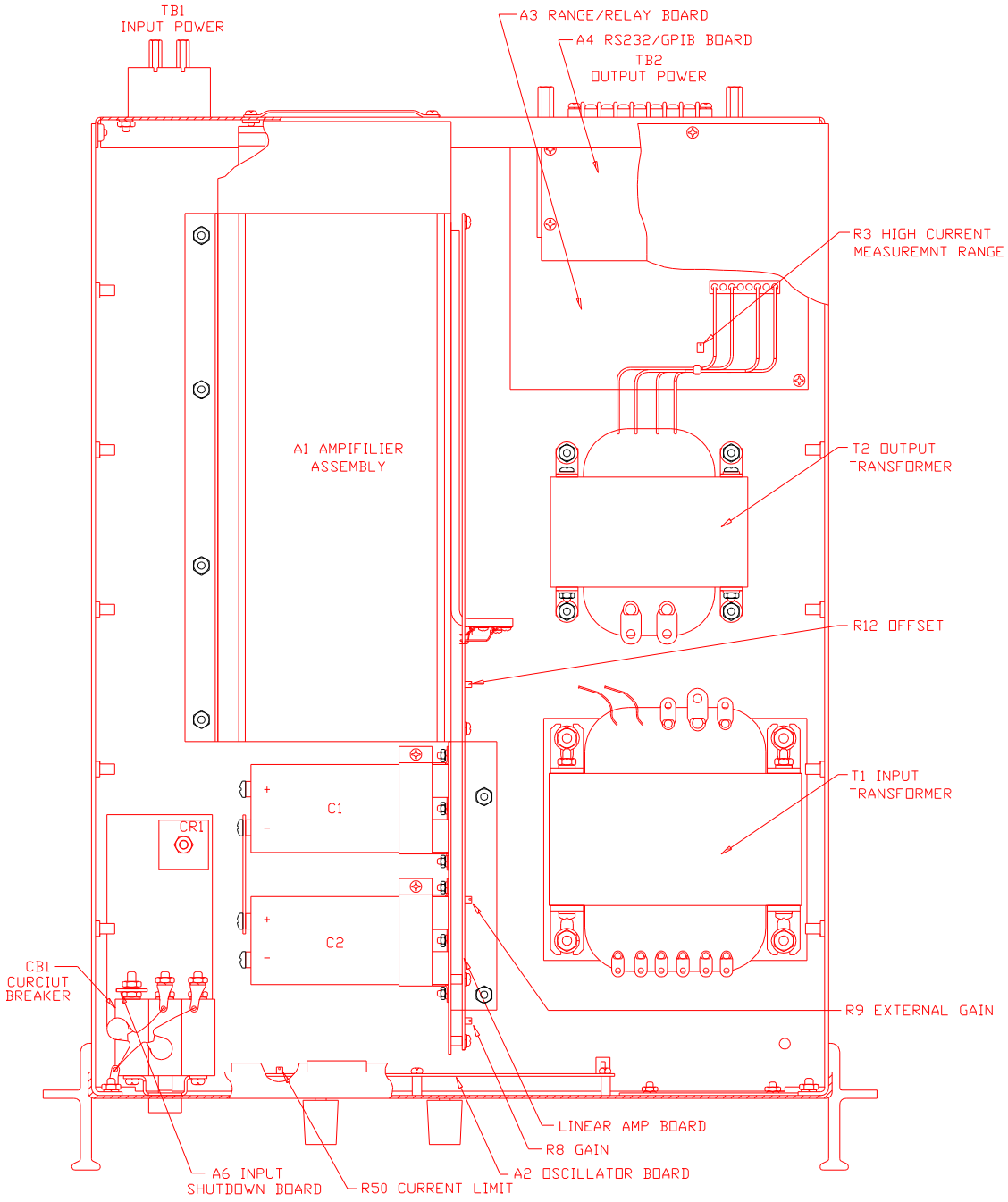


Figure 6-3. Make sure there is a good electrical connection to T2 by verifying the electrical resistance with the DMM. The resistance must be less than 1 ohm.

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Switch the DMM to the DC mode. Turn on the Front Panel circuit breaker. Adjust the offset adjustment, R12, for a DC voltage less than 0.0005 volts. Make sure the AC voltage is programmed to 0.0 volts for this adjustment. Refer to

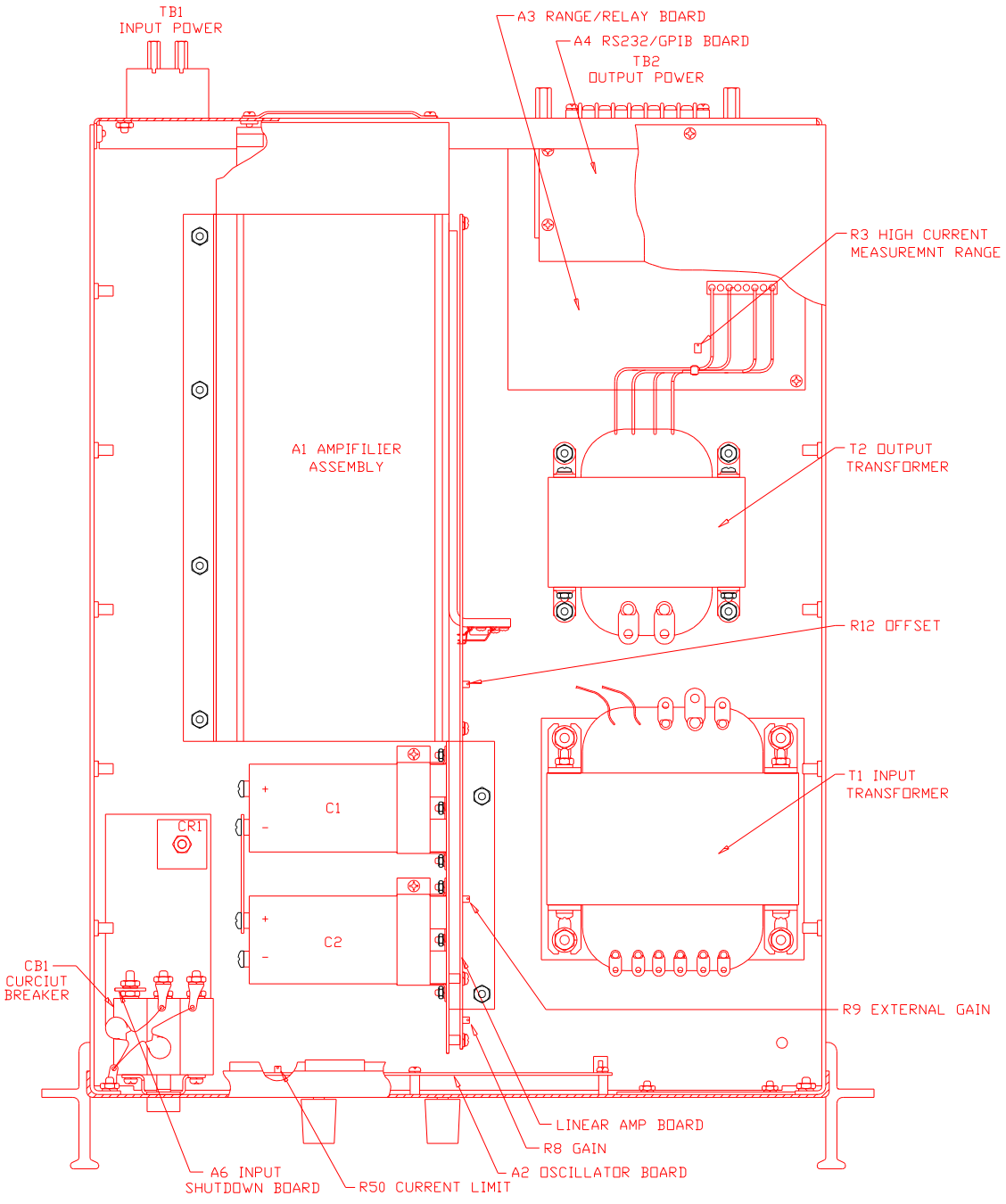


Figure 6-3 for the location of all adjustments.

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7 Service

7.1 General

This section describes suggested maintenance and troubleshooting procedures. The troubleshooting procedure is divided into two sections. The first section deals with basic operation and connection of the equipment. The second section requires opening the unit and using the LED indicators and a simple multimeter to troubleshoot the unit down to the module level. Only a qualified electronic technician should attempt this level of troubleshooting.

7.2 Basic Operation

Table 7-1: Basic Symptoms

PARAGRAPH	PROBLEM
7.2.1	Poor Output Voltage Accuracy
7.2.2	Poor Output Voltage Regulation
7.2.3	Distorted Output
7.2.4	Unit Shuts Down After 3-5 Seconds
7.2.5	No Output and no lights on front panel
7.2.6	No output but “Display” on front panel is on
7.2.7	Fault Lamp on
7.2.8	Can’t program AC Power System on GPIB/RS232

7.2.1 Poor Output Voltage Accuracy

If the power source exhibits poor programmed voltage accuracy, the following item may be at fault:

Table 7-2: Poor Output Voltage Accuracy

CAUSE	SOLUTION
The calibration is incorrect.	Calibrate the output.

7.2.2 Poor Output Voltage Regulation

If the AC Power Source exhibits poor voltage regulation the following item may be at fault:

Table 7-3: Poor Output Voltage Regulation

CAUSE	SOLUTION
The Remote Sense lines are not connected at the same point monitored by the external voltmeter used for load regulation check.	Connect AC voltmeter to Remote Sense lines on the Rear Panel Power Output terminal strip.

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7.2.3 Distorted Output

Table 7-4: Distorted Output

CAUSE	SOLUTION
Power source is grossly overloaded.	Reduce load.
The crest factor of the load exceeds 3:1.	Reduce load current peaks by reducing load.

7.2.4 Unit Shuts Down After 3-5 Seconds

Table 7-5: Unit Shuts Down After 3-5 Seconds

CAUSE	SOLUTION
Output shorted.	Remove output short.
Output grossly overloaded.	Remove overload.
Operating load with too high inrush or start up currents.	Consult factory for application advice.

7.2.5 No Output and No Lights on Front Panel

Table 7-6: No Output and No Lights on Front Panel

CAUSE	SOLUTION
Front panel power switched off.	Switch the breaker on.
No input power to the input connector.	Ensure correct input power.
Blown fuse.	Check fuse F1 and F2 on the DC power supply and replace with same type and rating. See Figure 7-2.

7.2.6 No Output but “Display” on Front Panel is On

Table 7-7: No Output But "Display" Is On

CAUSE	SOLUTION
“OUTPUT ON” switch is turned off.	Turn OUTPUT ON switch to “ON”.
Current limit programmed down or to zero.	Program current limit higher.
Voltage programmed down or to zero.	Turn amplitude control up.
Fault LED is lit.	Cycle Rear Panel power switch off and on.

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7.2.7 Fault Lamp On

If the power source Fault lamp is on, the following may be at fault:

CAUSE	SOLUTION
Ambient temperature is too high.	Operate power source between 0 and 50°C.
Fan or ventilation holes are blocked.	Remove obstructions.
Fan not working.	Replace fan. Consult factory.

If the Power Source is configured to operate in the Constant Voltage mode, the Fault lamp comes on when the output load current has exceeded the programmed current limit value. If the AC Power Source Fault lamp is on, the following items may be at fault:

CAUSE	SOLUTION
The output is overloaded.	Remove the overload.
The programmable current limit level is set too low for the load being driven.	Compute and reprogram the correct programmable current limit level.
The programmable current limit is incorrectly calibrated.	Perform the calibration in Section 6.4.2
The Remote Sense lines are not connected.	On the Rear Panel Power Output terminal block, connect terminal 2 to 3. Also connect terminal 5 to 6.

7.2.8 Can't Program AC Power System on GPIB or RS232

If the power source does not respond to IEEE-488 GPIB or RS232 programming, the following items may be at fault:

CAUSE	SOLUTION
The power source unit address is incorrect.	Update address. See section 8.3.
GPIB or RS232 cable is loose at power source rear panel.	Check connection, tighten jackscrews.
RS232/GPIB Assembly has failed.	Replace the RS232/GPIB Assembly.
Power connection to RS232/GPIB Assy is bad.	Remove top cover. Connect power to RS232/GPIB Board, J1. Refer to Figure 7-1.

7.3 Module Removal

Figure 7-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Module, A7, with the insulator removed.

