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USER'S GUIDE
Agilent Technologies
Series 661xxA
MPS POWER MODULES
& Model 66001A MPS KEYBOARD



Agilent Technologies

Agilent Part No. 5959-3386
Microfiche Part No. 5959-3387

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation of this power module. Failure to comply with these precautions or with specific warnings elsewhere in this guide violates safety standards of design, manufacture, and intended use of the power module. Agilent Technologies assumes no liability for the customer's failure to comply with these requirements.

GENERAL
When installed in a properly wired mainframe, this product is a Safety Class 1 instrument (provided with a protective earth terminal). Any LEDs used in this product are Class 1 LEDs as per IEC 825-l.
This ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada.

ENVIRONMENTAL CONDITIONS
With the exceptions noted, all instruments are intended for indoor use in an installation category II, pollution degree 2 environment. They are designed to operate at a maximum relative humidity of 95% and at altitudes of up to 2000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

BEFORE APPLYING POWER.
Verify that the power module line voltage switch is set to match the available line voltage.

GROUND THE INSTRUMENT.
To minimize shock hazard, the mainframe must be connected to an electrical ground. The mainframe must be connected to the ac power supply mains through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury. If

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.
Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

DO NOT SERVICE OR ADJUST ALONE.
Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT EXCEED INPUT RATINGS.
This mainframe is equipped with a power line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at line voltages or frequencies in excess of those stated on the line rating label may cause leakage currents in excess of 5.0 mA peak.

SAFETY SYMBOLS.

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.
Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an Agilent Technologies Sales and Service Office for service and repair to ensure that safety features are maintained.

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

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SAFETY SYMBOL DEFINITIONS

Symbol	Description	Symbol	Description
	Direct current		Terminal for Line conductor on permanently installed equipment
	Alternating current		Caution, risk of electric shock
	Both direct and alternating current		Caution, hot surface
	Three-phase alternating current		Caution (refer to accompanying documents)
	Earth (ground) terminal		In position of a bi-stable push control
	Protective earth (ground) terminal		Out position of a bi-stable push control
	Frame or chassis terminal		On (supply)
	Terminal for Neutral conductor on permanently installed equipment		Off (supply)
	Terminal is at earth potential (Used for measurement and control circuits designed to be operated with one terminal at earth potential.)		Standby (supply) - Units with this symbol are not completely disconnected from ac mains when this switch is off. To completely disconnect the unit from ac mains, either disconnect the power cord or have a qualified electrician install an external switch.

Herstellerbescheinigung
Diese Information steht im Zusammenhang mit den Anforderungen der Maschinenläminformationsverordnung vom 18 Januar 1991. * Schalldruckpegel Lp <70 dB(A) * Am Arbeitsplatz * Normaler Betrieb * Nach EN 27779 (Typprufung).

Manufacturer's Declaration
This statement is provided to comply with the requirements of the German Sound Emission Directive, from 18 January 1991. * Sound Pressure Lp <70 dB(A) *At Operator Position * Normal Operation * According to EN 27779 (Type Test).

Printing History

The current edition of this guide is indicated below. Reprints of this guide containing minor corrections and updates may have the same printing date. New editions are identified by a new printing date and, in some cases, by a new part number. A new edition incorporates all new or corrected material since the previous edition. Changes to the guide occurring between editions are covered by change sheets shipped with the guide.

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Agilent Technologies	**DECLARATION OF CONFORMITY** According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014	CE

Manufacturer's Name and Address

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USA

Alternate Manufacturing Site
Agilent Technologies (Malaysia) Sdn. Bhd
Malaysia Manufacturing
Bayan Lepas Free Industrial Zone, PH III
11900 Penang,
Malaysia

Declares under sole responsibility that the product as originally delivered

Product Names
a) Modular Power System Mainframe
b) Keyboard
c) dc Power Modules

Model Numbers
a) 66000A
b) 66001A
c) 66101A; 66102A; 6103A; 66104A; 66105A; 66106A

Product Options This declaration covers all options and customized products based on the above products.

Complies with the essential requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly.

EMC Information ISM Group 1 Class A Emissions

As detailed in Electromagnetic Compatibility (EMC), Certificate of Conformance Number CC/TCF/00/077 based on Technical Construction File (TCF) HPNJ4, dated Oct. 30, 1997

Assessed by: Celestica Ltd, Appointed Competent Body
Westfields House, West Avenue
Kidsgrove, Stoke-on-Trent
Straffordshire, ST7 1TL
United Kingdom

Safety Information and Conforms to the following safety standards.

IEC 61010-1:2001 / EN 61010-1:2001
UL 1244
CSA C22.2 No. 1010.1:1992

This DoC applies to above-listed products placed on the EU market after:

January 1, 2004
Date

Bill Darcy/ Regulations Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor, or
Agilent Technologies Deutschland GmbH, Herrenberger Straβe 130, D71034 Böblingen, Germany

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General Information

Introduction

This guide describes how to install, check out, operate, and calibrate the Agilent Series 661xxA power modules used in the Agilent 66000 Modular Power System. Programming the power module from the optional Agilent 66001A Keyboard is described in Appendix B of this guide. Programming the power module over the GPIB bus is covered in the module *Programming Guide* (see "Related Documents", below). Setting the GPIB address is described in the mainframe *Installation Guide*. For complete verification procedures, see the module *Service Guide* (listed under "Related Documents", below). The *Agilent 66000A Modular Power System Product Note* has specific application programs in several DOS-compatible languages and GPIB interface drivers.

Related Documents

Document	Agilent Part No.
Programming Guide for Agilent Series 66lxxA MPS Power Modules	5959-3362
Installation Guide for DC Module Connectors	5959-3366
Service Guide for Agilent Series 66lxxA Power Modules	5959-3364
Installation Guide for Agilent 66000A Modular Power System Mainframe	66000-90001
Service Guide for Agilent 66000A Modular Power System Mainframe	66000-90003
Quick Reference Card for Optional Agilent 66001A MPS Keyboard*	66001-90001
Agilent 66000A Modular Power System Product Note	5988-2800EN
* A Quick Reference Card is shipped with each Agilent 66000 mainframe.	

Safety Considerations

When properly installed in the mainframe, the power module is part of a subsystem that constitutes a Safety Class 1 instrument. The power module has a protective earth connection that is completed through a contact spring in the mainframe backplane. When the power module is moved in and out of the mainframe, the earth ground connection is made before ac power is connected and is removed after ac power is disconnected.

Instrument Identification

Agilent Technologies instruments are identified by a 10-digit serial number. The format is described as follows: first two letters indicate the country of manufacture. The next four digits are a code that identify either the date of manufacture or of a significant design change. The last four digits are a sequential number assigned to each instrument.

Item	Description
US	The first two letters indicates the country of manufacture, where US = USA; MY = Malaysia; SG = Singapore.
3648	This is a code that identifies either the date of manufacture or the date of a significant design change.
0101	The last four digits are a unique number assigned to each power supply.

Options

Option	Description
760	Output Connector with Isolation/Polarity Reversal Relays
0L2	Extra set of Documentation
0B3	Series 661xxA Service Guide

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Accessories

Agilent No.	Description
34551A	Rack mount for Agilent 66001A MPS keyboard

Description

The Agilent 66lxxA Series Power Modules are used in the Agilent 66000 Modular Power System (MPS) mainframe to provide a range of dc output voltages and currents. The modules are installed or removed from the front of the mainframe without the need for disconnecting any wires. Modules may be connected in series or parallel to provide increased output voltages or currents. The modules can be equipped with optional isolation and polarity reversal relays that are built into the module output connector.

The power module front panel has digital readouts of output voltage and current. It also has annunciators that indicate:

- constant voltage, constant current, or unregulated operation
- activation of a protection circuit
- disabling of the output
- remote operation (addressed by the controller)

Programming

The power module is programmed over the GPIB from a controller using SCPI (Standard Commands for Programmable Instruments). This makes power module programs compatible with those of all other instruments controlled with this language. Among the functions that can be programmed are output voltage and current, OVP (overvoltage protection), OCP (overcurrent protection), status registers, output relays, and output voltage and current calibration.

In addition, the power module has programmable trigger, list, and RI/DFI (remote inhibit/discrete fault indicator) subsystems. Triggers can occur from signals at the mainframe TRIG IN jack or from selected internal events. The list subsystem generates preprogrammed sequential outputs in response to triggers. The RI/DFI subsystem generates an output on the mainframe FLT line in response to selected internal events or turns off the output in response to an input on the mainframe INH line.

The power module also can be programmed locally from the optional Agilent 66001A MPS Keyboard. The keyboard has an alphabetical command menu for all power module SCPI commands. By scrolling through the menu and entering the appropriate parameters, commands may be created for development or debugging.

Output Characteristic

The power module can operate in either CV (constant voltage) or CC (constant current) mode over its voltage and current output range (see Table 1-1). The operating locus (see Output Characteristic Curve in Table 1-2) shows a single-range, limited two-quadrant capability. The operating point is determined by the voltage setting (V_S), the current setting (I_S) and the load impedance (R_l). Two operating points are shown. Point 1 is defined by the load line cutting the operating locus in the CV region, which defines the CV mode (curve A). In this mode, the power module will maintain the voltage at V_S for varying load currents (determined by $V \div R_l$) up to I_S. If the load demands a current greater than I_S, the power module switches to CC mode. CC mode (curve B) is defined by the load line cutting the operating locus in the CC region (see Point 2). Under this condition, the power module maintains the current at I_S at some voltage determined by $I_S \times R_l$.

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When the power module is operated beyond either rated output, the performance specifications are not guaranteed, although typical performance may be good. Operation in quadrant 2 is limited to about 10% of the maximum rated positive output current. This allows the power module to sink current for more rapid downprogramming in the CV mode.

Specifications and Supplemental Characteristics

Table 1-1 lists the specifications of the power modules. Specifications are warranted over the specified temperature range. Table 1-2 lists the supplemental characteristics, which are not warranted but are descriptions of performance determined either by design or type testing.