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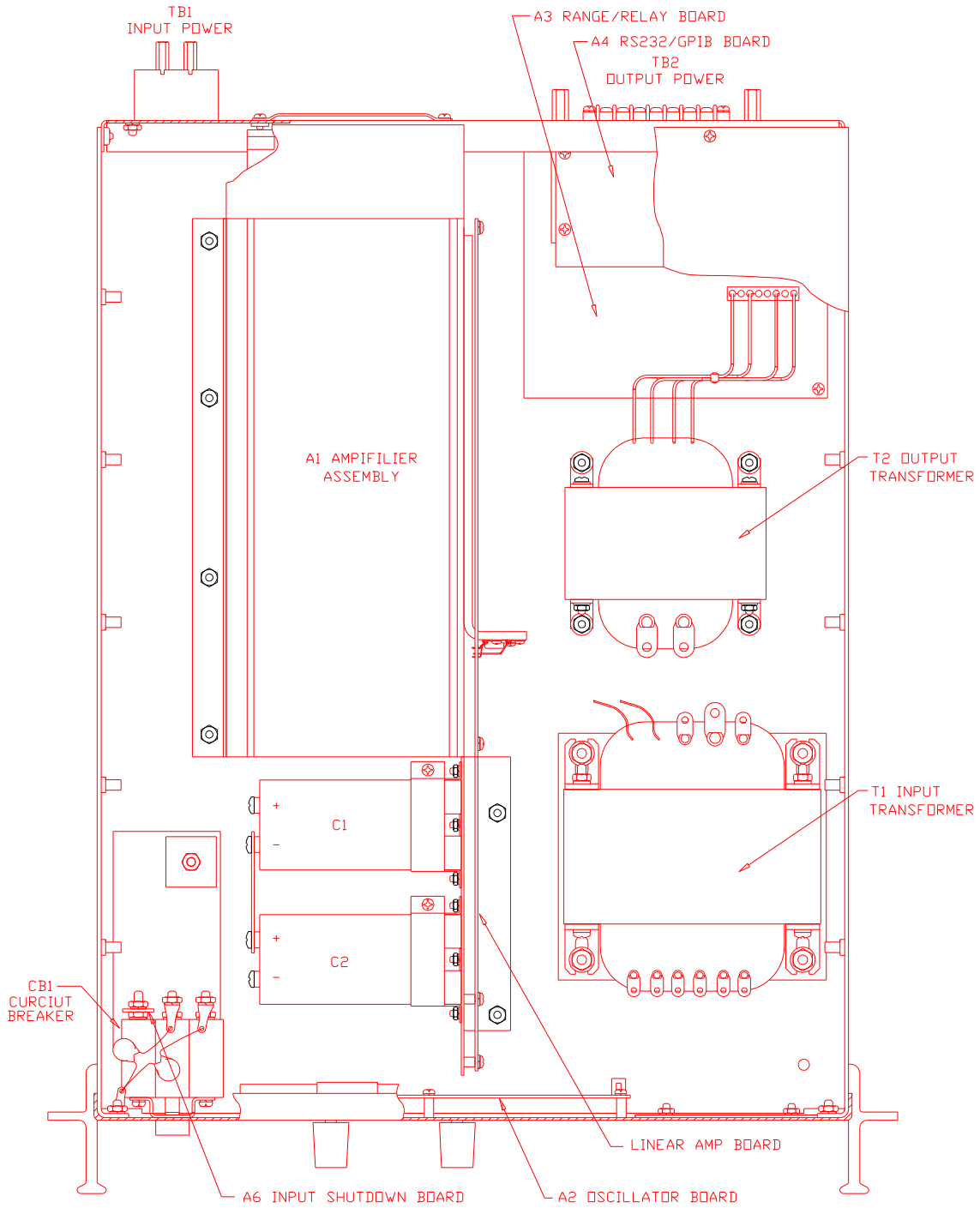


Figure 7-1: Assembly Location

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7.3.1 Oscillator Module Removal/Replacement

If a fault is found that requires the replacement of the Oscillator Module (Assembly A1) follow the following steps and refer to Figure 7-1 for the module locations:

1. Turn off the front panel circuit breaker. Remove the input power from the rear panel terminal block.

2. Remove the top cover.

3. Remove the front panel knobs.

4. Remove 5 screws that hold the oscillator assembly to the front panel. The oscillator assembly can now be removed.

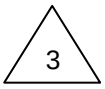
7.3.2 Amplifier Removal/Replacement

If a fault has been found that indicates the failure of the amplifier module (Assembly A7), check the condition of the +300 VDC fuse (F2) before replacing the amplifier. Refer to Figure 7-1 for the location of the fuse.

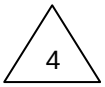
If it is determined that the amplifier module must be replaced, perform the following procedure:

1. Turn off the input circuit breaker.

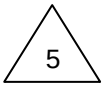
2. Disconnect AC input power at the rear panel.



Remove the AC Power Source top cover by removing (13) #6-32 x 5/16” FLH screws.



Remove the (2) #6-32 x 1” screws and lock washers that hold the amplifier module along the left chassis side panel.



Remove (2) #6-32 x 3/8” screws and lock washers located near the connector, attaching the red insulator to the center bracket.

6. Remove the amplifier by pulling it away from the connectors and lifting it up and out of the amplifier cage.

7. The amplifier may be replaced by following this procedure in reverse order.

8. Check the amplifier 20 A fuse (F2) located on the DC Supply Board, A6, and replace it if necessary.

9. After an amplifier has been replaced, readjust its gain.

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7.4 Replaceable Parts

In order to ensure prompt, accurate service, please provide the following information, when applicable for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments' part number for the sub-assembly where the component is located. (California Instruments PART #)

c. Component reference designator. (SEQ #)

d. Component description.

e. Component manufacturers' FSCM number. (VENDOR)

All replaceable part orders should be addressed to:

California Instruments Corporation.
Attention: Customer Service
9689 Towne Centre Drive
San Diego, California 92121-1964
United States of America

Orders may also be placed using the following fax number: 1 858 677 0904

SEQ #	C.I. PART #	DESCRIPTION	VENDOR	QTY
A1	4005-714-1	PC Assy, Oscillator	16067	1
A2	4005-715-1	PC Assy, Range/Relay	16067	1
A3	4005-702-2	PC Assy, RS232/GPIB	16067	1
A4	4005-716-1	PC Assy, Motherboard	16067	1
A6	4005-713-1	PC Assy, DC Supply	16067	1
A7	4009-456-3	PC Assy, Heatsink, SW Amp	16067	1
A9	4005-710-1	PC Assy, EMI Filter	16067	1
B1	241180	Fan, 4, 48 VDC	23936	1
F1	270064	Fuse, 1/2A, 250V (slo-blo)	71400	1
F2	270176	Fuse, 20A, 250V	71400	1

Table 7-8: Replaceable Parts

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8 Remote Control

8.1 Introduction

The TL Series can be furnished with a combination IEEE-488 and RS232C control interface at the time of purchase. This interface is part of the -OP1 option package. This interface option also includes the California Instruments Graphical User Interface program - PGUI32. This Windows™ program provides a soft front panel to the instrument when connected to a PC through the RS232C or IEEE-488 interface. Additional benefits are obtained from using the PC as a control interface. Some of these benefits include the ability to store measurement data to disk and produce output transients to simulate commonly occurring AC line conditions.

The PGUI32 is a Windows™ program and as such requires a PC capable of running Windows 95/98™, Windows ME™, or Windows NT™/2000. For best performance, a Pentium based PC is recommended. Intel™ 80486 based PC's will exhibit poor performance while generating transients due to their lack of processing speed.

Complete information on how to use the PGUI32 can be found in the on-line help supplied with the program. Use the Help menu or press on any of the many Help keys located in all program windows for an explanation of the relevant screen or function.

As always, California Instruments appreciates your patronage and would welcome any comments and suggestions you might have regarding this software or any of its other products. Use the End-user feedback form located on page **Error! Bookmark not defined.**. The same form can be used to report software bugs should you encounter any.

8.2 PGUI32 Program Requirements

To successfully install and operate the PGUI32 program, you will need the following equipment:

California Instruments AC power source. Supported models are :

- 251TL / 351TL
- 1001P
- 1251P
- 801RP
- 1251RP
- 2001RP / 2001RP-AV / 2001RP-LZ

PC capable of running Windows 95™, Windows 98™, Windows ME™ or Windows NT™/2000

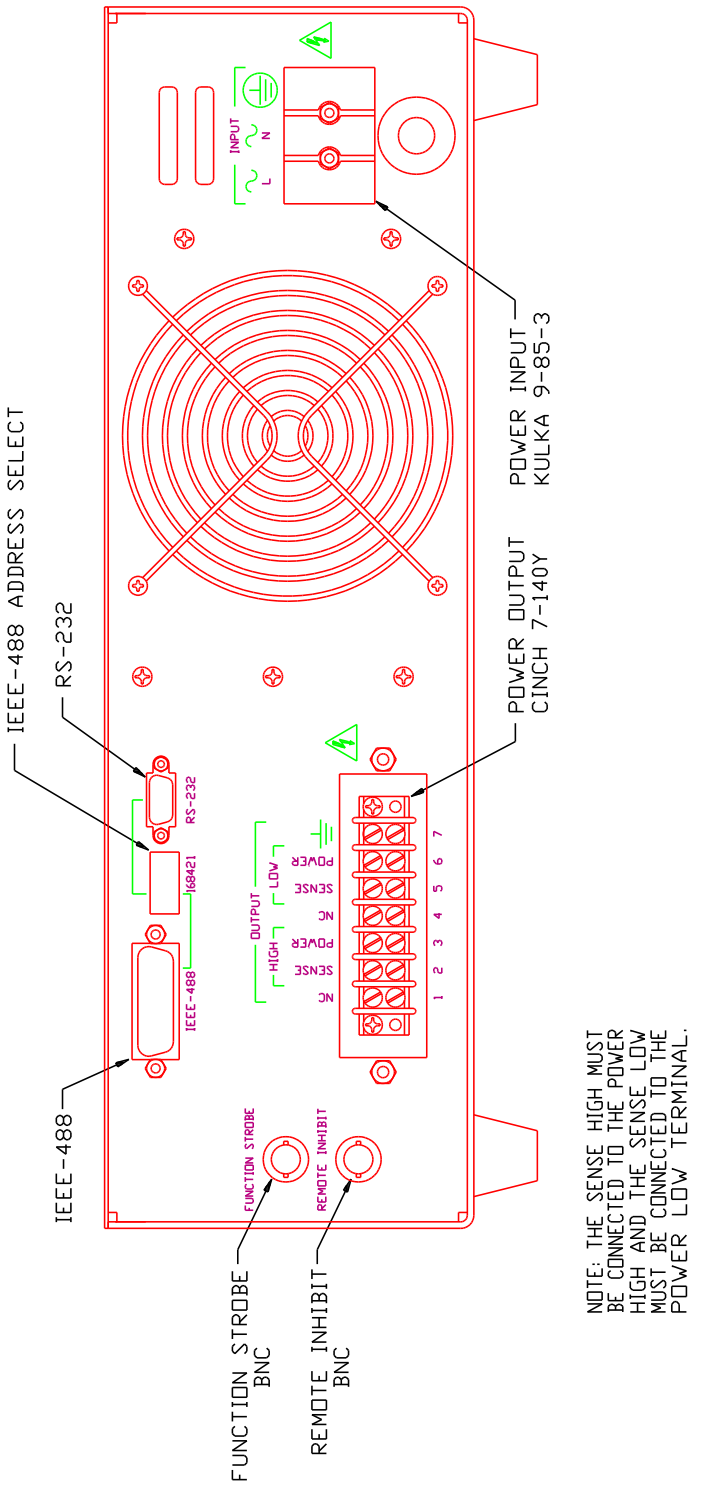
- RS232C communications port
- RS232C serial cable (supplied with the -OP1 option package.) See next section for RS232C cable wiring

  or

- National Instruments IEEE-488 Controller Card

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Figure 8-1: Rear Panel View



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Note: ***The PGUI32 can be run in the absence of a power source. If no AC source is available, the PGUI32 can be operated in a simulation mode. The program will detect these conditions and start up in simulation mode after notifying the operator. Measurements in this case will be simulated and should not be used for any analytical purpose.***

8.3 IEEE Interface

The 251 / 351TL can optionally be equipped with both RS232C and IEEE-488 interfaces. The desired interface is selected by moving the dip switch position 5 to the correct mode. Only one interface can be active at a time. Refer to Figure 8-1 for the location of this switch.

The IEEE address of the 251 / 351TL is set using the dip switch at the rear of the unit. Switch position 4 through 0 corresponds to bits 4 through 0 of the IEEE address. See figure below.



Figure 8-2: GPIB Address Selection Switch

- The black section represents the switches.
- The above configuration would cause the 251 / 351TL to be in GPIB mode at address 10.
- Listen only must be in the up position to work properly.

Note: ***Switch setting changes do not take effect until power is cycled.***

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8.4 RS232C Interface

A suitable cable to connect the 251 / 351TL AC Source to a 9 pin PC-AT style serial port is supplied with the source. If you are unable to locate this cable, you need to use a cable that conforms to the wiring diagram shown in Figure 8-3.

Note: ***This cable is not bi-directional so it is important to mark the PC side and the AC source side of this cable. If the cable is connected in reverse, it will not operate correctly.***

The TL Series expects a LF (Hex 10) terminator at the end of each string sent over the RS232C interface. If the programming environment you use to develop test programs does not append a LF terminator to each output string, the TL Series will not respond. This is true of programs like LabView™ using VISA drivers.

8.4.1 Serial Communication Test Program

The following sample program written in Quick-BASIC can be used to check communication to the TL Series AC source over the RS232C serial interface. The interface is optional and must be installed for this to work.

```
'California Instruments 251/351TL RS232C Communication Demo Program
'(c) 1998 Copyright California Instruments, All Rights Reserved
'
'This program is for demonstration purposes only and is not to be
'used for any commercial application
'=================================================================
'Function and Subroutine Declarations
DECLARE FUNCTION retstring$ ()

'=================================================================
'MAIN PROGRAM CODE
'=================================================================

'OPEN COM2. Replace with COM1, COM3 or COM4 for Com port used
'The input and output buffers are set to 2K each although
'this is not required for most operations.

OPEN "COM2:19200,n,8,1,BIN,LF,TB2048,RB2048" FOR RANDOM AS #1 LEN = 1
CLS
PRINT "**** 251/351TL INTERACTIVE MODE ****"
'Enter and endless loop to accept user entered commands
DO
  INPUT "Enter Command ('quit' to exit)--> ", cmd$
  IF cmd$ <> "QUIT" AND cmd$ <> "quit" THEN
    IF cmd$ <> "" THEN
      PRINT #1, cmd$ + CHR$(10);
    END IF
    IF INSTR(cmd$, "?") THEN
      PRINT "AC Source query response = "; retstring$
    END IF
    'Check for Errors after each command is issued
    PRINT "Sending non-query syntax check *ESR?"
    'On fast PC's we may have to hold off between commands
    FOR t = 0 TO 1000: NEXT t
    PRINT #1, "*ESR?" + CHR$(10);
    esr% = 0  'Clear last error
    'Mask off bits 5,4,3,2 only. Other bits are not used.
    esr% = VAL(retstring$) AND 60
    'Process esr% value for error bits
    IF esr% AND 4 THEN
      PRINT "*** Query Error Reported by AC Source ***"
```


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```
    END IF
    IF esr% AND 8 THEN
      PRINT "*** Instrument Dependent Error Reported by AC Source ***"
    END IF
    IF esr% AND 16 THEN
      PRINT "*** Command Execution Error Reported by AC Source ***"
    END IF
    IF esr% AND 32 THEN
      PRINT "*** Command Syntax Error Reported by AC Source ***"
    END IF
    'Clear ERR. -XXX Message from front panel if any error occured
    IF esr% <> 0 THEN
      PRINT #1, "*CLS" + CHR$(10);
    END IF
  END IF
LOOP UNTIL cmd$ = "QUIT" OR cmd$ = "quit"
'Close COM port on exit
CLOSE #1
END
'================================================================

FUNCTION retstring$
  'This function returns a response string from the P/RP/TL Series
  'AC power source. The QBasic statement LINE INPUT cannot be used
  'as the P/RP/TL Series does not return a CR <13> after a response
  'message. The LINE INPUT function waits for a CR before
  'returning a string. The P Series returns a LF <10> instead
  'so we need to poll each returned character for a LF to
  'assemble the response string. The COM port needs to be
  'opened AS random with a record length of 1 for it to support
  'this function. Also, the device number is assumed to be #1
  'Optionally, this value could be passed as a parameter to
  'make this program more generic.

  DIM char AS STRING * 1
  DIM resp AS STRING
  char = ""
  resp = ""
  DO
    char = INPUT$(1, #1)
    resp = resp + char
  LOOP UNTIL char = CHR$(10)
  'Return result
  retstring = LEFT$(resp, LEN(resp) - 1)