Table 1-1. Performance Specifications

Parameter	Agilent Model					
	66101A	**66102A**	**66103A**	**66104A**	**66105A**	**66106A**
Specifications are warranted over the temperature range 0 to 55° C with a resistive load and the output connected for local sensing. Derate the output current 1% per °C from 40° C to 55°C.						
Output Ratings						
Voltage:	0 - 8 V	0 - 20 V	0 - 35 V	0 - 60 V	0 - 120 V	0 - 200 V
Current:	0 - 16 A	0 - 7.5 A	0 - 4.5 A	0 - 2.5 A	0 - 1.25 A	0 - 0.75 A
Power:	128 W	150 W	157.5 W	150 W	150 W	150 W
Programming Accuracy @ calibration temperature ± 5 °C)*						
Voltage: 0.03% +	3 mV	8 mV	13 mV	27 mV	54 mV	90 mV
Current: 0.03% +	6 mA	3 mA	2 mA	1.2 mA	0.6 mA	0.4 mA
*Factory calibration temperature = 25 °C						
Ripple & Noise (from 20 Hz to 20 MHz with outputs ungrounded, or with either output terminal grounded)						
Constant Voltage: rms	2 mV	3 mV	5 mV	9 mV	18 mV	30 mV
Constant Voltage: p-p	5 mV	7 mV	10 mV	15 mV	25 mV	50 mV
Constant Current: rms	8 mA	4 mA	2 mA	1 mA	1 mA	1 mA
Readback Accuracy With respect to actual output @ calibration temperature following self calibration.*						
Voltage: 0.02% +	2 mV	5 mV	8 mV	16 mV	32 mV	54 mV
Current: 0.02% +	6 mA	3 mA	2 mA	1 mA	0.6 mA	0.3 mA
*Factory calibration temperature = 25 °C						
Load Regulation (change in output voltage or current for any load change within ratings)						
Voltage:	1 mV	1 mV	1 mV	2 mV	4 mV	7 mV
Current:	0.5 mA	0.2 mA	0.2 mA	0.1 mA	50 µA	30 µA

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Table 1-1. Performance Specifications (continued)

Parameter	Agilent Model 66101A	66102A	66103A	66104A	66105A	66106A
Line Regulation (change in output voltage or current for any line change within ratings)						
Voltage:	0.5 mV	0.5 mV	1 mV	2 mV	3 mV	5 mV
Current:	0.75 mA	0.5. mA	0.3 mA	0.1 mA	50 µA	30 µA
Transient Response Time (for output voltage to recover to within 100 mV of its previous level following a step change in load current that is up to 10% of the power module rated output current.	< 1 ms					
AC Input Ratings (selectable via module switch- see Chapter 2)						
Nominal line voltage (Vac)						
115 V switch setting	87- 132 Vac					
230 V switch setting	174- 250 Vac					
Frequency range:	47 - 63 Hz					
Output Terminal Isolation (maximum, from output to the mainframe chassis ground):	±240 Vdc					

Table 1-2. Supplemental Characteristics

Parameter	Agilent Model 66101A	66102A	66103A	66104A	66105A	66106A
Output Programming Range (Maximum programmable values):						
Voltage:	8.190 V	20.475 V	35.831 V	61.425 V	122.85 V	204.75 V
Current:	16.380 A	7.678 A	4.607 A	2.559 A	1.280 A	0.768 A
OV Protection:	9.6 V	24.0 V	42.0 V	72.0 V	144.0 V	240.0 V
Average Programming Resolution						
Voltage:	2.4 mV	5.9 mV	10.4 mV	18.0 mV	36.0 mV	60.0 mV
Current:	4.6 mA	2.3 mA	1.4 mA	0.75 mA	0.39 mA	0.23 mA
OV Protection:	50 mV	120 mV	200 mV	375 mV	750 mV	1.25 V
OVP Accuracy (@ calibration temperature ±5° C):*	250 mV	500 mV	800 mV	1 V	1.5 V	2.5 V
* Factory calibration temp = 25° C						
Readback Resolution						
Voltage:	0.305 mV	0.763 mV	1.335 mV	2.289 mV	4.577 mV	7.629 mV
Current:	0.587 mA	0.293 mA	0.169 mA	0.099 mA	0.049 mA	0.030 mA
Drift (Temperature Stability) (following a 30-minute warmup, change in output over 8 hours under constant line, load, and ambient temperature)						
Voltage: 0.02% +	0.4 mV	1 mV	2 mV	3 mV	6 mV	10 mV
Current: 0.02% +	8 mA	5 mA	2.5 mA	1.3 mA	0.63 mA	0.38 mA

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Table 1-2. Supplemental Characteristics (continued)

Parameter	Agilent Model 66101A	66102A	66103A	66104A	66105A	66106A
Temperature Coefficients (change in output per °C after a 30-minute warmup)						
Output Voltage: 30 ppm +	0.1 mV	0.2 mV	0.3 mV	0.6 mV	1.1 mV	1.8 mV
Output Current: 30 ppm +	0.2 mA	0.1 mA	0.05 mA	0.03 mA	0.01 mA	0.006 mA
Voltage Readback: 20 ppm +	0.1 mV	0.2 mV	0.2 mV	0.7 mV	0.7 mV	1.1 mV
± Current Readback: 20 ppm +	0.2 mA	0.1 mA	0.05 mA	0.02 mA	0.02 mA	0.02 mA
OV Protection:	1 mV	2 mV	4 mV	8 mV	16 mV	30 mV
Maximum Reverse Current (maximum current, without damage, that the power module will withstand while turned on and with the dc output reverse biased by an external dc source):	16 A	7.5 A	4.5 A	2.5 A	1.25 A	0.75 A
Typical Output Common Mode Noise Current*						
rms:	0.5 mA					
peak-peak:	5 mA					
* Referenced to mainframe chassis ground.						
Remote Sensing Capability						
Voltage drop per lead:	Up to 1/2 of rated output voltage					
Load voltage:	Subtract voltage drop in load leads from specified output voltage rating					
Load Regulation:	For each 1-volt change in the negative output lead due to load current change, add 2 mV to the voltage load regulation specification (see Table 1-1).					
Command Processing Time (average time for output to begin to change after receipt of digital data when the power module is connected directly to the GPIB):	20 ms					
Output Voltage Programming Response Time*						
Time for output to change from 10% to 90% of its total excursion:	< 20 ms					
Time for output to change from 90% to 10% of its total excursion:	< 20 ms			< 50 ms		
Time for output voltage to settle to within 0.1% of the final value:	120 ms					
* Excluding command processing time						

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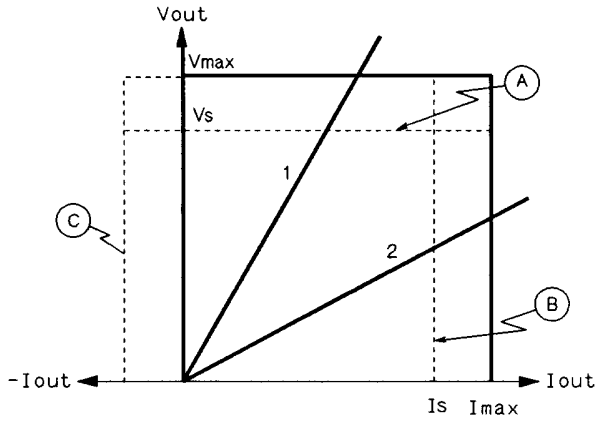
Table 1-2. Supplemental Characteristics (continued)

Parameter	Agilent Model					
	66101A	66102A	66103A	66104A	66105A	66106A
Trigger Response Time (average time for the output voltage or current to begin to change upon receipt of an external trigger) With GPIB activity: Without GPIB activity: Trigger Maximum Frequency (for repetitive external triggering, the maximum frequency for which the Trigger Response Time is valid) With GPIB activity: Without GPIB activity:	 5 ms 3 ms 75 Hz 85 Hz					
Dwell Time Programmable range: Resolution: Accuracy With GPIB activity: Without GPIB activity:	 10 ms to 65 s 2 ms ± 5 ms ± 2.5 ms					
Downprogramming:	Active downprogrammer sinks approximately 10% of rated output current					
Monotonicity:	Output is monotonic over entire rated voltage, current, and temperature range					
GPIB Interface Capabilities Interface Signals (see IEEE 488.1): Programming Language:	 AH1,C0,DC1, DT1,EI,LE4,PP0, RL1,SH1,SR1,TE6 SCPI (Standard Commands for Programmable Instruments)					
Serial Link Capabilities (maximum power modules sharing one GPIB primary address)	16					
Savable States Nonvolatile memory locations: Volatile memory locations: Nonvolatile memory write cycles:	10 5 (0 through 4) 5 (5 through 9) 40,000 (typical)					
Recommended Calibration Interval:	1 year					
Safety Compliance Complies with: Designed to comply with:	 CSA 22.2 No.231 & IEC 348 UL 1244 & VDE 0411					
RFI Suppression (designed to comply with):	FTZ 1046/84, Level B					
Dimensions Width: Height: Depth Pull tab inserted: Pull tab extended:	 48.3 mm (1.9 in) 141.2 mm (5.6 in) 571.4 mm (22.5 in) 606.4 mm (23.8 in)					
Weight Net: Shipping:	 2.7 kg (6 lb) 4.1 kg (9 lb)					

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Table 1-2. Supplemental Characteristics (continued)

Parameter	Agilent Model Number and Parameter Value
Output Characteristic Curve:	



A	CV OPERATING CURVE
B	CC OPERATING CURVE
C	QUADRANT 2 OPERATION DURING DOWNNPROGRAMMING

MAXIMUM RATED OUTPUT

HP Model	Vout	Iout	-Iout
66101A	8 V	16 A	1.6 A
66102A	20 V	7.5 A	0.75 A
66103A	35 V	4.5 A	0.45 A
66104A	60 V	2.5 A	0.25 A
66105A	120 V	1.25 A	0.125 A
66106A	200 V	0.75 A	0.075 A

OPCURVE.GAL

Table 1-3. Replaceable Parts List

Description	Agilent Part No.
Cable assembly, mainframe GPIB	
0.5 meters (1.6 ft)	10833D
1 meter (3.3 ft)	10833A
2 meters (6.6 ft)	10833B
4 meters (13.2 ft)	10833C
Cable assembly, mainframe serial link	5080-2148
Fuse, ac-line, 6 A	2110-0056
Output connector, standard	5060-3386
Output connector, with relays	5060-3387
Output connector converter board (converts 5060-3386 to 5060-3387)	5060-3351
Plug, mainframe INH/RFI input	1252-1488
Resistor, calibration	(see Appendix A)

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2

Installation

Inspection

Damage

When you receive your power module, inspect it for any obvious damage that may have occurred during shipment. If there is damage, notify the shipping carrier and the nearest Agilent Sales and Support Office immediately. Warranty information is printed in the front of this guide.