END FUNCTION
```

8.4.2 Serial Cable Diagram

California Instruments AC power sources require a special RS232C cable to communicate with a PC. Standard null-modem cables obtained from a computer hardware store most likely will not work. For this reason, all California Instruments power sources that operate over RS232C are supplied with a RS232C 9 pin female to 9 pin female cable.

If for some reason this cable cannot be located, the following cable diagram shown in Figure 8-3 should be used when constructing a serial cable.

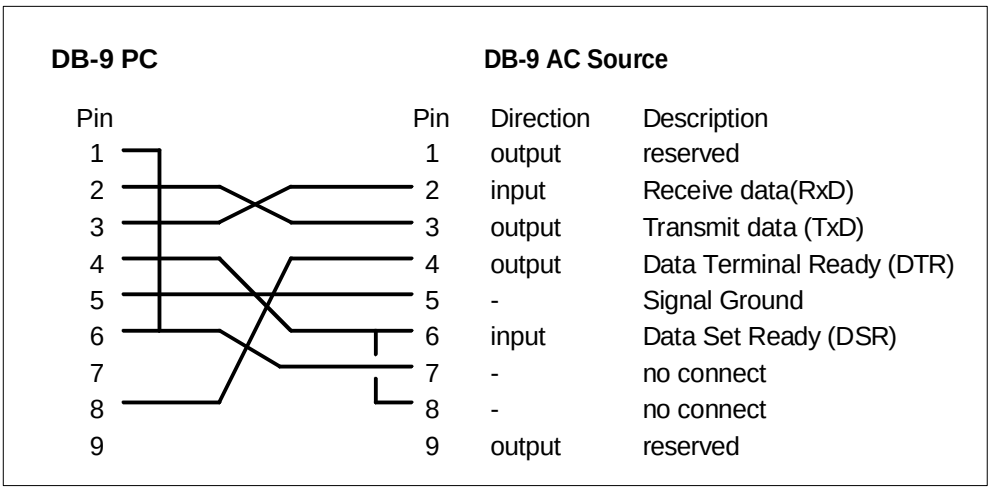


Figure 8-3: RS232C Interface Cable Wiring Diagram

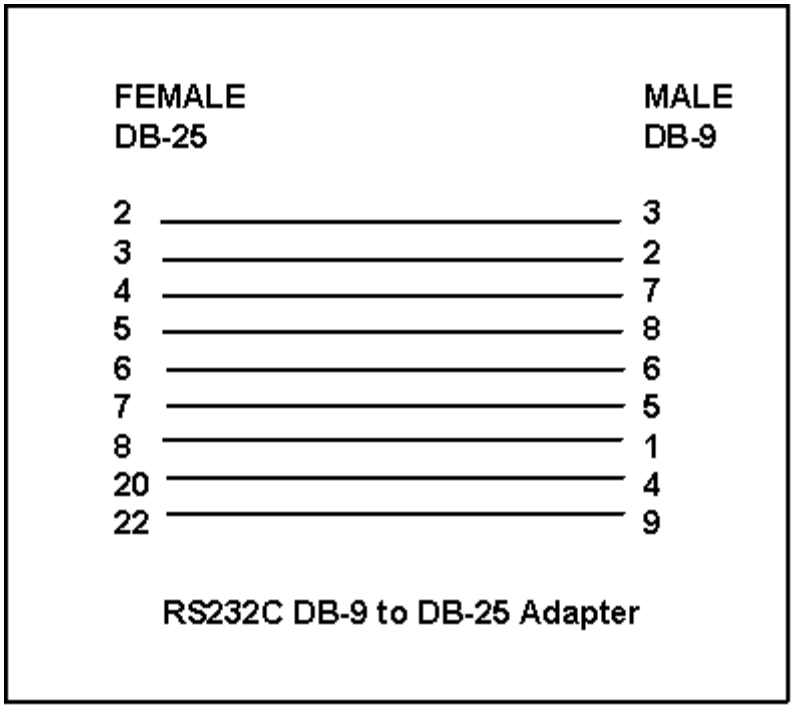


Figure 8-4: DB9 to DB25 Adapter Wiring Diagram

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8.5 PGUI32 Setup and Installation

This section covers installation of the PGUI32 from the distribution disk to the user's PC. Make sure the PC is capable of running Windows with at least 16 Mbytes of memory and 4 Mbytes of available hard disk space.

8.5.1 Connecting the AC Source to the PC When Using RS232

Connect the AC source to the PC using an RS232C cable.

The AC source com port settings are set as follows:

Baud rate:	19200 baud for model 251 / 351TL
Data bits:	8
Stop bits	1
Parity bits:	none
Handshake:	Hardware

The AC source is configured to accept the above setting.

Select the RS232 interface by sliding the interface selection dipswitch on the rear panel to the RS232 position.

8.5.2 Connecting the AC Source to the PC Using IEEE-488

Connect the AC source to the PC using an IEEE-488 interface cable. A National Instruments GPIB controller card is required to use the PGUI32 program.

Select the IEEE-488 interface by sliding the interface selection dip switch on the rear panel to the IEEE-488 position.

Set the desired IEEE address using DIP switch position 4 through 0 on the rear panel.

8.5.3 Installing the PGUI32 Software

The PGUI32 software is distributed on a CD-ROM. The PGUI32 must be installed from the CD using the setup program as all required files are compressed. You cannot copy the contents of the CD to your PC hard drive and run the program. To install the PGUI32, proceed as follows:

1. Turn on the PC and boot up in Windows™
2. Insert the CD in your CD-ROM drive.
3. From the Windows Start Menu, select RUN.
4. At the "Open" prompt, type D:Setup depending on which disk drive you used and click on the OK button.
5. Select the 251TL/351TL entry under low Power AC Sources from the list of model numbers.
6. Select the GUI Software tab and click on the "Execute Selection" button.

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7. Follow the instructions provided by the setup program to complete the installation.

8. When the installation has completed, remove the CD from the drive and store it in a safe place.

Reboot the PC to activate the new settings. You are now ready to start using the PGUI32 software.

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8.6 Trouble Shooting - RS232C

This section provides guidelines for resolving communication problems that may occur when using the PGUI32 software under Windows™.

You may encounter problems when using the serial interface with the PGUI32 program that is supplied with the interface option for this source.

Symptoms:

1. Unable to verify connection to the power source through RS232C interface. Time-out occurs and dialog box appears that asks if you want to switch to simulation mode. An error message (ERR -100) may appear on the front panel 7 segment LED display's of the power source.

- Or -

2. Verification is successful but slewing of voltage, frequency or current limit results in an ERR -100.

Things to check first:

1. Is the PC com port you selected to use really available for this purpose? On older PC's com port interrupts are often shared between com 1 and com3 as well as com2 and com 4. If any of these other com ports is in use, it may prevent you from using the com port that shares the same interrupt.

2. Did you use the RS232C cable that was supplied with the P/RP AC source? This is not a null-modem cable and cannot easily be obtained at a computer store. If you do not have the original cable, consult the PGUI32 on line help under Interface settings for a wiring diagram.

3. Did you connect the cable in the right direction? This cable is uni-directional and should be marked with a SOURCE and a PC label. Make sure you connect the SOURCE side of the cable to the back of the AC source and the PC side of the cable to the PC port.

Resolution for Symptom 1

The P and RP Series of AC sources require hardware handshaking to control data flow from the PC to the AC source. After receiving a command, the AC source asserts the DTR line to hold off further communication from the PC until the command just sent has been processed. Under Windows 95, it is possible to use a 16 byte transmit buffer if a 16550 UART is present. This FIFO exceeds the length of most AC source commands. When enabled, this mode may result in more than one command being placed in the UART output buffer. If this happens, the handshake from the AC source will not prevent the content of this buffer being sent to the AC source and thus will result in more than one command being sent to the AC source.

To resolve this problem, the UART FIFO length needs to be reduced or disabled altogether. The procedure to disabled the FIFO mode is outlined in the next paragraph.

Note: If turning off the UART FIFO conflicts with other applications that need to run on the same PC using the same COM port, this solution may not be acceptable. In this case, skip this step and proceed to the second symptom resolution which relies on a software implemented hold-off instead of turning off the FIFO buffer. If you are using Windows 3.1 and experience the same problem, the latter method is the only resolution available to you so you should skip the next paragraph as well.

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Procedure

1. Make sure the PGUI32 program is closed and no device is using the com port in use.
2. From the Windows™ desktop, right click on the “My Computer” icon which is located in the top left corner of the screen.
3. From the popup menu, select the “Properties” entry.
4. This brings up the System Properties dialog box
5. From the tabs shown at the top of the dialog box, select the “Device Manager” tab.
6. The relevant screen is shown in Figure 8-5.
7. Expand the Ports(COM&LPT) tree selection by clicking on the ‘+’ sign
8. Select the COM port you plan to use to communicate with the P or RP series power source.
9. With the correct COM port selected, click on the Properties button at the bottom left of the dialog box.
10. This brings up the settings dialog box for the COM port. In this example, COM2 is used.

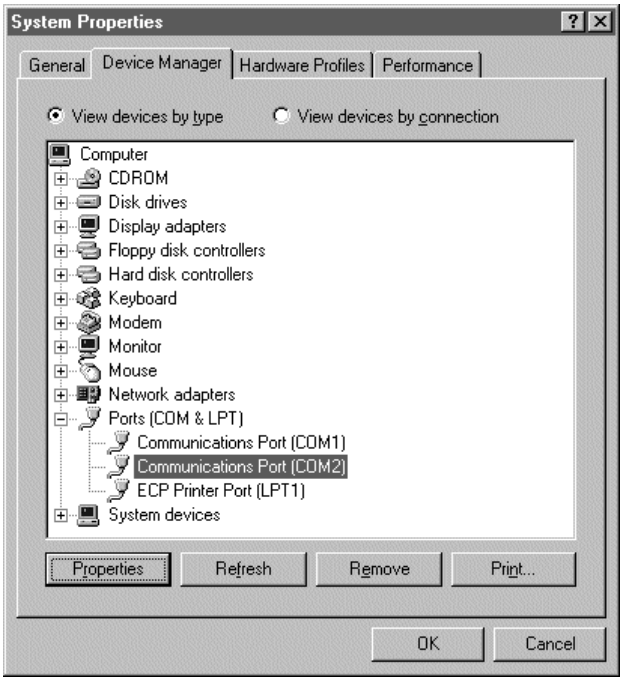


Figure 8-5: System Properties Dialog Box

11. From the tabs at the top of the dialog box, select the “Port Settings” tab.
12. This should bring up the dialog shown in Figure 8-7.
13. Next, select the Advanced button to bring up the advanced port settings dialog box shown in Figure 8-6.

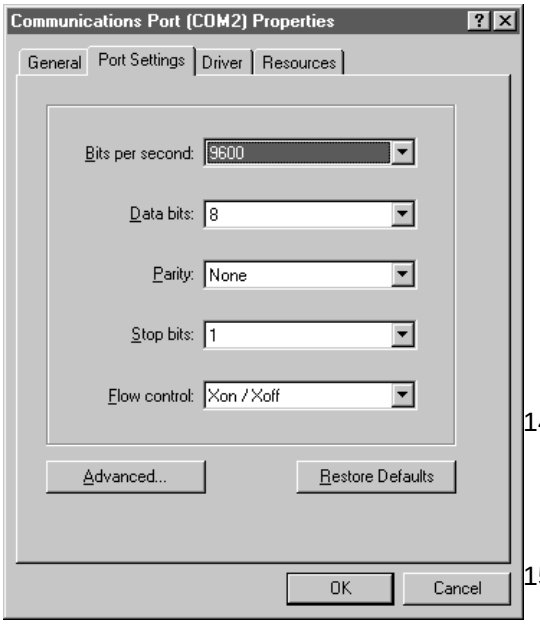


Figure 8-7: COM Port Properties Dialog Box

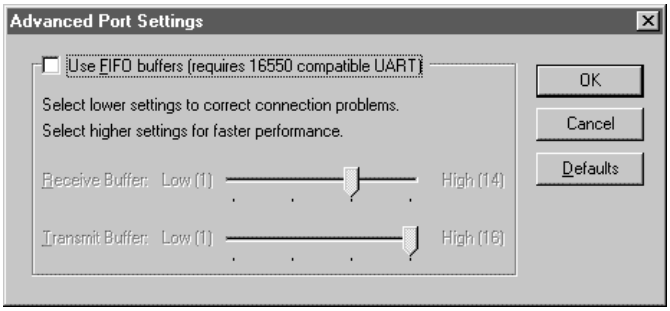


Figure 8-6: Advanced Port Settings Dialog Box

14. At the top of the dialog box, disable the “Use FIFO buffers (requires 16550 compatible UART)” checkbox. This will bypass the UART FIFO’s and enable the hardware handshake to work correctly.
15. Click on the all OK buttons to close all dialog boxes that remain open.
16. This should enable the PGUI32 to work correctly.

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Resolution for Symptom 2

Execute the suggested procedure to resolve symptom 1 first. If an occasional error continues to occur while slewing the voltage or frequency slider controls in the PGUI32 program, add a command delay to the PGUI32 Registry Interface section using the following procedure. This symptom may occur on some PC's.

The command delay holdoff value is shown in the Interface screen. Edit it's value by overwriting the value shown.

Higher values than 40 may be set for the CmdDelay parameter if this fix does not resolve your problem.

8.7 Trouble Shooting - IEEE-488 / GPIB

This section provides guidelines for resolving communication problems that may occur when using the Power Source with or without the PGUI32 software with a IEEE-488 / GPIB interface.

Symptoms:

1. Unable to verify connection to the power source through IEEE-488 interface. Time-out occurs any time an attempt is made to verify connection.

Things to check first:

1. Is the Power Source interface option set to use the IEEE-488 interface instead of the RS232C interface? The DIP switch on the rear panel is used to select the desired interface mode. Refer to section 8.3.

2. Does the bus address selected in the System, Interface dialog match the address set using the DIP switches on the Power Source? The GPIB address selected must match the settings on the DIP switch. If changes are made to the DIP switch setting, the Power Source power must be cycled off and on to have the new settings take effect.

3. Did you connect the cable in correctly and are both ends of the GPIB cable securely tied down?

Resolution for Symptom 1

When using a fast IEEE-488 bus controller, the Power Source's IEEE-488 interface may not handshake fast enough to satisfy the controllers timing requirement. If this is the case, a time-out will result any time a command is sent to the power source. To rectify this situation, the IEEE-488 controller must be set to use delayed bus timing. For National Instruments GPIB controller cards running under Windows™, this can be done from the device manager.

Select the GPIB interface and click on the NI-488.2M Settings tab. An Advanced button at the bottom of the screen will provide access to the Bus Timing parameter. Set this value to 2μsec to operate with the 251 / 351TL GPIB interface.

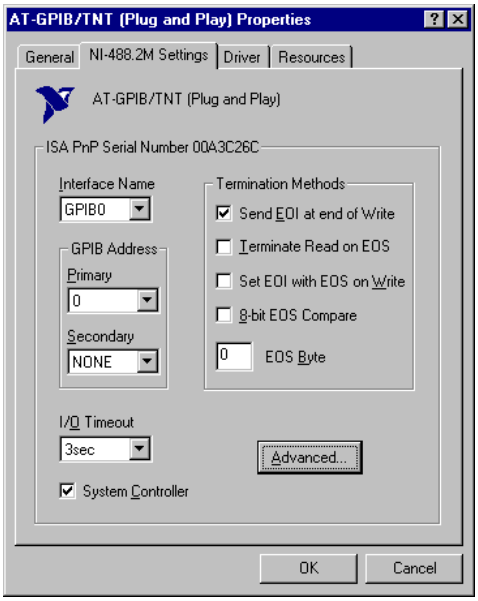


Figure 8-8: NI AT-GPIB/TNT Settings

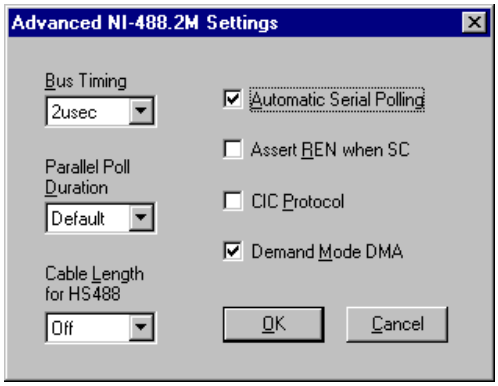


Figure 8-9: NI AT-GPIB/TNT Advanced Settings Dialog

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8.8 PGUI32 Distribution Files

The installation program will install the following files in the directories specified. Note that files with the same name that already exists in these directories will not be overwritten as part of the installation process. If older files of the same name are found, they will be replaced. If you need to retain a copy of these older version files, we recommend you back these files up prior to running the installation program.

Application directory files

The following files are copied to the application directory. The application directory name is chosen by the user during the installation process. The default directory for the PGUI32 is:

C:\Program Files\California Instruments\PGUI32

Pgui32.exe	Executable
Pgui32.hlp	On Line Help file
Pgui32.cnt	Help Contents file

Windows System directory files

The following shared files are stored in the Windows\System directory during installation:

Mscomm32.ocx	Microsoft Serial communications active control
ss32x25.ocx	Grid spreadsheet active control
Comdlg32.ocx	Microsoft Common dialog active control
Comctl32.ocx	Microsoft Common controls
Msvbvm60.dll	Microsoft Visual Basic 6.0 virtual machine library
Mfc42.dll	Microsoft Foundation Classes
Msvcrt.dll	Microsoft Visual C++ run-time library
Oleaut32.dll	Microsoft OLE automation server

IEC Test Programs Directory Files

File name	Description
Generic IEC 1000-4-11 Voltage Variations Test.411_Vars	Test levels for IEC 1000-4-11
Generic IEC 1000-4-11 Voltage Dips Test.411_Dips	Test levels for IEC 1000-4-11
EN 61326-1 Voltage Interrupts.411_Dips	Test levels for IEC 1000-4-11
Generic IEC 1000-4-14 Test Level 1.414_Fluc	Test levels for IEC 1000-4-14
Generic IEC 1000-4-14 Test Level 2.414_Fluc	Test levels for IEC 1000-4-14
Generic IEC 1000-4-28 Freq Vars Test Level 1.428_Vars	Test levels for IEC 1000-4-28
Generic IEC 1000-4-28 Freq Vars Test Level 2.428_Vars	Test levels for IEC 1000-4-28
Generic IEC 1000-4-28 Freq Vars Test Level 3.428_Vars	Test levels for IEC 1000-4-28

User files for above tests may be distributed as well. These files use a 4XX_USER extension.

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Test Sequence Program Directory Files

File name	Description
Sample sequence test file.SEQ	Sample output sequence file

Note: The location of these files as well as the files themselves may change with future versions of the PGUI32. Consult the included readme file for last minute program information.

8.9 Software Registration

Updates of this and other California Instruments programs are posted on a regular basis on the California Instruments web site. You can find available programs by selecting the Software, GUI's and Drivers menu. To gain access to these downloads, you will need to register as a user on our web site. Instructions on how to register and request the required access level for software downloads, visit our web site at

www.calinst.com

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9 Introduction to SCPI

SCPI (Standard Commands for Programmable Instruments) is a programming language for controlling instrument functions over the RS232 or IEEE 488 bus. The same SCPI commands and parameters control the same functions in different classes of instruments. For example, you would use the same MEAS:VOLT? command to measure the AC source output voltage or the output voltage of a SCPI-compatible Multimeter.

9.1 Conventions Used in This Manual

Angle brackets<>	Items within angle brackets are parameter abbreviations. For example, <NR1> indicates a specific form of numerical data.
Vertical bar	Vertical bars separate alternative parameters. For example, 0 | 1 indicates that either "0" or "1" can be used as a parameter.
Square Brackets[]	Items within square brackets are optional. The representation [SOURce:]VOLT means that SOURce: may be omitted.
Boldface font	Boldface font is used to emphasize syntax in command definitions. CURR <NRf> shows a command definition.
Upper case font	Upper case font is used to show program lines in text. OUTP 1 shows a program line.

9.2 The SCPI Commands and Messages

This paragraph explains the syntax difference between SCPI Commands and SCPI messages.

The AC source supports two types of commands, IEEE-488-2 common and SCPI subsystem commands.

- IEEE-488-2 common commands are generally not related to specific operations but to controlling overall AC source functions such as reset, status and synchronization. All common commands consist of a three-letter mnemonic preceded by an asterisk:

  *RST *IDN? *SRE 255

- SCPI Subsystem commands perform specific AC source functions. They are organized into an inverted tree structure with the "root" at the top. Some are single commands while others are grouped within specific subsystems. **You must include the root header in all commands sent to the AC source.**

Refer to appendix A for the AC source SCPI tree structure.

Types of SCPI Messages

There are two types of SCPI messages, program and response.

- A program message consists of one or more properly formatted SCPI commands sent from the controller to the AC source. The message, which may be sent at any time, requests the AC source to perform some action.

- A response message consists of data in a specific SCPI format sent from the AC source to the controller. The AC source sends the message only when commanded by a program message called a "query."

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The SCPI Command Tree

As previously explained, the basic SCPI communication method involves sending one or more properly formatted commands from the SCPI command tree to the instrument as program messages. The following figure shows a portion of a subsystem command tree, from which you access the commands located along the various paths (you can see the complete tree in appendix A).

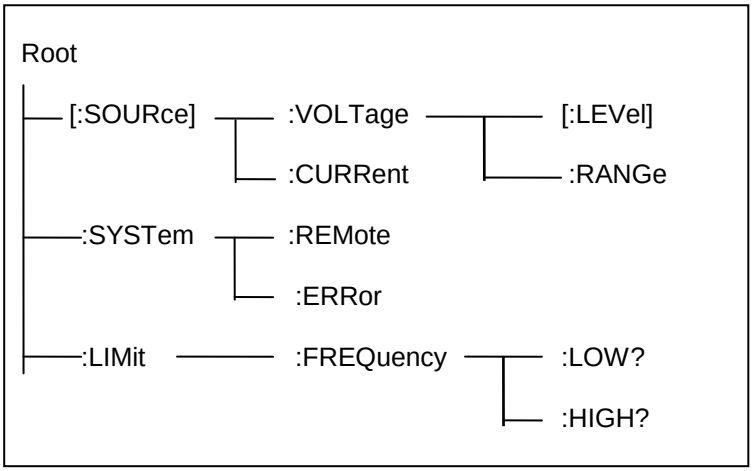


Figure 9-1: Partial Command Tree

The Root Level

Note the location of the ROOT node at the top of the tree. Commands at the root level are at the top level of the command tree. The SCPI interface is at this location when:

- the AC source is powered on
- a device clear (DCL) is sent to the AC source
- the SCPI interface encounters a message terminator
- the SCPI interface encounters a root specifier

Active Header Path

In order to properly traverse the command tree, you must understand the concept of the active header path. When the AC source is turned on (or under any of the other conditions listed above), the active path is at the root. That means the SCPI interface is ready to accept any command at the root level, such as SOURCe or MEASurement.

If you enter SOURCe the active header path moves one colon to the right. The interface is now ready to accept :VOLTage :FREQuency, or :CURRent as the next header. You must include the colon, because it is required between headers.

If you now enter :VOLTage, the active path again moves one colon to the right. The interface is now ready to accept either :RANGe or :LEVel as the next header.

If you now enter :RANGe you have reached the end of the command string. The active header path remains at :RANGe If you wished, you could have entered :RANGe 150 ;LEVel 115 and it would be accepted as a compound message consisting of:

1. SOUR:VOLT:RANG 150.

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2. SOUR:VOLT:LEV 115.

The entire message would be:

SOUR:VOLT:RANG 150;LEV 115.

The message terminator after LEVel 115 returns the path to the root.

Note: The TL Series interface buffer is limited to 42 characters, however. As such, compound commands are not recommended as they often exceed this message length limit.

Moving Among Subsystems

In order to combine commands from different subsystems, you need to be able to restore the active path to the root. You do this with the root specifier (:). For example, you could set the output frequency to 60 Hz and set the display mode to frequency.

FREQ 60

DISP:MODE 0

Because the root specifier resets the command parser to the root, you can use the root specifier and do the same thing in one message:

FREQ 60;:DISP:MODE 0

Including Common Commands

You can combine common commands with system commands in the same message. Treat the common command as a message unit by separating it with a semicolon (the message unit separator). Common commands do not affect the active header path; you may insert them anywhere in the message.

VOLTage 115;*ESE 255

OUTPut 0;*RCL 2

9.3 Using Queries

Observe the following precautions with queries:

- Set up the proper number of variables for the returned data.
- Read back all the results of a query before sending another command to the AC source. Otherwise a Query Error will occur and the non-returned data will be lost.

9.4 Structure of a SCPI Message

SCPI messages consist of one or more message units ending in a message terminator. The terminator is not part of the syntax, but implicit in the way your programming language indicates the end of a line (such as a newline or end-of-line character).

The Message Unit

The simplest SCPI command is a single message unit consisting of a command header (or keyword) followed by a message terminator.

FREQuency?<newline>

VOLTage?<newline>

The message unit may include a parameter after the header. The parameter usually is numeric:

VOLTage 20<newline>

OUTPut 1<newline>

Combining Message Units

The following command message is briefly described here, with details in subsequent paragraphs.

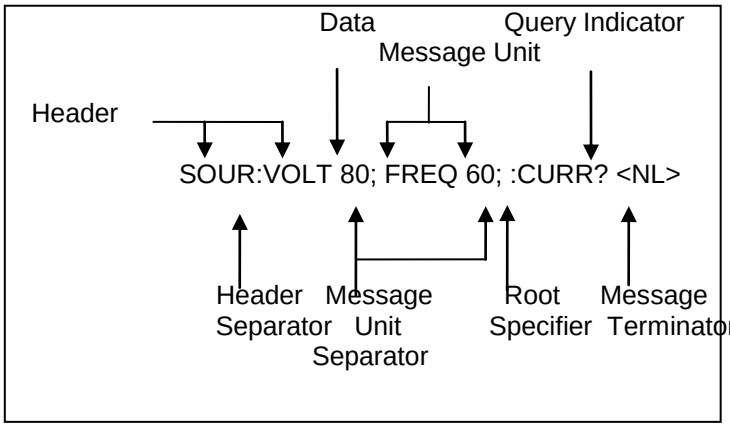


Figure 9-2: Command Message Structure

The basic parts of the above message are:

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Message Component	Example
Headers	SOURC VOLT FREQ CURR
Header Separator	The colon in SOUR:VOLT
Data	80 60
Data Separator	The space in VOLT 80 and FREQ 60
Message Units	VOLT 80 FREQ 60 CURR?
Message Unit Separator	The semicolons in VOLT 80; and FREQ 60;
Root Specifier	The colon in :CURR?
Query Indicator	The question mark in CURR?
Message Terminator	The <NL> (newline) indicator. Terminators are not part of the SCPI syntax

Note: **The use of compound messages such as the one shown in Figure 12-2 is not recommended as they typically exceed the available receive buffer length of the TL/RP Series interface.**

Headers

Headers are instructions recognized by the AC source. Headers (which are sometimes known as "keywords") may be either in the long form or the short form.

Long Form — The header is completely spelled out, such as VOLTAGE, SYSTEM, and OUTPUT.

Short Form — The header has only the first three or four letters, such as VOLT, SYST, and OUTP.

The SCPI interface is not sensitive to case. It will recognize any case mixture, such as VOLTAGE, VOLTage or Voltage. Short form headers result in faster program execution.

Note: In view of the 42 character receive buffer size of the TL/RP Series, the short form is recommended under all circumstances.

Header Convention

In the command descriptions in chapter 10 of this manual, headers are emphasized with boldface type. The proper short form is shown in upper-case letters, such as DELay.

Header Separator

If a command has more than one header, you must separate them with a colon (SYSTem:ERRor LIMit:FREQuency:LOW).

Optional Headers

The use of some headers is optional. Optional headers are shown in brackets, such as VOLTage[:LEVel] 100.

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Query Indicator

Following a header with a question mark turns it into a query (VOLTage?, VRANGe?).

Message Unit Separator

When two or more message units are combined into a compound message, separate the units with a semicolon (VOLT 100;FREQ 60).

Root Specifier

When it precedes the first header of a message unit, the colon becomes the root specifier. It tells the command parser that this is the root or the top node of the command tree. Note the difference between root specifiers and header separators in the following examples:

SOURce:VOLTage:LEVel 100	All colons are header separators
:SOURce:VOLTage:LEVel 100	Only the first colon is a root specifier
SOURce:VOLTage:LEVel 100;:FREQuency 55	Only the third colon is a root specifier

You do not have to precede root-level commands with a colon; there is an implied colon in front of every root-level command.

Message Terminator

A terminator informs SCPI that it has reached the end of a message. The only permitted message terminator is:

- newline (<NL>), which is ASCII decimal 10 or hex 0A.

In the examples of this manual, there is an assumed message terminator at the end of each message. If the terminator needs to be shown, it is indicated as <NL> regardless of the actual terminator character.

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9.5 SCPI Data Formats

All data programmed to or returned from the AC source is in ASCII. The data type may be numerical or character string.

Numerical Data Formats

Symbol	Data Form
Talking Formats	
<NR1>	Digits with an implied decimal point assumed at the right of the least-significant digit. Examples: 273
<NR2>	Digits with an explicit decimal point. Example:.0273
<NR3>	Digits with an explicit decimal point and an exponent. Example: 2.73E+2
<Bool>	Boolean Data. Example: 0 | 1
Listening Formats	
<Nrf>	Extended format that includes <NR1>, <NR2> and <NR3>. Examples: 273.2 , 2.73E2
<Bool>	Boolean Data. Example: 0 | 1

Character Data

Character strings returned by query statements may take either of the following forms, depending on the length of the returned string:

<CRD> Character Response Data. Permits the return of character strings.

<AARD> Arbitrary ASCII Response Data. Permits the return of undelimited 7-bit ASCII. This data type has an implied message terminator.

<SRD> String Response Data. Returns string parameters enclosed in double quotes.

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10 SCPI Command Reference

Where appropriate, related commands or queries are included. These are listed because they are either directly related by function, or because reading about them will clarify or enhance your understanding of the original command or query.

This chapter is organized as follows:

- Subsystem commands, arranged by subsystem
- IEEE 488.2 common commands

10.1 Subsystem Commands

Subsystem commands are specific to AC source functions. They can be a single command or a group of commands. The groups are comprised of commands that extend one or more levels below the root. The description of common commands follows the description of the subsystem commands.

The subsystem command groups are listed in alphabetical order and the commands within each subsystem are grouped alphabetically under the subsystem. Commands followed by a question mark (?) take only the query form. When commands take both the command and query form, this is noted in the syntax descriptions.

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10.2 Calibration Subsystem

The commands in this subsystem allow you to do the following:

- Enable and disable the calibration mode
- Calibrate all measurement circuits and store new calibration coefficients in nonvolatile memory.

Subsystem Syntax

CALibrate	
:STATe	Enables or disables the calibration mode
:MEASure	
:CURRent	
[:FSC]	Calibrate full scale AC current measurement
:ZERO	Trim AC current measurement offset
:PCURrent	
[:FSC]	Calibrate full scale AC peak current measurement
:ZERO	Trim AC peak current measurement offset
:POWer	
[:FSC]	Calibrate full scale AC power measurement
:ZERO	Trim AC power measurement offset
:VOLTage	
[:FSC]	Calibrate full scale AC voltage measurement
:ZERO	Trim AC voltage measurement offset
[:SOURce]	
:VOLTage	Calibrate output voltage

10.2.1 Calibration State

CALibrate:STATe

This command puts the AC source in calibration mode. The calibration mode is required to use the data entry form of the calibration commands. Without setting the correct state using this command, only the query form can be used to query any calibration coefficients but no new calibration can be performed. Calibration queries return the calibration coefficient for the specified measurement parameter. Calibration coefficients range from -127 to + 127.

Note ***Any changes made to calibration coefficients are not saved in non-volatile memory until the SYSTem:SAVE command is issued before turning the Cal state off.***

CAL:STAT 0	Turns calibration mode off.
CAL:STAT 1	Turns calibration mode on.

Command Syntax	CALibrate:STATe 0|1		
Parameters	<Bool>		
Examples	CAL:STAT 1	CAL:STAT 0	
Related Commands	CAL[:SOUR]	CAL:MEAS	SYST:SAVE

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10.2.2 Measurement Calibration

All measurement calibrations are performed by adjusting the measurement reading up or down using a calibration coefficient. The coefficient value ranges from -127 (adjust full-scale downward, zero upward) to + 127 (adjust full-scale upward, zero downward). When used in combination with the MEAS commands, an automated measurement calibration procedure can be implemented by adjusting the coefficient and reading the new measurement value iteratively until the delta between an external reference measurement device and the AC source internal measurement is within the specified accuracy.

CALibrate:MEASure:CURRent[:FSCale]

This command affects the calibration of the AC current measurement at full scale.

Command Syntax	CALibrate:MEASure:CURRent[:FSCale] <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:CURR -23
Query Syntax	CALibrate:MEASure:CURRent?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:VOLTage

CALibrate:MEASure:CURRent:ZERO <NRf>

This command affects the calibration of the AC current measurement zero offset.

Command Syntax	CALibrate:MEASure:CURRent:ZERO <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:CURR:ZERO +12
Query Syntax	CALibrate:MEASure:CURRent:ZERO?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:CURRent

CALibrate:MEASure:PCURrent[:FSCale] <NRf>

This command affects the calibration of the AC peak current measurement at full scale.

Command Syntax	CALibrate:MEASure:CURRent[:FSCale] <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:CURR -23
Query Syntax	CALibrate:MEASure:CURRent?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:VOLTage

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CALibrate:MEASure:PCURrent:ZERO <NRf>

This command affects the calibration of the AC current measurement zero offset.

Command Syntax	CALibrate:MEASure:CURRent:ZERO <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:CURR:ZERO +12
Query Syntax	CALibrate:MEASure:CURRent:ZERO?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:CURRent

CALibrate:MEASure:POWer[:FSCale] <NRf>

This command affects the calibration of the power measurement at full scale.

Command Syntax	CALibrate:MEASure:POWer[:FSCale] <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:POW 78
Query Syntax	CALibrate:MEASure:POWer?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:CURRent

CALibrate:MEASure:POWer:ZERO <NRf>

This command affects the calibration of the power measurement zero offset.

Command Syntax	CALibrate:MEASure:POWer:ZERO <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:POW:ZERO -5
Query Syntax	CALibrate:MEASure:POWer:ZERO?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:POWer

CALibrate:MEASure:VOLTage[:FSCale] <NRf>

This command affects the calibration of the rms voltage measurement at full scale.

Command Syntax	CALibrate:MEASure:VOLTage[:FSCale] <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:VOLT 56
Query Syntax	CALibrate:MEASure:VOLTage?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:CURRent

CALibrate:MEASure:VOLTage:ZERO <NRf>

This command affects the calibration of the rms voltage measurement zero offset.

Command Syntax	CALibrate:MEASure:VOLTage:ZERO <NRf>
Parameters	<NRf> (value range -127 to +127)
Examples	CAL:MEAS:VOLT:ZERO +4
Query Syntax	CALibrate:MEASure:VOLTage:ZERO?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CALibrate:MEASure:VOLTage

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10.2.3 Output Calibration

The AC voltage output calibration is performed by adjusting the output up or down using a calibration coefficient. The coefficient ranges from -127 (adjust upward) to + 127 (adjust downward). An external traceable reference AC voltmeter should be used for this purpose.

CALibrate[:SOURce]:VOLTage <NRf>

This command will set the calibration coefficient for the AC full scale output voltage.

Command Syntax	CALibrate[:SOURce]:VOLTage <NRf>
Parameters	<NRf> (a value between -127 and +127)
Examples	CAL:VOLT -2
Query Syntax	CALibrate:VOLTage?
Returned Parameters	<NR1> (value range -127 to +127)
Related Commands	CAL:STAT

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10.3 Measurement Subsystem

This subsystem programs the measurement capability of the TL Series AC source.

Subsystem Syntax

:MEASure	
:VOLTage?	Returns the rms value of voltage
:CURRent?	Returns the rms value of current
:AMPLitude	
:MAX?	Returns peak current
:RESet	Reset the peak current measurements
:CRESTfactor?	Returns current crest factor
:RANGe	Selects measurement range 0 = High, 1 = Low, 2 = AUTO
:POWer	
[:REAL]?	Returns real power in Watt
:APParent?	Returns apparent power in VA
PFACtor?	Returns power factor

MEASure:VOLTage?

This query returns the AC rms voltage being sourced at the output terminals. Note that the output relay must be closed or no voltage will be present at the output terminals.

Query Syntax	MEASure:VOLTage?
Parameters	None
Examples	MEAS:VOLT?
Returned Parameters	<NR2>
Related Commands	OUTP 0|1

MEASure:CURRent?

This query returns the rms value of the output AC current being sourced at the output terminals. Note that the output relay must be closed to obtain current flow.

Query Syntax	MEASure:CURRent?
Parameters	None
Examples	MEAS:CURR?
Returned Parameters	<NR2>
Related Commands	OUTP 0|1 MEAS:CURR:AMPL:MAX?

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MEASure:CURRent:AMPLitude:MAX?

This query returns the peak current value of the output AC current being sourced at the output terminals. Note that the output relay must be closed to obtain current flow. The peak current measurement circuit uses a sample and hold method and latches the highest peak current value found since the last peak measurement reset command.

Query Syntax	MEASure:CURRent:AMPLitude:MAX?
Parameters	None
Examples	MEAS:CURR:AMPL:MAX?
Returned Parameters	<NR2>
Related Commands	OUTP 0 | 1 MEAS:CURR?

MEASure:CURRent:AMPLitdue:RESet

This command resets the peak current measurement sample and hold circuit to zero.

Query Syntax	MEASure:CURRent:AMPLitude:RESet
Parameters	None
Examples	MEAS:CURR:AMPL:RES
Related Commands	MEAS:CURR:AMPL:MAX?

MEASure:CURRent:CREStfactor?

This query returns the rms value of the output AC current being sourced at the output terminals. Note that the output relay must be closed to obtain current flow.

Query Syntax	MEASure:CURRent:CREStfactor?
Parameters	None
Examples	MEAS:CURR:CRES?
Returned Parameters	<NR2>
Related Commands	MEAS:CURR? MEAS:CURR:AMPL:MAX?

MEASure:CURRent:RANGe

This commands selects the measurement range to use for current, peak current and power measurements. Available choices are high range (0), low range (1) or auto ranging (2).

Query Syntax	MEASure:CURRent:RANGe
Parameters	0 | 1 | 2
Examples	MEAS:CURR:RANG?
Returned Parameters	<NR2>
Related Commands	MEAS:CURR? MEAS:CURR:AMPL:MAX?

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MEASure:POWer[:REAL]?

This query returns the true power delivered to the unit under test by the AC source. Note that the output relay must be closed to obtain current flow.

Query Syntax	MEASure:POWer[:REAL]?
Parameters	None
Examples	MEAS:POW?
Returned Parameters	<NR2>
Related Commands	MEAS:VOLT? MEAS:CURR?

MEASure:POWer:APParent?

This query returns the apparent power delivered to the unit under test by the AC source. Note that the output relay must be closed to obtain current flow.

Query Syntax	MEASure:POWer:APParent?
Parameters	None
Examples	MEAS:POW:APP?
Returned Parameters	<NR2>
Related Commands	MEAS:POW?

MEASure:POWer:PFACtor?

This query returns the power factor. The power factor is the ratio between real power and apparent power. This value is always between 0.00 and 1.00. If the current measured is too low to determine the power factor, a 1.00 value is returned.

Query Syntax	MEASure:POWer:PFACtor?
Parameters	None
Examples	MEAS:POW:PFAC?
Returned Parameters	<NR2>
Related Commands	MEAS:POW? MEAS:POW:APP?

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10.4 Source Subsystem

This subsystem programs all the output parameters of the TL Series AC source.

Subsystem Syntax

[SOURce:]	
CURRent:	Set the rms current limit in amps.
VOLTage:	
[LEVel]	Set the rms output voltage value in volts.
RANGe:	
[LEVel]	Set the output voltage range.
AUTO	Enables or disables the AUTO range mode.
FREQuency:	Set the output frequency value in Hz.

[SOURce:]CURRent

This command sets the rms current limit of the output. If the load current exceeds the programmed current limit, the unit responds in one of two ways, depending on the current limit mode that is configured. (Hardware configuration only). In the default constant current mode, the output voltage will fold back as much as needed to retain the current at the programmed limit. No error message is generated when operating in this mode. If constant voltage mode is configured instead, the output latches into a disabled state when current limiting occurs. The output voltage is set to 5.0 volt when this condition occurs and the output relay state is set to 0 (output relay open). A "–300, Device specific error" fault is generated.

Note that the CURRent command is coupled with the VRANGe. This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating.

Command Syntax	[SOURce:]CURRent <NRf>
Parameters	0 to a value specified by the LIM:CURR
Unit	A (rms amperes)
*RST	Defined by the PON
Examples	CURR 5
Query Syntax	CURRent?
Returned Parameters	<NR2>
Related Commands	VOLT:RANG

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[SOURce:]FREQuency

This command sets the frequency of the output sinewave.

Command Syntax	[SOURce:]FREQuency <NRf>
Parameters	range specified by the LIM:FREQ:LOW and LIM:FREQ:HIGH commands
Unit	Hz (Hertz)
*RST Value	defined by PON
Examples	FREQ 50
Query Syntax	FREQuency?
Returned Parameters	<NR2>
Related Commands	LIM:FREQ;LOW? LIM:FREQ:HIGH?

[SOURce:]VOLTage

This command programs the AC rms output voltage level of the power source. The maximum voltage value allowed is determined by the selected voltage range. For 251/351TL models configured for single voltage range, only one range is available.

Command Syntax	[SOURce:]VOLTage[:LEVel] <NRf>
Parameters	0 to maximum voltage range specified by the VRAN command
Unit	V (rms voltage)
*RST Value	0 volt
Examples	VOLT 250 VOLT:LEV 25
Query Syntax	[SOURce:]VOLTage[:LEVel]?
Returned Parameters	<NR2>
Related Commands	VOLT:RANGe

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[SOURce:]VOLT:RANGe[:LEVel]

This command sets the voltage range of the power source . Two voltage ranges are available: a 135 volt range and a 270 volt range. However, TL units with optional voltage ranges are available as well. In this case, the actual voltage range values will be different. To determine the actual range values, use the query format of the RANGE command. The returned values for high and low range (eg. 135 and 270) should be used to change range. In most cases, the high voltage range value will be two times the low voltage range value. Sending a parameter other than the actual range values will not be accepted.

For TL models configured for single voltage range, only one range is available. In this case, the VOLT:RANG commend will return the value for the only available range. Attempting to select any other voltage range will result in a "–100, Command Error". The presence of a single voltage range unit may be determined using the Limit subsystem, see section 10.6.

Some TL Series may use other voltage range values than shown here. It is recommended to query the actual range values using the LIM:VOLT? query as part of your application program. See section 10.6.

When the range is set to 135, the maximum rms voltage that can be programmed is 135 volts.

The VOLT:RANG command is coupled with the CURRent command. This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating.

Command Syntax	[SOURce:]VOLTage:RANGe[:LEVel] <NRf>
Parameters	135 | 270
*RST Value	defined by the PONS
Examples	VOLT:RANG 135
Query Syntax	VOLT:RANGe?
Returned Parameters	<NR2>
Related Commands	VOLT LIM:VOLT? VOLT:RANG:AUTO

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[SOURce:]VOLT:RANGe:AUTO

This command sets the AC source range to the AUTO mode. While in AUTO mode, the AC source automatically switches to the optimal voltage range for the voltage programmed. Note that switching voltage ranges causes the output to be interrupted momentarily. If power to the unit under test cannot be interrupted, the AUTO range should not be used.

To determine the actual voltage range in which the unit is operating, the VOLT:RANG? command query can be used.

For TL models configured for single voltage range, only one range is available. In this case, the VOLT:RANGe:AUTO command has no meaning and should not be used.

The maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating. Programming a current limit value that exceeds the high voltage range capability does NOT cause the voltage range to change, even while in AUTO mode. Only voltage changes can prompt an automatic voltage range change.

Command Syntax	[SOURce:]VOLTage:RANGe:AUTO <Bool>
Parameters	<Bool> 0 | 1
*RST Value	0
Examples	VOLT:RANG:AUTO 1
Query Syntax	VOLT:RANG:AUTO?
Returned Parameters	<Bool>
Related Commands	VOLT LIM:VOLT? VOLT:RANG:LEV

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10.5 Output Subsystem

This subsystem controls the main output function of the RP Series source.

Subsystem Syntax

OUTPut

[:RELay]	Opens or closes the output relay.
DROP	Drops the output voltage for a specified amount of time or indefinitely.
STARt:	
[STATe]	Enables or disables the start phase angle mode
PHASe	Sets the start phase angle value in degrees.

OUTPut[:RELay]

The output of the AC source can be isolated from the unit under test by opening the output relay. The programmed output voltage is set to zero before opening the relay and is returned to its programmed value when closing the relay. This avoids hot switching the output relay contacts.

Command Syntax	OUTPut[:RELay] <bool>
Parameters	<Bool> 0 | 1
*RST Value	defined by the PONS
Examples	OUTP 1
Query Syntax	OUTPut?
Returned Parameters	0 | 1
Related Commands	OUTP:DROP OUTP:STAR

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OUTPut:DROP

The output drop command may be used to interrupt the voltage to the UUT without opening the output relay. This method used an electronic means of interrupting the AC source output which enables short interruptions of as little as 1 msec or as long as 4000 sec.
In addition to short interruption times, the drop command can be set to use any of four start phase angles at which to execute the voltage drop.
The parameter passed with the OUTP:DROP command is the drop duration in seconds. This value can range from 0.001 (1 msec) to 4000 (1 hour, 6 min, 40 sec) but only four digits of resolution are allowed. If no parameter is passed, the output is drop indefinitely or until a voltage command is issued. Thus valid time periods are:

Time range	
0.001 - 9.999	1 msec to 10 secs
10.00 - 99.99	10 secs to 100 secs
100.0 - 999.9	100 secs to 1000 secs
1000 - 4000	1000 secs to 4000 secs
no parameter	Infinite time. Use VOLT command to turn output on.

Turing on output voltage at a specified phase angle

The following command sequence will turn the output voltage on at a specified phase angle. This may be required to measure worst case inrush current.

```
/* Set up sequence
VOLT 0                  Set output voltage to zero
OUTP 1                  Close output relay
OUTP:STAR:STAT 1        Enable start phase mode
OUTP:STAR:PHAS 90       Set start phase angle to 90 degrees
OUTP:DROP               Put AC source in infinite drop mode
/* Turn on sequence
VOLT 230                Turn on voltage to 230 V at 90 degrees
```

Output drop status query

The status of a drop in progress can be queried using the query format of the OUTP:DROP command. This query will return a <Bool> indicating if the output time specified has expired (0) or the drop is still in progress (1).

Command Syntax	OUTPut:DROP <NRf>	
Parameters	<NRf> | none	
*RST Value	none	
Examples	OUTP:DROP 0.001	
Query Syntax	OUTP:DROP?	
Returned Parameters	0 | 1	
Related Commands	OUTP:STAR:STAT	OUTP:STAR:PHAS

OUTPut: STARt[:STATe]

The output start state command is used to enable or disable the start phase logic of the AC source controller. If disabled (State = 0), any voltage drops with the OUTP:DROP command or voltage changes with the VOLT command are executed immediately without regard for the phase angle of the output sinewave.
If enable (State = 1), any voltage drops or voltage changes take place at one of four user specified phase angles. See the OUTP:STAR:PHAS command for available phase angle settings.

Command Syntax	OUTPut:STARt[:STATe] <bool>
Parameters	<Bool> 0 | 1
*RST Value	0
Examples	OUTP:STAR 1
Query Syntax	OUTP:STAR?
Returned Parameters	0 | 1
Related Commands	OUTP:DROP OUTP:STAR:PHAS

OUTPut: STARt:PHASe

The output start phase command is used to set the start phase angle for drop or voltage programming commands. This phase angle information is used only if the OUTP:DROP:STATe is on (1). If not, all drops and voltage changes occur at random phase angles.
Available phase angle values are 0°, 90°, 180° and 270°. All other values when passed as a parameter to this command will generate a syntax error.

Command Syntax	OUTPut:STARt:PHASe <NR2>
Parameters	0 | 90 | 180 | 270
*RST Value	0
Examples	OUTP:STAR:PHAS 90
Query Syntax	OUTPut?
Returned Parameters	0 | 90 | 180 | 270
Related Commands	OUTP:DROP OUTP:STAR:STAT

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10.6 Limit Subsystem

This subsystem controls the voltage frequency and current limit of the power source. These limits are set at the factory and depend on the power source rating. It is not accessible by the user. The query format is accessible however.

Subsystem Syntax