Items Supplied

In addition to this manual, check that the following items are included with each power module (see Table 1-3 for part numbers):

- One output connector
- One Series 66lxxA *Programming Guide*
- One or more Manual Change Sheets may be included with each guide. If there are change sheets, make the indicated corrections to the guides.

Switches

Before inserting the power module in the mainframe, read the following information to determine if you need to change any of the switch settings.

Line Voltage Switches

Figure 2-1 shows the location of the line voltage switches and the ac line fuse. **The line voltage switches are shipped in the 230-volt position.** If required, use a flat-bladed screwdriver or similar tool to move both switches to the proper position for your nominal line voltage.

Line Voltage	Switch Position
110, 120 Vac	115
200, 220, 230, 240 Vac	230

Note If you change the line switch position, remember to also correct the line voltage label on the rear of the mainframe. The mainframe contains no line voltage switches.

Configuration Switch

Figure 2-2 shows the location of the power module configuration switch. Table 2-1 indicates the functions of the switch and the factory-default settings. If you need to change any of the settings, refer to the applicable function.

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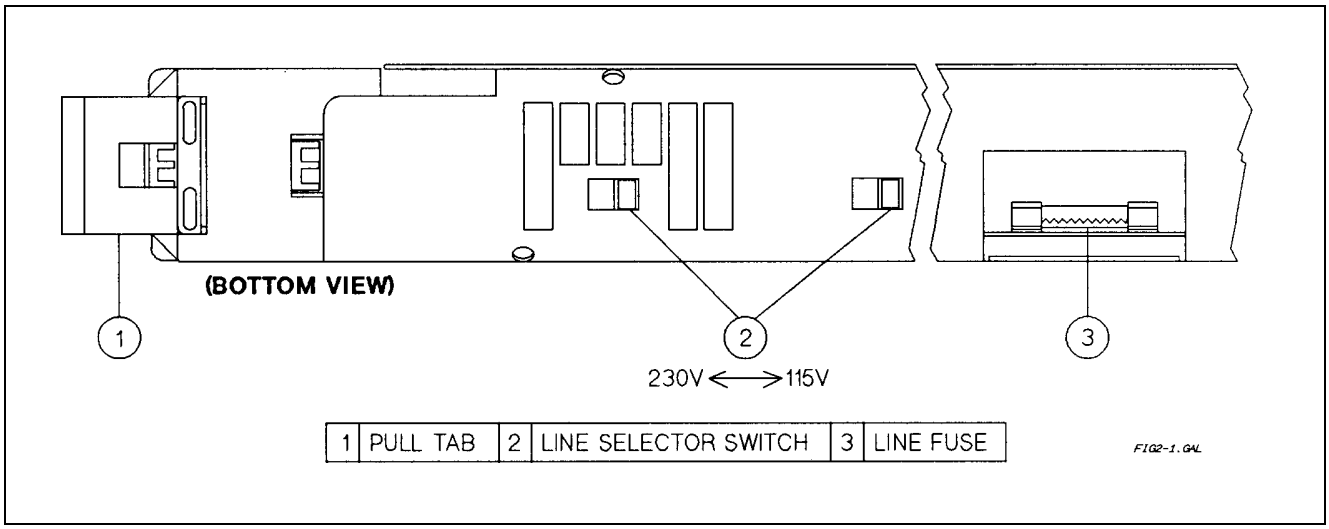


Figure 2-1. Power Module Line Fuse and Switches

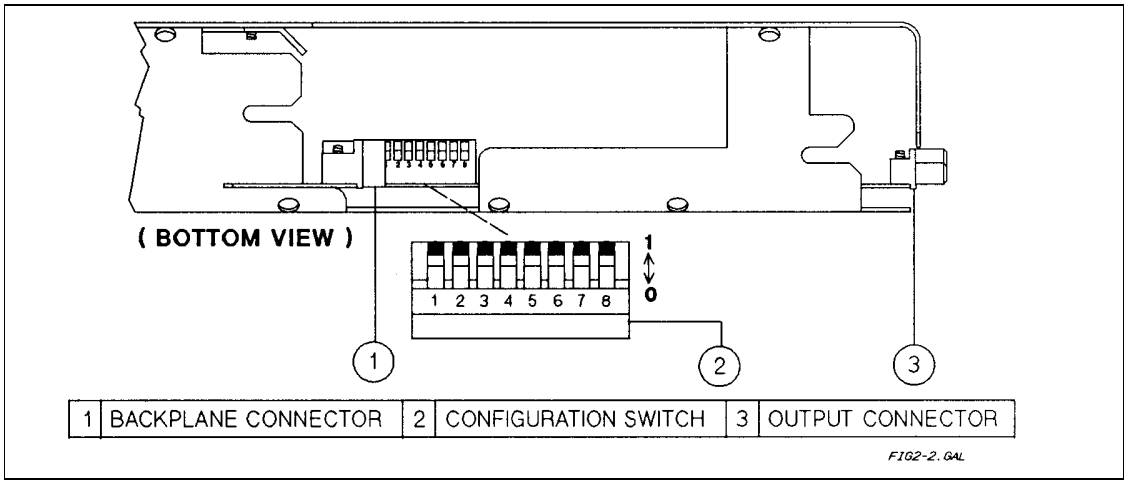


Figure 2-2. Power Module Configuration Switch

Table 2-1. Settings for Power Module Configuration Switch

Desired Function	Required Switch Setting 1	2	3	4	5	6	7*	8*
RI disabled	0	0					1	1
RI unlatched (live)	0	1					1	1
RI latching †	1	1					1	1
Display disabled			0				1	1
Display enabled †			I				1	1
Inhibit calibration				0	0		1	1
Factory calibration				0	1		1	1
Normal calibration †				1	1		1	1
Power on state is ***RCL 0**						0	1	1
Power on state is ***RST†**						1	1	1

†= factory default setting "0" Off or open "1" On or closed.
*Positions 7 and 8 are for service functions. For normal operation, they must be set to 1.

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Remote Inhibit (RI) Function Switches

This function allows the power module outputs to be shut down from a signal (low-true TTL level) applied to the mainframe INH input. The INH input is internally connected to the mainframe remote inhibit (RI) line. This line is normally high and is distributed to all power modules in the mainframe. An external switch closure that shorts the mainframe INH input is detected by the power module as an RI signal.

Note See "Chapter 3 - Connections" in the mainframe *Installation Guide* for more information on external INH connections.

Within each power module, the RI signal is applied to the RI section of the configuration switch (see Figure 2-2). The RI switch allows you to select one of the following responses to the RI input signal:

Switch Setting	RI Action
RI disabled	The module ignores the RI input signal
RI latched	The module shuts down and remains shut down when the RI signal goes true. A software command is required to restore the output (see "Chapter 4 - Basic Power Module Commands").
RI nonlatched (real-time)	The module shuts down only as long as the RI signal is true (TTL low). The output is restored when the RI signal goes false (TTL high).

Display Function Switch

A single switch configures the display function. Use it to permanently turn the power module voltage and current display indicators off or on (the annunciators are unaffected by this switch). If the switch is left in the ON position, the display may be turned on or off by software commands (see the power module *Programming Guide*).

Calibration Function Switches

The calibration switches allow you to select one of the following modes of calibration:

Switch Setting	Calibration Mode
Normal calibration	Permits normal calibration (requires entry of a password)
Factory calibration	Restores original factory calibration (no password is required)
Inhibit calibration	Prevents calibration

The factory position is useful if the power module has been miscalibrated or if the calibration password has been lost.

Power-On Function Switch

This switch allows you to determine the operating state of the power module when it is turned on. With the switch set to 1 (on), the power module will be in the factory-default reset state (see ***RST** in "Chapter 3 - Language Dictionary" of the power module *Programming Guide*). If you move the switch to *0*, the power module will turn on to whatever state you save to memory location 0. See "Chapter 4 - Basic Power Module Commands" for more information.

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Installing The Module In The Mainframe

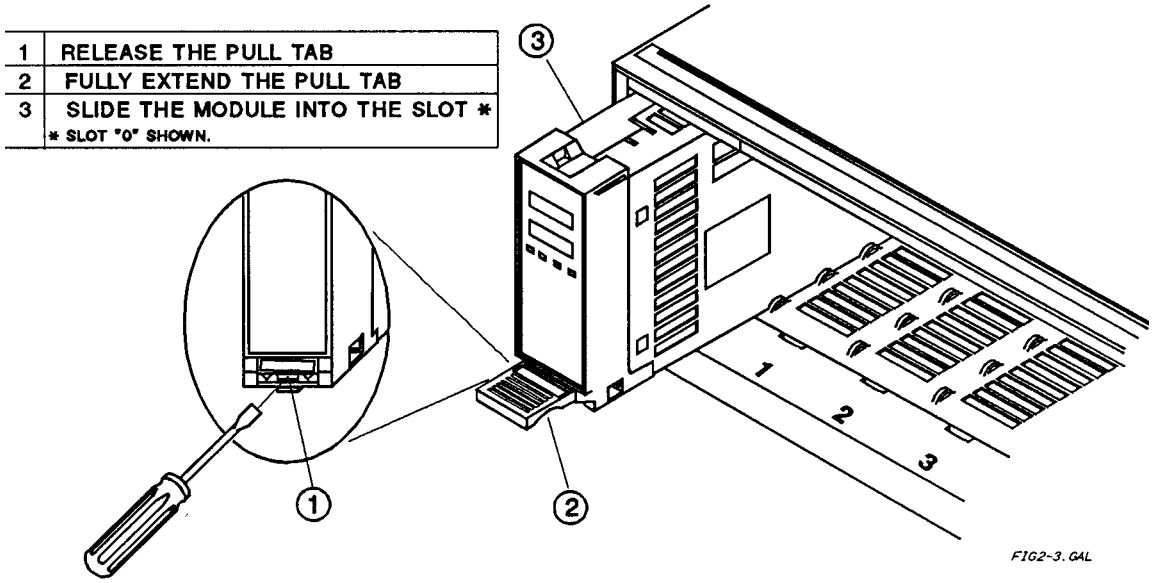


Figure 2-3. Power Module Installation

Note A fully loaded mainframe can weigh over 36 kg (80 lbs). Install the mainframe into the rack (see the "Mainframe *Users Guide")* before installing the modules into the mainframe.

1. Turn off the mainframe power switch.
2. Make certain the pull tab extends from the module (see Figure 2-3).
3. Slide the module into the mainframe slot. You may use any available slot.
4. Push the module into the backplane connector until you feel the module connector snap into the backplane connector.
5. Push the lock tab into the front of the module. If the module is not properly plugged into the backplane connector, the lock tab will not retract into the module.
6. If desired, mark or label the power module with its slot address.

Important Marking or labeling the power module will prevent replacing it in the wrong slot if it is subsequently removed from the mainframe. Also, with two mainframes linked together, a slot can be either of two numbers, depending on whether it is in the main or the auxiliary mainframe (see "Connecting the Controller" in this chapter).

Connecting The Load

Output Connector

One output connector (see Table 1-3) is shipped with each power module. This can be either a standard or relay type. The *Installation Guide* supplied with the connector shows how to open the connector, connect the wires, and secure the connector to the mainframe.

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Output Connections

Before making the actual connections, you must decide on the system configuration. The following factors are described in the rest of this chapter:

- using the correct wire size
- maintaining isolation guidelines
- selecting local or remote voltage sensing
- connecting modules in series or in parallel
- using output relays
- connecting to capacitive or inductive loads

Selecting the Proper Wire Size

WARNING **Fire Hazard**. To satisfy safety requirements, load wires must be large enough not to overheat when carrying the short-circuit output current of the device connected to the power module. See Table 2-2 for the characteristics of AWG (American Wire Gage) copper wire.

Table 2-2. Current Capacity and Resistance of Stranded Copper Conductors

AWG No.	*Ampacity	**Resistance	
		(Ω/m	Ω/ft)
20	8.33	0.0345	0.01054
18	15.4	0.0217	0.00663
16	19.4	0.0137	0.00417
14	31.2	0.0086	0.00262
12	40	0.0054	0.00165

*In free air **At 20 °C

Output Isolation

WARNING The output connector ground terminal is a low-noise ground provided for convenience, such as for grounding wire shields. This terminal is not designed to function as an equipment safety ground.

The power module output terminals are isolated from earth ground. If required, either output terminal may be grounded.

CAUTION The potential between either output terminal and ground must not exceed ±240 Vdc. Failure to observe this restriction may damage the power module.

Local Voltage Sensing

Figure 2-4A shows the load connection for local sensing. There is a switch on the output connector that selects either local or remote sensing of the output voltage. The connector is shipped with the switch in the **LOCAL** position. In order to configure the output for local sensing, make certain this switch is set to **LOCAL**.

Note The position of the Local/Remote switch also can be determined by software (see VOLT:SENS:SOUR? in "Chapter 3 - Language Dictionary" of the *Programming Guide*).

With local sensing, the power module voltage readback circuit senses the voltage at the output terminals. Since this does not compensate for voltage drops in the terminal screw connections and output leads, use Local sensing only in applications requiring low output currents or where the load regulation is not critical.

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Remote Voltage Sensing

Figure 2-4B shows the wiring for remote sensing. There is a switch on the output connector that selects either local or remote sensing of the output voltage. To configure the output for remote sensing, do the following:

- Connect sense leads to the load
- Make certain that the connector switch is set to **REMOTE**

Note If you leave the connector switch in **LOCAL**, the power module will regulate the programmed voltage at the connector, not at the load.

Because they do not carry load current, you may use smaller gauge wire for the remote sense leads.

Be careful to avoid open circuits in the sense leads, such as leaving the output connector sense switch in the **Local** position. If this happens, the power module will regulate at its output terminals instead of at the load.

Note If the sense terminals are left open, the voltage at the output terminals will increase approximately 3 to 5% over the programmed value. The readback voltage will not indicate this increase because readback is measured at the sense terminals.

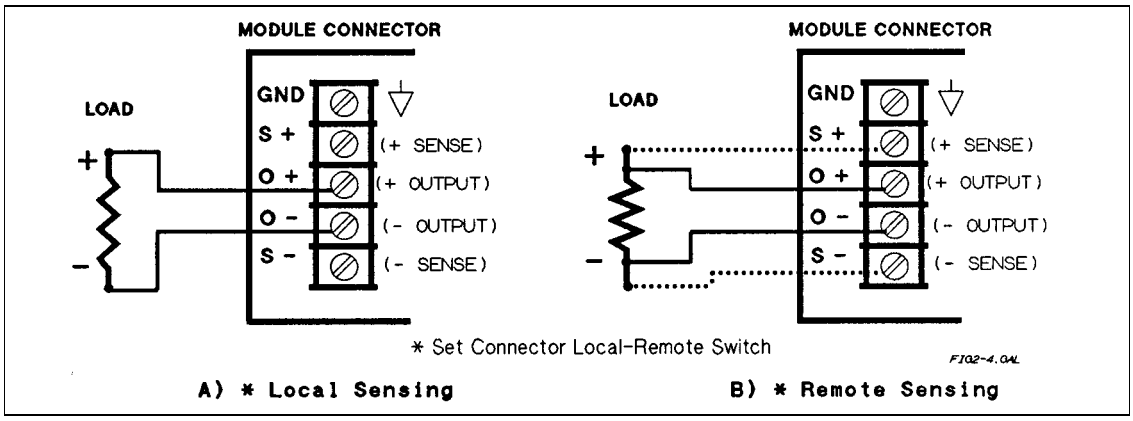


Figure 2-4. Load Connection

The dashed lines in the connection drawings illustrate remote sense connections. In this case, the remote sense terminals of the power module are connected to the load rather than the output terminals. This allows the power module to automatically compensate for the voltage drop in the load leads as well as to accurately read back the voltage at the load. In remote-sense applications, the voltage readback from across the load is not the output voltage of the power module. The actual output voltage is the sum of the load voltage and the voltage drop in the load lead. Keep this output voltage within the power module's maximum voltage rating. Failure to do this may result in an unregulated condition, especially when the line voltage is low.

Voltage Readback

In remote sense applications, the voltage readback occurs directly at the load. This allows the power module to automatically compensate for the voltage drop in the load leads and to provide an accurate voltage readback directly across the load.

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Output Rating

The rated output voltage and current specified in Table 1-1 applies at the output terminals of the power module. With remote sensing, the power module must increase its output to compensate for voltage dropped in the load leads. If you attempt to provide full rated output voltage at the sense terminals (load), the power module's output voltage may exceed its maximum rating. This may trip the OV protection circuit, which senses the voltage at the output terminals, or cause an unregulated output condition, particularly when the ac line voltage is low.

Output Noise

Noise picked up by the sense leads may appear at the output of the power module and can adversely affect the load regulation. To minimize noise pickup, twist the sense leads and route them parallel and close to the load leads. It may be necessary to use shielded sense leads in noisy environments. If you do, ground the shield only at the output connector ground screw. *Do not use the shield as one of the sense leads.*

Parallel Operation

Power modules may be connected in parallel to obtain increased output current. The power modules must be individually programmed; they **do not** function in the autoparallel mode that is commonly used by many Agilent power supplies.

Figure 2-5 shows two power modules connected in parallel. You must keep the same impedance to the load by using leads of equal length and wire size from each module to the load. Select one module (usually the one with the lesser current capacity) to operate in the "CV Mode". The other module then must operate in the "CC Mode" module. If you are using remote sensing, connect the sense leads to the module operating in the CV mode.

Since you must program one module to operate in CV mode and the other to operate in CC mode, refer to the output characteristic curve shown at the end of Chapter 1 to see what this means. Curve ① shows a module operating in CV mode; its output voltage remains constant over the range of its operating current. Curve ② shows a module operating in CC mode; its output current remains constant over the range of its operating voltage.

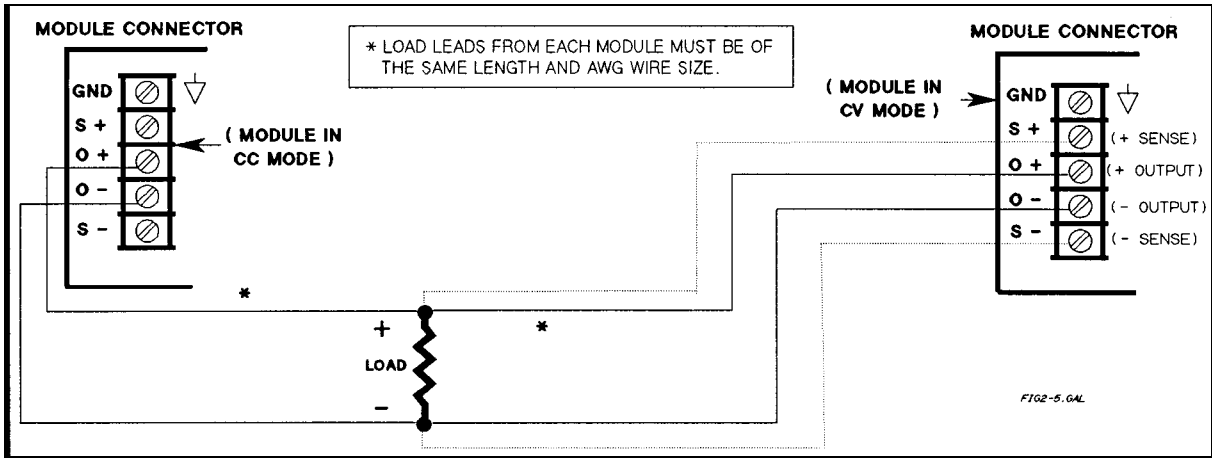


Figure 2-5. Connecting Power Modules in Parallel

For proper parallel operation, observe the following rules:

1. Program both module outputs **OFF**.
2. Program the CV mode module for the desired output voltage.
3. Program the CV mode module's OVP voltage to the desired value; always higher than the output voltage.
4. Program the output and OVP voltages of the CC module slightly higher (about 1 volt) than those of the CV module. This is to ensure that the CC module stays in CC mode.