```
LIMit:
    CURRent?          Queries the upper current limit
    FREQuency:
              LOW?    Queries the lower frequency limit
              HIGH?   Queries the upper frequency limit
    VOLTage?          Queries the upper voltage limit
```

LIMit:CURRent?

This command queries the maximum current limit the power source will operate at in the low voltage range.

Command Syntax	LIMit:CURRent <NRf>	
Parameters	maximum current limit at low voltage range	[command protected]
Query Syntax	LIMit:CURRent?	
Returned Parameters	<NR2>	

LIMit:FREQuency:LOW?

This command queries the lower frequency limit of the power source. On some TL models, the frequency range may have been factory configured to a fixed single value. In this case, the High and Low frequency limits will be set to the same value and both queries will return the same number. Sending a frequency command with any value other than the set value will result in a “-100, Command Error”.

Command Syntax	LIMit:FREQuency:LOW <NRf>
Parameters	Low freq limit [command protected]
Query Syntax	LIMit:FREQuency:LOW?
Returned Parameters	<NR2>

LIMit:FREQuency:HIGH?

This command queries the upper frequency limit of the power source. On some TL models, the frequency range may have been factory configured to a fixed single value. In this case, the High and Low frequency limits will be set to the same value and both queries will return the same number. Sending a frequency command with any value other than the set value will result in a “-100, Command Error”.

Command Syntax	LIMit:FREQuency:HIGH <NRf>
Parameters	High freq limit [command protected]
Query Syntax	LIMit:FREQuency:HIGH?
Returned Parameters	<NR2>

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LIMit:VOLTage?

This command queries the maximum voltage the power source will operate at in the high voltage range. For TL models configured for single voltage range, only one range is available. In this case, this command will return the value for the only available voltage range. The presence of a single range configuration can be derived from the limit value returned. If the voltage limit value is less than 201 volt, the TL is configured for single voltage range operation. If a value above 200 volt is returned, the TL has a high and a low voltage range. On dual range configurations, the maximum voltage in the high range is returned and this value must be even. The low range value is half that of the high range. On single voltage range units, the value voltage of the only available range is returned and this value can be odd or even.

Only the Query format of this command is available to the user.

Command Syntax	LIMit:VOLTage<NRf>
Parameters	maximum voltage available in high voltage range[command protected]
Query Syntax	LIMit:VOLTage?
Returned Parameters	<NR2>

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10.7 Display Subsystem

DISPlay:MODE

This command is used to control the right hand side AC source display. The command will allow the multifunction 7 segment LED display to switch between display of frequency, current, peak current, power or power factor data.

The encoding for the mode command is as shown in the table below,

Parameter	Value
Frequency	1
Current	2
Peak Current	3
Power	4
Power Factor	5

Table 10-1: Mode Command Encoding

Command Syntax	DISPlay:MODE <NR2>
Parameters	1 | 2 | 3 | 4 | 5
*RST Value	1
Examples	DISP:MODE 2
Query Syntax	DISPlay:MODE?
Returned Parameters	<NR1>
Related Commands	none

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10.8 System Commands

The system commands control the system level functions of the AC Source.

Subsystem Syntax

SYSTem:

ERRor?	Returns the error number and error string
KLOCk	Keyboard Lock. Sets the power on REMOTE/LOCAL state.
LOCal	Go to local mode
PON	Define the power on register number
REMote	Go to remote mode
SAVE	Saves calibration coefficients if calibration state is on

SYSTem:ERRor?

This query returns the next error number followed by its corresponding error message string from the remote programming error queue. The queue is a FIFO (first-in, first-out) buffer that stores errors as they occur. As it is read, each error is removed from the queue. When all errors have been read, the query returns 0,"No Error". If more errors are accumulated than the queue can hold, the last error in the queue is -350,"Queue overflow".

Query Syntax	SYSTem:ERRor?
Parameters	None
Returned Parameters	<NR1>,<SRD>
Example	SYST:ERR?

SYSTem:KLOCk

This command sets or clears the power on LOCAL or REMOTE state. When set (1), the AC Source will power up in remote state, locking out all keyboard controls. The local state can only be entered by sending a bus command. This mode may be used to prevent operator access to front panel controls under all conditions. Note that changing the state of the KLOC setting does not change the REMOTE or LOCAL state. This setting only affects the REMOTE/LOCAL state at power-up.

Command Syntax	SYSTem:KLOCk
Parameters	0 | 1
Example	SYST:KLOC 1
Query Syntax	SYST:KLOC?
Returned Parameters	<NR1>
Related Commands	SYST:REM SYST:LOC

SYSTem:LOCal

This command sets the interface in Local state, which enables the front panel controls. This command only applies to the RS232C interface. If IEEE 488 is used, the remote/local state is determined by the REN line on the IEEE 488 interface.

Command Syntax	SYSTem:LOCal
Parameters	None
Example	SYST:LOC
Related Commands	SYST:REM

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SYSTem:REMote

This command sets the interface in the Remote state, which disables all front panel controls. This command only applies to the RS232C interface. If IEEE 488 is used, the remote/local status is determined by the REN line on the IEEE 488 interface.

Command Syntax	SYSTem:REMote
Parameters	None
Example	SYST:REM
Related Commands	SYST:LOC

SYSTem:PON

This command is used to define the register value the power source will use to initialize its parameters at power up. If data in the selected register is not valid or the selected register is 8, the initialization will be with factory default values. Refer to Table 4-1: Factory Default Power on Settings on page 31.

Command Syntax	SYSTem:PON <NRf>
Parameters	0 to 8 or 0 to 7 for -AV option units
Examples	SYST:PON 1
Query Syntax	SYST:PON?
Returned Parameters	<NR1>
Related Commands	*SAV

SYSTem:SAVE

This command saves the calibration coefficients for output and measurement calibration to the non volatile memory of the AC source. This command is only valid while the AC source is in the Calibration mode. (See section 10.2.1 for details).

Command Syntax	SYSTem:SAVE
Parameters	none
Examples	SYST:PON
Related Commands	CAL:STAT

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10.9 Common Commands

Common commands begin with an * and consist of three letters (command) or three letters and a ? (query). Common commands are defined by the IEEE 488.2 standard to perform some common interface functions. The power source responds to the required common commands that control status reporting, synchronization, and internal operations. RP Series units also respond to optional common commands that control stored operating parameters.

Common commands and queries are listed alphabetically. If a command has a corresponding query that simply returns the data or status specified by the command, then both command and query are included under the explanation for the command. If a query does not have a corresponding command or is functionally different from the command, then the query is listed separately. The description for each common command or query specifies any status registers affected. Refer to Chapter 12 which explains how to read specific register bits and use the information that they return.

Common Commands Syntax

*CLS	Clear status
*ESE <n>	Standard event status enable
*ESE?	Return standard event status enable
*ESR?	Return event status register
*IDN?	Return instrument identification
*RCL <n>	Recall instrument state
*RST	Reset
*SAV <n>	Save instrument state
*SRE <n>	Set service request enable register
*SRE?	Return service request enable register
*STB?	Return status byte

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10.9.1 *CLS

This command clears the following registers (see chapter 12 for descriptions of all status registers):

- Standard Event Status
- Status Byte
- Error Queue

Command Syntax	*CLS
Parameters	None

10.9.2 *ESE

This command programs the Standard Event Status Enable register bits. The programming determines which events of the Standard Event Status Event register (see *ESR?) are allowed to set the ESB (Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event. All of the enabled events of the Standard Event Status Enable Register are logically OR-ed to cause the Event Summary Bit (ESB) of the Status Byte Register to be set. See Section 16 for descriptions of the Standard Event Status registers.

The query reads the Standard Event Status Enable register.

Table 10-2: Bit Configuration of Standard Event Status Enable Register

Bit Position	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Bit Name	PON	not used	CME	EXE	DDE	QYE	not used	not used
Bit Weight	128		32	16	8	4		

CME	Command error	DDE	Device-dependent error
EXE	Execution error	QYE	Query error
PON	Power-on		

Command Syntax	*ESE <NRf>
Parameters	0 - 255
Power-On Value	128
Example	*ESE 129
Query Syntax	*ESE?
Returned Parameters	<NR1>(Register value)
Related Commands	*ESR? *STB?

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10.9.3 *ESR?

This query reads the Standard Event Status register. Reading the register clears it. The bit configuration of this register is the same as the Standard Event Status Enable register (see *ESE).

Query Syntax	*ESR?
Parameters	None
Returned Parameters	<NR1>(Register value)
Related Commands	*CLS *ESE *ESE?

If the *ESR? returns the value of the status bits in the ESR register. Refer to Table 10-3 for the status bits and their meaning.

Table 10-3: Bit Configuration of Standard Event Status Register

Bit Position	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Bit Name	PON	not used	CME	EXE	DDE	QYE	not used	not used
Bit Weight	128		32	16	8	4		

CME	Command error	DDE	Device-dependent error
EXE	Execution error	QYE	Query error
PON	Power-on		

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10.9.4 *IDN?

This query requests the source to identify itself. It returns the data in four fields separated by commas. Note that any installed options are not reflected in the *IDN? query response. The presence of these options that may affect the power source's capabilities must be determined by querying the Limit system. See section 10.6.

Query Syntax	*IDN?	
Returned Parameters	<AARD>	
	Field	Information
	CI	Manufacturer
	xxxxxx	Model number and letter
	nnnnnn	Serial number or 0
	Rev. x.x	Revision level of firmware
Example	"CI,351TL,12345,Rev 1.0"	

The following table shows the series of queries that may be used to detect the presence of a TL and to determine the frequency range setting of a TL Series unit:

Step	Query command	Response	Interpretation
1	*IDN?	"CI,351TL,12345,Rev 1.0"	TL series unit
2	LIM:VOLT?	270	251/351TL standard unit
		135	251/351TL, single Vrange
3	LIM:FREQ:LOW?	16	Standard frequency range
		400	Fixed 400 Hz
4	LIM:FREQ:HIGH?	8000	Standard frequency range
		400	Fixed 400 Hz

10.9.5 *RCL

This command restores the AC source to a state that was previously stored in memory with a *SAV command to the specified location. The TL Series offers eight non-volatile memory locations for storing instrument setups.

Command Syntax	*RCL <NRf>
Parameters	0 through 7
Example	*RCL 3
Related Commands	*RST *SAV



WARNING: ***Recalling a previously stored state may place hazardous voltages at the AC source output if the output relay state saved is ON.***

10.9.6 *RST

This command resets the AC source to a setting defined by the values in the register defined by PON if valid or by the following factory-defined states:

*Table 10-4: *RST Default Parameter Values*

Item	Value	Item	Value
VOLT	5.0 V	FREQ	60 Hz
CURR	2.8 351TL 2.6 251TL	VOLT:RANGe:LEVel	135 V
		VOLT:RANGe:AUTO	0 (OFF)
OUTP	0 (OFF)	DISP:MODE	1 (FREQ)
OUTP:STARt:STATe	0 (OFF)	OUTP:STARt:PHASe	0

NOTE: The factory defaults cannot be used on units set to 400 Hz fixed frequency. Instead, one of the setup registers 0 through 7 must be selected for the power on state. Executing the *RST command will recall the settings from the assigned setup register. Use the SYSTem:PON to select one of the available setup registers for the power on and *RST states.

Command Syntax	*RST
Parameters	None
Related Commands	*SAV

Table 10-5: Status Registers - Power on Conditions

Register	Status on Power On	Status after *RST
- ESE register	All 0's	All 0's
- ESR register	PON bit = 1, all others 0	PON = 0, all others unaffected
- STB register	All 0's	All 0's
- SRE register	All 0's	All 0's

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10.9.7 *SAV

This command stores the present state of the AC source to a specified location in memory. The RP Series offers eight non-volatile memory locations for storing instrument setups.

Command Syntax	*SAV
Parameters	0 through 7
Related Commands	*RCL *RST

10.9.8 *SRE

This command sets the condition of the Service Request Enable Register. This register determines which bits from the Status Byte Register (see *STB for its bit configuration) are allowed to set the Master Status Summary (MSS). A 1 in any Service Request Enable Register bit position enables the corresponding Status Byte Register bit and all such enabled bits then are logically OR-ed to cause Bit 6 of the Status Byte Register to be set. See Section 12 for more details concerning this process.

When the controller conducts a STB? command, the MSS bit is not cleared. When *SRE is cleared (by programming it with 0), the source cannot generate an MSS bit.

Command Syntax	*SRE <NRf>
Parameters	0 to 255
Default Value	128
Example	*SRE 255
Query Syntax	*SRE?
Returned Parameters	<NR1>(Register binary value)
Related Commands	*ESE *ESR

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10.9.9 *STB?

This query reads the Status Byte register, which contains the status summary bits and the Output Queue MAV bit. Reading the Status Byte register does not clear it. The input summary bits are cleared when the appropriate event registers are read (see Section 12 for more information).

Table 10-6: Bit Configuration of Status Byte Register

Bit Position	**7**	**6**	**5**	**4**	**3**	**2 - 0**
Bit Name	OPER	MSS	ESB	MAV	QUES	not used
Bit Weight	128	64	32	16	8	

OPER	operation status summary	MSS	master status summary
ESB	event status byte summary		
QUES	questionable status summary	MAV	message available

Query Syntax	*STB?
Returned Parameters	<NR1> (Register binary value)

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11 Programming Examples

11.1 Introduction

This chapter contains examples on how to program the AC source. Simple examples show you how to program:

- Output functions such as voltage and frequency
- Measurement functions

The examples in this chapter use generic SCPI commands. See Section 9 for information about encoding the commands as language strings. Where appropriate, optional commands are shown for clarity in the examples.

11.2 Programming the Output

Power-on Initialization

When the AC source is first turned on, it wakes up with the output state defined by the PON register number. If the register number or the register has no valid data, the AC source initializes to the following state.

```
VOLT  5.0
FREQ 60
OUTP 0
VOLT:RANG 135
```

The following commands are given implicitly at power-on:

```
*RST
*CLS
*SRE 128
*ESE 0
```

*RST is a convenient way to program all parameters to a known state. Refer to Table 10-4 under the *RST command in paragraph 10.9.6 to see how each programmable parameter is set by *RST.

Enabling the Output

To enable the output, use the command:

```
OUTPut 1
```

Voltage and Frequency

The AC rms output voltage is controlled with the VOLTage command. For example, to set the AC output voltage to 125 volts rms, use:

```
VOLTage 125
```

The maximum voltage that the AC source can output is limited by the rms value of the waveform. This value is defined by the LIMIT subsystem.

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Voltage Ranges

The power source has two voltage ranges that are controlled by a relay. The command that controls the range is:

VOLTage:RANGe 135 | 270

When the range is set to (135), the maximum rms voltage that can be programmed is 135 volts rms, but it is only on this range that the maximum output current rating is available.

The VOLT:RANGe command is coupled with the CURRent command. This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating.

Frequency

The output frequency is controlled with the FREQuency command. To set the output frequency to 50 Hz, use:

FREQuency 50

Turning on output voltage at a specified phase angle

The following command sequence will turn the output voltage on at a specified phase angle. This may be required to measure worst case inrush current.