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5. In order to maintain proper regulation, the load must always draw at least as much current as is programmed for the module that is in CC mode. You can maintain regulation over a range of current only as long as this condition remains true.
6. As near as is permitted by condition 5, program the current levels of both modules for a balanced distribution of the total output current. Do not program the CV module near its maximum output current level.
7. Program the outputs of both modules **ON.**
8. When the system is operating, observe that the **CV** annunciator of the CV module stays on and the **CC** annunciator on the CC module stays on. If not, repeat steps 1 through 7.
9. Once the modules are properly set up, **do all subsequent voltage programming from the CV module;** the CC module will track that module.

CAUTION Remember that although the CV module is controlling the output voltage, the CC module is programmed to a slightly higher voltage. Do not allow the CC module to go into CV mode. **Do not program the CV module to 0 volts without first disabling the outputs of both power modules.** Otherwise, the CV module could sink up to 10% of its rated output current from the CC module.

As an example, assume that an Agilent 66102A (20 V @ 7.5 A) and an Agilent 66103A (35 V @ 4.5 A) are connected in parallel to supply a load of 10 amperes at 18 volts. The Agilent 66102A is selected as CC mode module and will supply approximately 7.6 A, maximum. The Agilent 66103A will be the CV module and will supply the remaining current (2.4 A). When the two modules are operated in parallel, you may expect the system to regulate at 18 Volts and 10 amperes as long as the load current remains above 7.6 amperes (see rule 5, above).

The following program shows how to program the two power modules. Generic code (SCPI commands) are shown; they may be sent either from the keyboard or from a GPIB controller.

```
OUTP OFF                Send to both modules

VOLT:LEV 18             Program the CV mode module
VOLT:PROT 18.5
CURR:LEV 2.4

VOLT:LEV 19             Program the CC mode module
VOLT:PROT 19.5
CURR:LEV MAX

OUTP ON                 Restore the outputs of both modules
```

Series Operation

CAUTION To prevent damage to the equipment, floating voltages must not exceed 240 Vdc. No output terminal may be more than 240 V from chassis ground.

Figure 2-6 shows how the outputs of two power modules may be connected in series to increase the output voltage. **Connect only power modules that have the same maximum output current ratings**. It is recommended that you set up both modules to operate in CV mode with their current outputs equal to the full load current. If the external load is a storage device, such as a battery or large capacitance, be careful how you shut down the system. For example, turning off just one module could damage the remaining module by subjecting it to double its maximum output voltage from the storage device.

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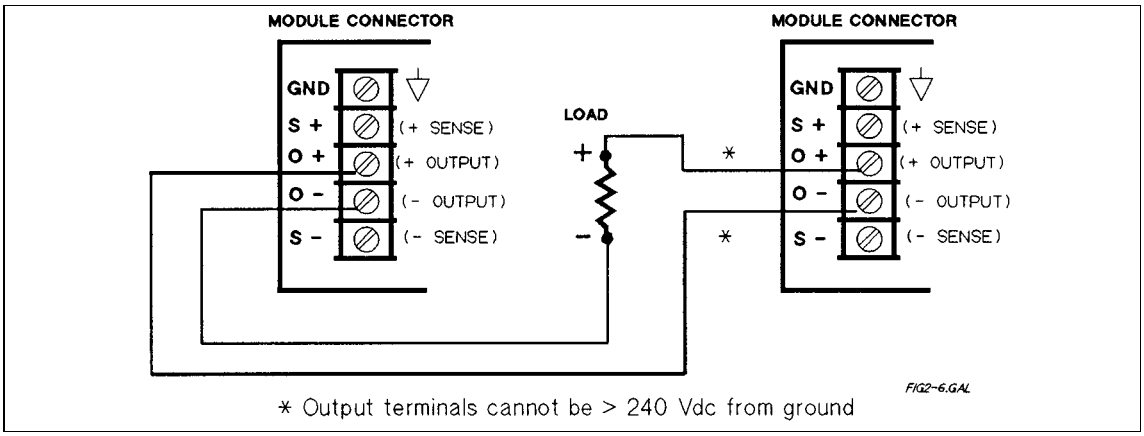


Figure 2-6. Connecting Power Modules in Series

CAUTION	Each power module has a reverse voltage protection diode across its output. If a reverse voltage is applied, the power module has no control over the current through this diode. To avoid damaging the power module, never connect it to a reverse voltage that can force it to conduct current in excess of the power module's maximum reverse current (see Table 1-2).

Multiple Loads

When connecting multiple loads to the power module with local sensing, use a separate pair of wires for each load (see Figure 2-7). Each pair of wires should be as short as possible and twisted or bundled to reduce lead inductance and noise pickup. If cabling or terminal considerations require the use of distribution terminals located outside the output connector, then remote voltage sensing is recommended. Connect the sense leads either at the distribution terminals or directly at one of the loads if it is more critical than the others.

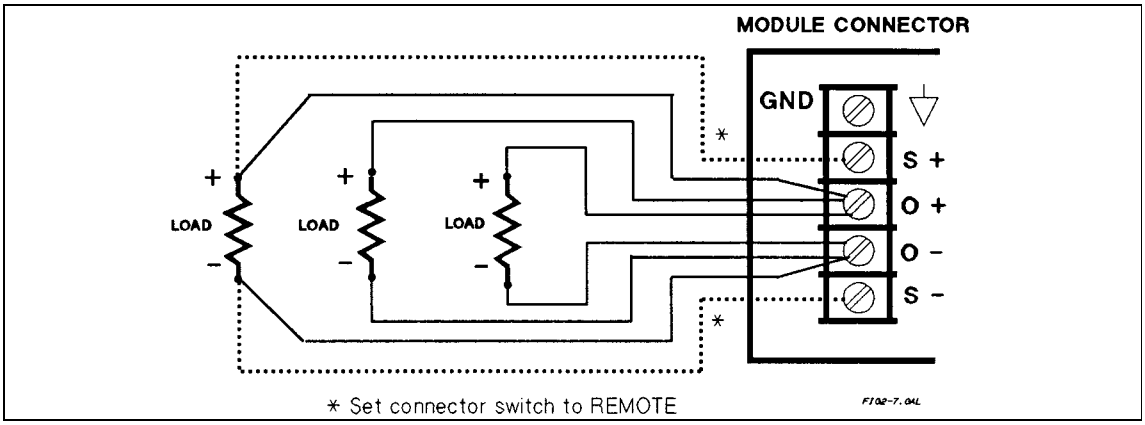


Figure 2-7. Connecting Multiple Loads

Optional Relay Connector

If you are using the Option 760 output connector with isolation or polarity reversal relays, the output and sense lead terminal connections are the same as those of the standard output connector. When the output connector **Remote/Local** switch is in **Remote**, both the output leads and the sense leads are under relay control. An existing standard connector can be converted into a relay connector. The Installation Guide provided with the connector (see "Related Documents" in Chapter 1) includes instructions for doing this.

Capacitive Loads

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The power module is designed to be stable for load capacitances up to the following values:

Agilent 66101A	50,000 µF	Agilent 66104A	4,500 µF
Agilent 66102A	20,000 µF	Agilent 66105A	2,750 µF
Agilent 66103A	10,000 µF	Agilent 66106A	1,650 µF

Inductive Loads

You may safely connect the power module output to inductive loads up to 100 mH. (Higher inductances are possible with a modified module. Consult the factory for details.)

OVP Considerations

The OVP circuit senses the voltage at the output terminals, not at the sense terminals. Therefore the voltage sensed by the OVP circuit can be significantly higher than the voltage being regulated at the load. You must program the OVP trip voltage high enough to compensate for the expected drop from the power module output to the load.

Battery Charging

The power module OVP trip circuit has a downprogrammer that discharges the output whenever OVP trips. If the output is connected to a battery and the OVP is tripped (or the power module voltage is programmed below the battery voltage), the power module will sink current from the battery. The down programmer limits the value of this current to no more than 10% of the power module's maximum rated output current.

Connecting The Controller

The Agilent 66000A Mainframe has a GPIB port for connection to the controller. Each power module has a GPIB primary address determined by a switch on the mainframe, and a GPIB subaddress determined by the mainframe slot in which the module is installed. If the mainframe GPIB address is set to 705, this becomes the power module's primary address.

The Agilent 66000A Mainframe mode switch determines the IEEE 488 secondary addresses (also referred to as subaddresses) of the modules that are installed in the mainframe. With the mainframe mode switch set to **MAIN**, modules are assigned secondary addresses of 00 to 07, which correspond to the slot locations indicated on the mainframe. The mainframe mode switch must be set to **MAIN** when the mainframe is connected directly to the GPIB. For example, if a module is installed in slot 3 of a mainframe that is set to GPIB address 705, the complete address of the module is 70503.

The mainframe mode switch must be set to **AUX** (auxiliary) when the mainframe is serially-linked to another mainframe that is directly connected to the GPIB. In mainframes that have the mode switch set to **AUX**, modules are assigned secondary addresses of 08 to 15. Secondary address 08 corresponds to slot location 0 on the mainframe and secondary address 15 corresponds to slot location 7 on the mainframe. For example, if a module is installed in slot 3 of a mainframe that is serially linked to another mainframe at GPIB address 705, the complete address of the module is 70511.

Module Slot Locations/Addresses

	Mainframe Mode Switch = MAIN								Mainframe Mode Switch = AUX							
Slot Location	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Secondary Address	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15

For details concerning GPIB cabling and addressing, see "Chapter 2 - Installation" in the Agilent 66000A Mainframe *Users Guide*.

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3

Turn-On Checkout

Introduction

This chapter provides a quick test of the power module functions. See "Chapter 4 - Basic Power Module Commands" for more details of power module operation.

Note

These procedures assume you have checked and, if required, correctly set the following switches for each module:

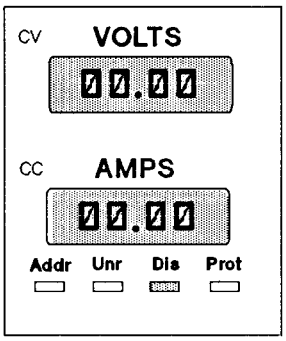
- the line voltage switch (see Figure 2-1)
- the configuration switch (see Table 2-2)
- the output connector **Local/Remote** switch

The procedures for doing this are given in Chapter 2.