```
/* Set up sequence
VOLT 0                  Set output voltage to zero
OUTP 1                  Close output relay
OUTP:STAR:STAT 1        Enable start phase mode
OUTP:STAR:PHAS 90       Set start phase angle to 90 degrees
OUTP:DROP               Put AC source in infinite drop mode
/* Turn on sequence
VOLT 230                Turn on voltage to 230 V at 90 degrees
```

Current Limit

To set the RMS current limit use:

CURRent <n>

where <n> is the RMS current limit in amperes.

If the load attempts to draw more current than the programmed limit, The AC source is programmed to turn off its output if the RMS current limit is reached.

Note:	***The CURRent command is coupled with the VOLTage:RANGe.This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating.***

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11.3 Making Measurements

The source has the capability to return current, peak current, crest factor, true power, apparent power, power factor and voltage measurements.

Voltage Measurement

To measure the RMS voltage, use:

```
OUTP 1                  /* Close  output relay if it was not closed already.
MEAS:VOLT?
```

Current Measurements

To measure the RMS current, use:

```
MEAS:CURR?
```

To measure the peak current, use:

```
MEAS:CURR:AMPL:RES      /* resets track and hold for peak curr. meas.
                        /* It may be need to turn the output on or program
                        /* as specific voltage at this time before taking a
                        /* peak current reading.
MEAS:CURR:AMPL:MAX?     /* retrieves peak current reading.
```

To measure the current crest factor, use:

```
MEAS:CURR:CRES?
```

Power Measurements

To measure the true power, use:

```
MEAS:POW:REAL?
```

To measure the apparent power, use:

```
MEAS:POW:APP?
```

To measure the power factor, use:

```
MEAS:POW:PFAC?
```

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12 Status Registers

You can use status register programming to determine the operating condition of the AC source at any time. For example, you may program the AC source to generate an MSS bit when an event such as a current limit occurs. When the MSS bit is set, your program can then act on the event in the appropriate fashion.

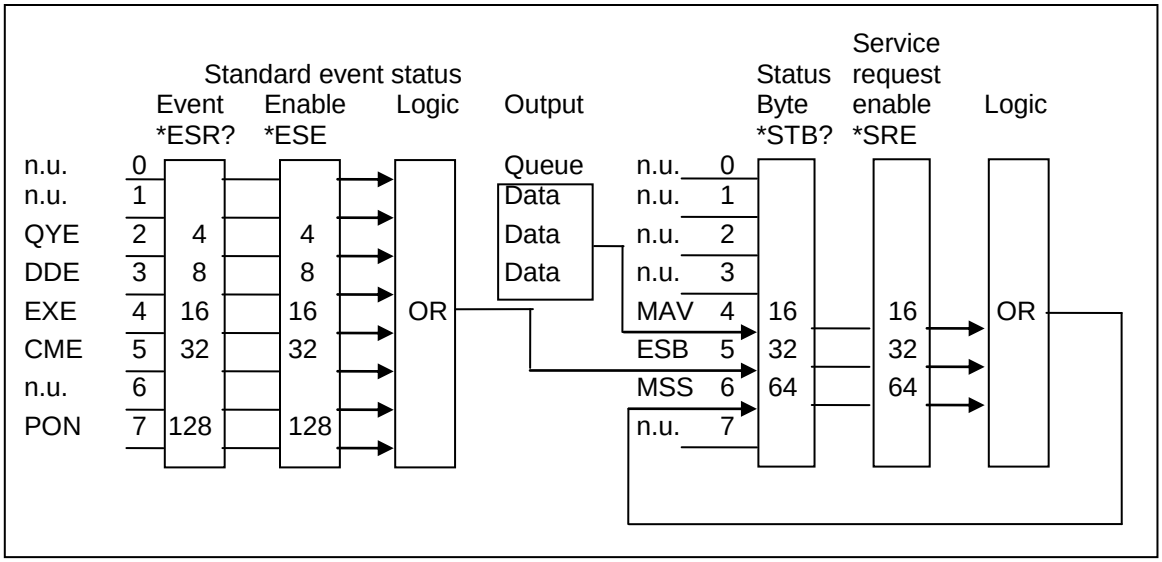


Figure 12-1: AC Source Status System Model

Figure 12-1 shows the status register structure of the AC source. The Standard Event, Status Byte, and Service Request Enable registers and the Output Queue perform standard IEEE-488 functions as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation.

12.1 Power-On Conditions

Refer to the *RST command description in paragraph 10.9.6 for the power-on conditions of the status registers.

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12.2 Standard Event Status Group

This group consists of an Event register and an Enable register that are programmed by Common commands. The Standard Event register latches events relating to interface communication status. It is a read-only register that is cleared when read. The Standard Event Enable register functions similarly to the enable registers of the Operation and Questionable status groups.

Command	Action
*ESE	programs specific bits in the Standard Event Enable register.
*ESR?	reads and clears the Standard Event register.

The PON bit in the Standard Event register is set whenever the AC source is turned on.

12.3 Status Byte Register

This register summarizes the information from all other status groups as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The bit configuration is shown in Table 10-6.

Command	Action
*STB?	reads the data in the register but does not clear it (returns MSS in bit 6)

The MSS Bit

This is a real-time (unlatched) summary of all Status Byte register bits that are enabled by the Service Request Enable register. MSS is set whenever the AC source has one or more reasons for needing service. *STB? reads the MSS in bit position 6 of the response but does not clear any of the bits in the Status Byte register.

The MAV bit and Output Queue

The Output Queue is a first-in, first-out (FIFO) data register that stores AC source-to-controller messages until the controller reads them. Whenever the queue holds one or more bytes, it sets the MAV bit (bit 4) of the Status byte register.

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12.4 Examples

The following section contains examples of commonly used operations involving the status registers.

You can determine the reason for an MSS bit set by the following actions:

Step 1 : Determine which summary bits are active. Use:

*STB?

Step 2 : Read the corresponding Event register for each summary bit to determine which events caused the summary bit to be set. Use:

ESR?

Note: ***When an Event register is read, it is cleared. This also clears the corresponding summary bit.***

Step 3 : Remove the specific condition that caused the event. If this is not possible, the event may be disabled by programming the corresponding bit of the status group Enable.

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Appendix A: SCPI Command tree

Command Syntax Tree

Root	Level 1	Level 2	Level 3	Level 4
	CALibrate	:STATe		
		:MEASure	:CURRent	[:FSCale]
				:ZERO
			:PCURrent	[:FSCale]
				:ZERO
			:POWer	[:FSCale]
				:ZERO
			:VOLTage	[:FSCale]
				:ZERO
		[:SOURce]:VOLTage		
	[SOURce]	:CURRent		
		:FREQuency		
		:VOLTage	[:LEVel]	
			:RANGe	
		:OUTPut		
	OUTPut	[:RELay]		
		:DROP		
		:STARt	[:STATe]	
			:PHASe	
	MEASurement	:CURRent?		
			:AMPLitude	:MAX?
				:RESet
			:CRESTfactor	
			:RANGe	
		:POWer	[:REAL]?	
			:APParent?	
			:PFACtor?	
		:VOLTage?		
	DISPlay	:MODE		
	SYSTem	:PON		
		:REMote		
		:LOCal		
		:KLOCk		
		:SAVE		
	LIMit	:CURRent		
		:VOLTage		
		:FREQuency	:LOW	
			:HIGH	

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Appendix B: SCPI Conformance Information

SCPI Version

The TL Series AC power sources conform to SCPI version 1990.0.

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Appendix C: Error Messages

Error Number	Error Message String	Error Causes
0	"No error"	
-100	"Command error"	Generally the result of sending a command that uses incorrect syntax.
-200	"Execution error"	Generally the result of sending a value that is out of range, i.e., a VOLT 200 command when the unit is in the 150 V (Low) range.
-300	"Device specific error"	Generally the result of an overcurrent (current limit trip) or over temperature condition.
-350	"Queue overflow"	Generally caused by too many errors being generated without reading error status, causing error buffer to overflow.
-400	"Query error"	Generally caused by sending a query followed by another command without accepting the query response first.

Table 12-1: Bus Error Messages

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Index

A

Acoustic 8
Altitude 8

B

bugs 61

C

CALibrate:MEASure:CURRent:ZERO 84
CALibrate:MEASure:CURRent[FSCale] 84
CALibrate:MEASure:PCURrent:ZERO 85
CALibrate:MEASure:PCURrent[FSCale] 84
CALibrate:MEASure:POWer:ZERO 85
CALibrate:MEASure:POWer[FSCale] 85
CALibrate:MEASure:VOLTage:ZERO 85
CALibrate:MEASure:VOLTage[FSCale] 85
CALibrate:STATe 83
CALibrate[:SOURce]:VOLTage 86
Calibration 42
CLS 103
command
  subsystem 82
commands
  bus 82
  common 77
comments 61
Connect 67
Construction
  internal 7
Conventions 75
Cooling 7
Current
  Constant current mode 32
  Constant Voltage 32
CURRent 90

D

Dimensions 7
DISPlay:MODE 99

E

Emissions 8
ESE 103
ESR? 104
EXT 9
EXT option 23
-EXT Option 33
External Input 33
external oscillator input 9

F

factory
  default power on setting 31
Finish
  paint 7
form
  End-user feedback 61
formats
  data 81
forms
  bug report 61
Frequency
  specification 4
FREQuency 91
frequency range
  2001RP-AV 97
  fixed 97
front panel 23, 61
  lock 24
Function Strobe 33
Functional Test 20

G

GPIB 63
  address selection 63
  troubleshooting 72

H

hard disk space
  required to install 67
header
  optional 79
  separator 79
Header 76
Humidity 8

I

IDN? 105
IEEE-488 ..... 40, 63
  address selection 63
  troubleshooting 72
Immunity 8
initialization
  changing 31
Input power factor 2
Inrush Current 2
installation 17, 67
  program 67
Installing
  software 67

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Insulation 8
Introduction 1
Isolation Voltage 2

K

keyboard
  lock out 100
knob 26

L

LabView
  RS232C terminator 64
LED 55
LED indicators 55
LIMit:CURRent? 97
LIMit:FREQuency:HIGH? 97
LIMit:FREQuency:LOW? 97
LIMit:VOLTage? 98
Line Current: 2
Line Frequency 2
Line Voltage 2

M

maintenance 55
Material
  chassis 7
MEASure:CURRent:AMPLitdue:RESet 88
MEASure:CURRent:AMPLitude:MAX? 88
MEASure:CURRent:CREStfactor? 88
MEASure:CURRent:RANGe 88
MEASure:CURRent? 87
MEASure:POWer:APParent? 89
MEASure:POWer:PFACtor? 89
MEASure:POWer[
  REAL]? 89
MEASure:VOLTage[:AC]? 87
memory
  required to install 67
models
  supported 61

O

OUTPut:DROP 95
OUTPut:STARt:PHASe 96
OUTPut:STARt[:STATe] 96
OUTPut[:RELay] 94
Overcurrent 7
overload 24
Overtemperature 7

P

PGUI32 61

Q

queries 78

R

RCL 105
remote control 24
Remote Inhibit 33
replacement parts 60
Requirements
  PGUI32 61
root 80
Root 76
RS232C 40
RST 106

S

Safety 8
SAV 107
SCPI 75
  message 75
  program message 75
  response message 75
Separator 79
Setup
  program 67
Shock 8
Short Circuit
  current 7
shuttle 26
simulation mode 63
software registration 74
SOURce:CURRent 90
SOURce:FREQuency 91
SOURce:VOLTage 91
SOURce:VOLTage:RANGe:AUTO 93
SOURce:VOLTage:RANGe[:LEVel] 92
SRE 107
status 24
STB? 108
suggestions 61
SYSTem:ERRor? 100
SYSTem:KLOCk 100
SYSTem:LOCal 100
SYSTem:PON 101
SYSTem:REMote 101
SYSTem:SAVE 101

T

Temperature
  operating,storage 8
terminator 80
  RS232C 64
Transients
  Input 7
troubleshooting 55

V

Vibration 8
Voltage

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specification 2
VOLTage 91
voltage range
dual 98
single 98
voltage ranges 19
VOLTage:RANGe:AUTO 93
VOLTage:RANGe[:LEVel] 92

W

Weight 7
wiring
input 17

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