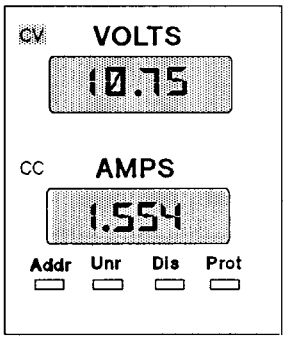
Module Panel Display

The power module display provides the information shown in Table 3-1. There are no operating controls on the power module.

Table 3-1. Power Module Front Panel Display



A) NORMAL TURN-ON RESPONSE



B) CONSTANT VOLTAGE OPERATION

INDICATOR	FUNCTION
VOLTS	Digital readout of output voltage
AMPS	Digital readout of output current
CV	Lights when power module is in constant voltage mode
CC	Lights when power module is in constant current mode
Addr	Lights when power module is addressed over GPIB
Unr	Lights when power module output is unregulated
Dis	Lights when power module output is disabled
Prot	Lights when power module protection circuit is activated (overvoltage, overcurrent, overtemperature, or remote inhibit)

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Power Module Turn-On State

When you turn on the mainframe, the power module goes through a self-test. All front panel readout digits and annunciators turn on briefly. The panel then remains in the state shown in Table 3-1A.

Note The figure assumes the power module still retains its factory default turn-on state. You can change this state if desired (see "Chapter 4 - Basic Power Module Commands").

Checking Basic Module Functions

The power module is designed for remote programming over the GPIB. It also can be locally programmed from the optional Agilent 66001A MPS Keyboard. Table 3-2 gives the SCPI commands for the remotely programmed tests. You can send these same commands from the keyboard (see "Appendix B").

Table 3-2. Testing Basic Functions with SCPI Commands

Command	Action	Display Response						
		VOLTS	AMPS	CV	CC	Addr*	Dis	Prot
Output Voltage (Disconnect Load)								
VOLT 5.1	Set output voltage to 5.1 V	0.00	0.00	Off	Off	On	On	Off
OUTP ON	Enable the output	5. 10	0.00	On	Off	On	Off	Off
Overvoltage Protection								
VOLT:PROT 4.9	Activate OVP circuit (by setting protection voltage below output voltage)	0.00	0.00	Off	Off	On	Off	On
VOLT:PROT MAX	Clear OVP circuit	5. 10	0.00	Off	Off	On	Off	Off
OUTP:PROT:CLE	Clear OVP circuit	5. 10	0.00	On	Off	On	Off	Off
Save and Recall Functions								
*SAV 5	Save present state to location 5	5.10	0.00	On	Off	On	Off	Off
VOLT 3.55	Set output voltage to 3.55 V	3.55	0.00	On	Off	On	Off	Off
OUTP OFF	Turn off the output	0.00	0.00	Off	Off	On	On	Off
*SAV 6	Save present state to location 6	0.00	0.00	Off	Off	On	On	Off
*RCL 5	Restore state 5	5.10	0.00	On	Off	On	Off	Off
*RCL 6	Restore state 6	0.00	0.00	Off	Off	On	On	Off
Output Current (With output disabled, short the output terminals with a wire size sufficient to carry the maximum current of the module.)								
CURR 3.1	Set output current to 3.1 amps	0.00	0.00	Off	Off	On	On	Off
OUTP ON	Enable the output	0.00	3.10	Off	On	On	Off	Off
Overcurrent Protection								
CURR:PROT:STAT ON	Activate OCP circuit (by enabling OCP when the output is shorted)	0.00	0.00	Off	Off	On	Off	On
CURR:PROT:STAT OFF	Clear OCP circuit	0.00	0.00	Off	On	On	On	Off
OUTP:PROT:CLE	Clear OCP circuit	0.00	3.10	Off	On	On	Off	Off

*Addr will not light if the module is controlled from the keyboard.

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In Case Of Trouble

Mainframe Failure

You can assume there is a problem with the mainframe if there is more than one module in the mainframe and none of the module fans are on. The trouble also is probably in the mainframe if the module fans are on and the their displays are enabled (see "Configuration Switch" in "Chapter 2 - Installation") but their **VOLTS** and **AMPS** displays do not light. If a module does not appear to be operating but its **VOLTS** and **AMPS** display light, move the module to another address slot. If the above condition still occurs, then the problem probably is in the module.

Module Line Fuse

If a power module's fan is on but its front panel does not light, the module line fuse may be blown. Proceed as follows:

1. Remove the power module from the mainframe.

Note You can remove and insert the power module without turning off the mainframe power provided the module output is either disabled or is programmed to zero and there is no GPIB bus, trigger bus, or RI/DFI activity. If you are in doubt, turn off the mainframe power.

2. Check the line fuse (see Figure 2-1). If it is defective, replace it with one of the same type and rating (for the Agilent part number, see Table 1-3).

CAUTION Do not use a slow-blow fuse as a replacement.

3. Replace the power module in the mainframe.

Module Output Connector

If the module panel indicates a normal voltage but there is no output at the load, the problem may be in the output connector. This is even more probable if the connector has relays. The following tests may isolate the problem:

- If another module is working normally, use its mainframe slot for the suspected module (be careful to guard against any difference in module output voltage). If there is still no output, the problem is in the module. If the module has an output in the new slot, the problem is with its original output connector.
- To check a suspected connector with a good module, proceed as follows (see *DC Module Connectors Installation Guide* for details of the connector and its jumpers):
  1. Disable the power module output (**Dis** annunciator on).
  2. Remove the output connector from mainframe.
  3. Examine the connector plug for bent pins.
  4. Remove the cover from the output connector.
  5. If there is no relay board, go to step 6. Otherwise, proceed as follows:
     a. Remove the relay board by pulling it straight up.
     b. Examine relay board connector for bent pins.
     c. Examine the connector board to ensure that the required jumpers have been cut to enable relay operation.
  6. Examine the jumpers on the connector board. If any jumpers have been cut, they must be replaced.

Error Messages

A power module may fail either during selftest or while operating (runtime). In either case, the module display may show an error message indicating the reason for the failure.

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Selftest Error Messages

Table 3-3 lists the displayed selftest error messages. All these errors are hardware failures that require service.

Note If you are using the optional Agilent 66001A MPS Keyboard, it will also display selftest error messages.

Table 3-3. Selftest Error Messages

Display	Failed Test
U 1	Internal RAM
U 2	External RAM
U 3	ROM checksum
U 4	(Not used)
U 5	(Not used)
U 6	12 V supply
U 7	5 V supply

Display	Failed Test
U 8	Ambient temperature reading
U 9	(Not used)
U 10	Voltage programming, low range
U 11	Current programming, low range
U 12	Voltage programming, high range
U 13	Current programming, high range

The power module also can detect an EEPROM checksum error. This error is not identified by number, but causes the following symptoms:

- The power module starts up with both the VOLTS and AMPS full-scale programming and metering ranges accepting values up to 1000.
- Self-test error code 330 is stored in the SCPI error queue where it can be read by software (see "Chapter 5 - Error Messages" in the Programming Guide).
- The software identify query (*IDN?) returns 0A in the model field.
- The calibration password is set to 0.

An EEPROM checksum error can occur due to the following operating conditions:

- Excessive number of write cycles to an EEPROM (see Table 1-2). This condition is not recoverable and requires service.
- Loss of ac input power during a checksum calculation. This condition, which is very unlikely, is recoverable. You may be able to recover by performing the following steps from the controller or keyboard:
  1. Enable the calibration mode (CAL:STAT ON,0)
  2. Save an operating state to EEPROM. (e.g., *SAV 2)
- This forces the power module to write to EEPROM and establishes a new checksum.

Runtime Error Messages

Table 3-4 lists the runtime error messages. Runtime errors cease normal power module operation, disable the output, and display a code on the front panel. The error code is preceeded by "U" and is displayed on both the **VOLTS** and **AMPS** displays. Runtime errors are hardware malfunctions that require service.

Table 3-4. Runtime Error Messages

Display	Meaning
U 101	EEPROM write error

Display	Meaning
U 102	Internal software error

Display	Meaning
U 103	Unexpected interrupt

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4

Basic Power Module Commands

Introduction

"Chapter 3 - Language Dictionary" of the *Programming Guide* describes all the power module commands. This chapter introduces you to the commands that control the following basic functions:

- output state
- protection circuits
- fixed-mode output
- list-mode output
- triggers
- the RFI function
- the DFI function

The power module can be programmed from a controller over the GPIB or from an optional Agilent 66001A MPS Keyboard plugged into the mainframe. In order to apply the information in this chapter, you must have a working knowledge of either method. Information concerning programming is presented as follows:

Method of Control	**Consult**
GPIB Controller	*Programming Guide for Agilent Series 66lxxA MPS Power Modules*
MPS Keyboard	Appendix B of this guide

GPIB Controller

The power module is programmed by SCPI (Standard Commands for Programmable Instruments) commands sent as strings within your language statements. "Chapter 2 Introduction to Programming" of the *Programming Guide* explains how to do this. The syntax of each command in given in Chapter 3 of that guide.

MPS Keyboard

If you have installed the optional MPS keyboard, you can execute the commands given here. You do not have to understand the details of SCPI programming, because the keyboard menu allows you to step through all commands. If you have a keyboard, it is highly recommended that you use it until you are familiar with the general concepts of power module operation.

Note The keyboard menu omits optional SCPI headers. That is why some commands displayed on the keyboard will not look exactly like the syntax given in Chapter 3 of the *Programming Guide*.

Synopsis Of Commands

The following tables summarize the SCPI commands by function. The short form without optional headers is used in this chapter. For example, the full command for turning on the output as given in the *Programming Guide* is **OUTPut [: STATe]** ON. Here the optional **[STATe]** (in brackets) is omitted and only the short form (in capital letters) OUTP ON is used.

The query form of a command **(OUTP?)** is omitted unless the command is only of the query form (such as **MEAS:VOLT?).**

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Controlling the Output State

The following commands control the power module output state:

Table 4-1. Power Module Output Commands

Command	Function
OUTP *ON*	Enables the output.
OUTP *OFF*	Disables the output. (If an optional output relay is installed, the command is executed in a sequence that prevents "hot switching".)
OUTP*1,NOR*	Enables the output without affecting the output relay.
OUTP *0,NOR*	Disables the output without affecting the output relay.
OUTP: REL *1*	Closes the (optional) output relay contacts.
OUTP:REL *0*	Opens the (optional) output relay contacts.
OUTP:REL:POL *NORM*	Makes the (optional) output relay polarity the same as the module output.
OUTP:REL:POL *REV*	Makes the (optional) output relay polarity opposite to the module output. The output is disabled while the relay polarity is being reversed.)

Controlling Protection Functions

The following commands control the power module protection circuits.

Table 4-2. Power Module Protection Commands

Command	Function
CURR:PROT:STAT *ON*	Turns on the OCP (overcurrent protection), which disables the output if the output current exceeds the programmed current.
CURR: PROT: STAT *OFF*	Turns off the current protection.
VOLT:PROT <value>	Programs the OVP (overvoltage protection) level. The protection circuit will trip if the output voltage exceeds the OVP level.
OUTP:PROT:CLE	Clears any active protection conditions (panel **Prot** annunciator goes off). Before the command can comply, you must remove the condition that caused the protection circuit to trip.
OUTP:PROT:DEL *.05*	Specifies a delay (in seconds) between the time a protection condition is detected and the actual activation of the protection circuit. (Does not apply to OVP.)

Controlling Fixed-Mode Output

The following commands control the power module fixed-mode voltage and current output.

Table 4-3. Power Module Fixed-Mode Output Commands

Command	Function
CURR:MODE *FIX*	Sets the current mode to fixed (as opposed to list). *FIX* is the factory default power on state.
CURR <value>	Programs the immediate output current level (in amperes).
CURR:TRIG <value>	Programs the triggered output current level (in amperes). See "Trigger Commands".
MEAS:CURR?	Returns the present value of the output current.
VOLT:MODE *FIX*	Sets the voltage mode to fixed (as opposed to list). *FIX* is the factory default power on state.
VOLT <value>	Programs the immediate output voltage level (in amperes).
VOLT: TRIG <value>	Programs the triggered output voltage level (in amperes). See "Trigger Commands".
MEAS:VOLT?	Returns the present value of the output voltage.
VOLT:SENS?	Returns the position of the output connector sense switch *(INT* is local; *EXT is* remote).

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Controlling List-Mode Output

The following commands control the power module list-mode voltage and current output. Lists require a trigger to begin execution. For an explanation of lists and triggers, see "Chapter 5 - Synchronizing Power Module Output Changes": in the *Programming Guide*.

Table 4-4. Power Module List-Mode Output Commands

Command	Function
CURR:MODE *LIST* LIST:CURR <value>,<value> LIST:CURR:POIN?	Sets the current mode to list (as opposed to fixed). Programs the output current values (or points) in the list. When you execute the list, the output will sequentially step through the list values. Returns the number of points programmed in the current list.
VOLT:MODE *LIST* LIST:VOLT <value>,<value> LIST:VOLT:POIN?	Sets the voltage mode to list (as opposed to fixed). Programs the output voltage values (or points) in the list. When you execute the list, the output will sequentially step through the list values. Returns the number of points programmed in the voltage list.
LIST:DWEL <value>,<value> LIST:DWEL:POIN?	Programs the dwell value, in seconds, for each value in a voltage or current list. There must be one dwell value for each value in the voltage or current list. Returns the number of points programmed in the dwell list.
LIST: STEP *ONCE* LIST: STEP AUTO	Commands the list to execute only one value (point) when a trigger is received. This specifies a trigger-paced list. Commands the list to execute all values (points) when a trigger is received. This specifies a dwell-paced list.

Controlling Triggers

The following commands control the power module trigger subsystem. For a detailed description of this subsystem, see "Chapter 5 - Synchronizing Power Module Output Changes": in the *Programming Guide.*

Table 4-5. Power Module Trigger Commands

Command	Function
INIT INIT:CONT	Initiates the trigger subsystem to detect one trigger. No triggers will be processed unless the subsystem is initiated. Keeps the trigger subsystem continuously initiated so it will process each incoming trigger.
TRIG:SOUR *BUS|EXT|HOLD|LINK| TTLT* TRIG:DEL <value> TRIG *TRG TRIG:LINK <parameter>	Specifies which trigger source is to be accepted by the trigger subsystem (see the *Programming Guide*). *HOLD* prevents response to all triggers. Programs the delay time (in seconds) between the detection of a trigger and its execution. Either command sends a trigger signal to the power module over the GPIB bus. When TRIG:SOUR *LINK* is programmed, this command specifies the link parameter for the trigger (see *Programming Guide*).
OUTP: TILT *ON* OUTP: TTLT *OFF* OUTP:TTLT:SOUR *BUS|EXT|HOLD|LINK* OUTP:TTLT:LINK	Enables the power module Trigger Out signal, which is a 20-µs negative-true TTL pulse available at the mainframe TRIGGER OUT jack. To use this output, you must program a TTLT trigger source (OUTP:TTLT:SOUR). Disables the power module Trigger Out signal. Specifies which trigger source is to be used for the Trigger Out signal. *HOLD* prevents a response to any source. When OUTP: SOUR *LINK* is programmed, this command specifies the link parameter for the trigger (see *Programming Guide).*

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Using the RI/DFI Functions

RI (Remote Inhibit) Input

The signal applied to the mainframe digital connector INH input (see "Chapter 3 Connections" of the mainframe *Installation Guide)* is the RI (remote inhibit). The module function switch described in "Chapter 2 - Installation" allows you to enable or disable the RI input and, when enabled, to specify RI as either latching or nonlatching. If the module function switch is set to enable RI, then the input signal will disable the power module output. If the function switch is also set to RI nonlatching, then removing the signal from the INH input restores the power module output. If the function switch is set to RI latching, an RI status bit is latched and the power module remains disabled after the input signal is removed. The RI status bit is removed either by reading the Status Questionable Event register (**STAT: QUES?)** or by clearing it (***CLS**). See the *Programming Guide* for specifics.

The detected RI bit can be used to generate a DFI signal that appears at the mainframe FLT output. This signal, in turn, can be wired to the RI inputs of other power modules to also disable their outputs (see the wiring diagram in Chapter 3 of the mainframe *Installation Guide).*

DFI (Discrete Fault Indicator) Output

When the DFI function is enabled (OUTP:DFI ON), you can program the Status Subsystem to cause any status condition (including RI) to generate a DFI output, which appears as a TTL low-true signal at the mainframe digital connector FLT output. See "Chapter 4 - Status Reporting" in the *Programming Guide* for details of programming the Status Subsystem.

Table 4-6. DFI Output Commands

Command	Function
OUTP:DFI *ON*	Enables the DFI function.
OUTP:DFI *OFF*	Disables the DFI function.
OUTP: DFI: SOUR *LINK*	Specifies the source for DFI events. The only source is *LINK.*
OUTP: DFI: LINK <parameter>	Specifies what power module status events are linked to the DFI function. Table 3-1 in the Programming Guide identifies all the DFI link parameters.

Only one parameter may be specified for OUTP: DFI: LINK, such as OUTP: DFI: LINK CC. However, you can specify entire status groups by specifying a summary bit. For example, OUTP: DFI: LINK QUES specifies the Questionable Status summary bit, which is the logical OR of OV, OC, OT, RI, and UNR. The default link parameter SUM3 is the logical OR of the QUES, OPER, and ESB summary bits. This gives DFI access to all three status register groups (see "Chapter 4 - Status Reporting" in the *Programming Guide* for more information).

Changing The Power On State

Switch 6 of the module function switches (see "Chapter 2 - Installation") determines the state of the power module when you turn it on. With the switch in the factory-default position (1), the module turns on in the reset (***RST**) state. You will find the parameters for this state listed under the ***RST** command in "Chapter 3 - Language Dictionary" of the *Programming Guide.* If you store your own parameters in location 0 (***SAV 0**), and set the switch to *0*, then the module will assume that state when you turn it on.

Note The ***RST** state is a safe turn-on state that should not be replaced without careful consideration.

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A

Calibration

Introduction

The power module may be calibrated either over the GPIB from a controller or from an Agilent 66001A Modular Power System keyboard. Instructions are included for either method. The procedures given here apply to all Series 66l0xA Power Modules.

Note The Agilent 66000A mainframe does not require calibration.

Enabling Or Disabling The Calibration Function

There are two ways of controlling access to the calibration function. One is by hardware and the other is with software.

Hardware Control

The CAL positions of the power module function switch (see Table 2-1 in "Chapter 2 Installation") allows hardware control over the calibration function. The factory-default setting is for normal calibration. Setting the switches to the Inhibit calibration position prevents any calibration from being performed.

Software Control

The password parameter of the CAL: STAT command allows software control over the calibration function. The standard factory password is the module model number (for example, *66102* for the Agilent 66102A). By changing the password, you can either restrict or allow unlimited access to the calibration function (see "Changing the Calibration Password").

Changing The Calibration Password

You can change the password only when the module is in the calibration mode (which requires you to know the present password). To change the password from *66101* to *81591,* send the following commands:

```
CAL:STAT ON, 66102
CAL:PASS 81591
```

If you change the password to *0*, then all password protection is removed. The Calibration Subsystem then will accept the CAL: STAT ON command without a password.

Performing a Calibration

Perform the procedures in the order given. The assumed password is *66102;* use your actual password in the procedures.

Important These instructions do not include verification procedures. If you need to perform verification as part of your calibration procedure, refer to the Series Agilent 66I0xA Service Manual.

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Equipment Required

The equipment listed in Table A-1, or equivalent, is required for calibration.

Table A-1. Equipment Required for Calibration

Equipment	Characteristics	Recommended Model
Voltmeter	D-c accuracy 0.005%, 6 digits; resolution 1 μV	Agilent 3458A
Shunt Agilent 66101A, 66102A	0.01Ω, 100 A, 100 W, 0.04% @ 100 W, 0.01% @ 1W, power coeff. 0.0004%/watt in air	Guildline 9230/100
Agilent 66103A, 66104A, 66105A, 66106A	0.1 Ω, 15 A, 25 W, 0.04% @ 25 W, 0.01% @ 1W, power coeff. 0.002%/watt in air	Guildline 9230/15
GPIB Controller or Keyboard	HP Vectra (or IBM compatible) with GPIB Interface or Agilent BASIC series	Agilent 66001A MPS

Calibrating Voltage

WARNING Calibration may cause dangerous voltages to be present at the power module output.

The following procedure calibrates the output voltage and the overvoltage protection (OVP). During voltage calibration, you will enter two readings from the external DVM. You must calibrate the voltage before calibrating the OVP. You do not have to enter any external readings when calibrating the OVP.

Table A-2. Voltage Calibration Procedure

Keyboard Entry	Controller Entry †	Function
Connect the equipment as shown in Figure A-lA		
Output Voltage Calibration		
[*] [R] [↓] [Enter]	*RST	Reset the power module
(Before proceeding, set the module output, via the keyboard or the GPIB, for 1.0 V at 0.5 A)		
[O] [1] [Enter]	OUTP ON	Enable the output
[C] [S] [↓] [1] [66102] [Enter]	CAL:STAT 1,66102	Using your password, enable the calibration mode
[C] [V] [L] [M] [↓] [Enter]	CAL:VOLT:LEV MIN	Select the lower calibration point
[C] [V] [‡] [‡] [‡] [‡] [Enter]	CAL: VOLT: DATA <NRf>	Enter the digital voltmeter reading
[C] [V] [L] [M] [Enter]	CAL:VOLT:LEV MAX	Select the upper calibration point
[C] [V] [‡] [‡] [‡] [‡] [Enter]	CAL:VOLT:DATA <NRf>	Enter the digital voltmeter reading
Note: The following step overwrites the existing voltage calibration constants stored in nonvolatile memory.		
[C] [S] [Enter]	CAL:SAV	Save the new calibration constants
Overvoltage Protection Calibration		
If the optional output relay is installed, either disconnect it or set it to the *OFF* (open) state.		
[C] [V] [P] [Enter]	CAL:VOLT:PROT	Perform OVP calibration
Note: It takes a few seconds for the power module to make the measurement. When completed, the new constant is automatically stored in nonvolatile memory.		
† See Figure A-2 for program listing.		
‡ Enter the voltage measured by the external digital multimeter.		

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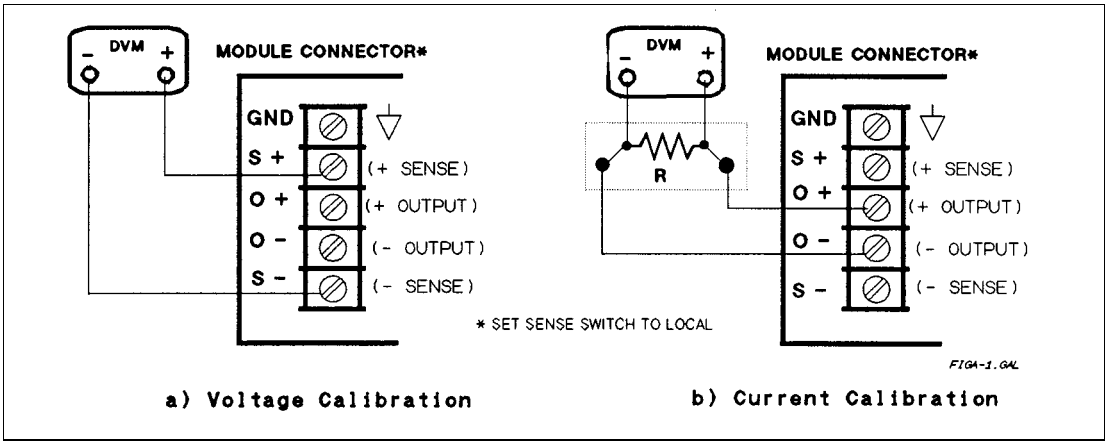


Figure A-1. Calibration Test Setup

Calibrating Current

The following procedure calibrates the output current. During the calibration, you will make two voltage measurements across the output shunt and enter the computed current.

Table A-3. Current Calibration Procedure

Keyboard Entry	Controller Entry †	Function
O 0 Enter	OUTP OFF	Disable the output
Connect the equipment as shown in Figure A-lB. (Before proceeding, set the module output, via the keyboard or the GPIB, for 1.0 V at 0.5 A.)		
O 1 Enter	OUTP ON	Enable the output
C S ↓ 1 66102 Enter	CAL:STAT 1,66102	Using your password, enable the calibration mode
C C L M ↓ Enter	CAL:CURR:LEV MIN	Select the lower calibration point
Wait for the meter reading to stabilize. Then read the meter and enter the calculated current value.‡		
C C ↕ ↕ ↕ ↕ Enter	CAL: CURR:DATA <NRf>	Enter lower current value
C C L M Enter	CAL:CURR:LEV MAX	Select the upper calibration point
Wait for the meter reading to stabilize. Then read the meter and enter the calculated current value.‡		
C C ↕ ↕ ↕ ↕ Enter	CAL: CURR: DATA < NRf>	Enter the upper current value
Note: The following step overwrites the existing current calibration constants stored in nonvolatile memory.		
C S Enter	CAL:SAV	Save the new calibration constants

† See Figure A-2 for program listing.

‡ Calculate the current value as follows:

$$I = \frac{V_R}{R}$$

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Using The CAL:AUTO Command

Normal calibration procedures also calibrate the readback circuits that respond to the MEAS: CURR? and MEAS: VOLT? commands. During normal operation, the readback accuracy is affected by temperature changes within the power module. Use of the CAL:AUTO command reduces the temperature error component of the readback accuracy specification. See "Chapter 3 - Language Dictionary" of the *Programming Guide* for information about this command.

Recovering The Factory Calibration Constants

The original factory calibration constants are stored in EPROM and can be recovered. This may prove helpful in situations where miscalibration is suspected and it is not possible to recalibrate. To restore factory calibration, proceed as follows:

1. Remove the power module from the mainframe and set the calibration switches to the factory position (see Table 2-1 in "Chapter 2 - Installation").
2. Replace the power module and cycle the power (on and then off).
3. Remove the power module from the mainframe and restore the calibration switches to the normal position.
4. Replace the module in the mainframe.

The module now has its original factory calibration constants. However, *password protection has been removed* from the CAL:STAT ON command.

Recovering From A Lost Calibration Password

The standard factory password is the module model number (for example, 66102). If no one has changed the password, entering the model number will enable the calibration mode (for example, CAL:STAT ON,66102).

If the password is unknown, then the only alternative is to perform the procedure given under "Recovering the Factory Calibration Constants". This removes the password protection from the CAL: STAT ON command. However, it also *changes the calibration constants to their original factory values.*

Calibration Error Messages

If you enter calibration commands from the keyboard, it will display the error messages listed in Table A-4.

Table A-4. Keyboard Calibration Error Messages

CAL ERROR	An entered value is not within acceptable range
DOES NOT CAL	Computed calibration constant is out of range
PASSWD ERROR	You entered an incorrect password
WRONG MODE	The power module is not in CV or CC mode, as required

Agilent Basic Calibration Program

The following program can be run on any controller operating under Agilent BASIC. The assumed slot address is *0* and calibration password is *66101*. If required, change these parameters in the appropriate statements.

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```
10        ! VOLTAGE CALIBRATION PROGRAM
20        ! CONNECT INSTRUMENTS AS SHOWN IN FIGURE A-la
30        !
40        DIM Resp$[255],Err_msg$[255]
50  Volt_cal:       !
60      Err_found=0
70      INPUT "CONNECT INSTRUMENTS AS SHOWN IN FIGURE A-la ... Press any key to continue." ,Resp$
80      Resp$=""
90      ASSIGN @Ps TO 70500                                   ! ASSIGN POWER SUPPLY GPIB ADDRESS
100                                                           ! NOTE: DEFAULT MODULE SLOT IS 0
110                                                           !
120     OUTPUT @Ps;"*RST;OUTPUT ON"                           ! INITIALIZE POWER SUPPLY
130     OUTPUT @Ps;"VOLT MAX"
140     OUTPUT @Ps;"CURR MAX"
150     OUTPUT @Ps;"CAL:STATE ON, 66101"                      ! PASSWORD IS OPTIONAL - ONLY
160                                                           ! REQUIRED IF SET TO NON-ZERO
170                                                           ! NOTE: DEFAULT = MODEL NUMBER
180     OUTPUT @Ps;"CAL:VOLTAGE:LEVEL MIN"
190     INPUT "ENTER VOLTAGE MEASUREMENT FROM EXTERNAL VOLTMETER",Volt_read
200     OUTPUT @Ps;"CAL:VOLTAGE ";Volt_read
210     OUTPUT @Ps;"CAL:VOLTAGE:LEVEL MAX"
220     INPUT "ENTER VOLTAGE MEASUREMENT FROM EXTERNAL VOLTMETER",Volt_read
230     OUTPUT @Ps;"CAL:VOLTAGE ";Volt_read
240     OUTPUT @Ps;"CAL:VOLTAGE:PROT"                         ! CALIBRATE OVERVOLTAGE PROTECTION
250                                                           ! CIRCUITRY
260     GOSUB Save_cal
270     IF Err_found THEN
280       INPUT "ERRORS have occurred, REPEAT VOLTAGE CALIBRATION (Y OR N)?",Resp$
290       IF TRIM$(UPC$(Resp$[ l,l ]))="Y" THEN GOTO Volt_cal
300     END IF
310     IF Err_found THEN
320       PRINT "VOLTAGE CALIBRATION NOT SAVED"
330      ELSE
340       PRINT "VOLTAGE CALIBRATION COMPLETE"
350      END
360       !
370       ! CURRENT CALIBRATION PROGRAM
380       ! CONNECT INSTRUMENTS AS SHOWN IN FIGURE A-lb
390       !
400       Current_cal:       !
410       Err_found=0
420       INPUT "CONNECT INSTRUMENTS AS SHOWN IN FIGURE A-lb ... Press any key to continue.",Resp$
430       Resp$=""
440       OUTPUT @Ps;"CAL:STATE ON, 66101"                    ! PASSWORD IS OPTIONAL - ONLY
450                                                           ! REQUIRED IF SET TO NON-ZERO
460                                                           ! NOTE: DEFAULT = MODEL NUMBER
470                                                           !
          480       ! REFER TO TABLE A-1 FOR CORRECT SHUNT VALUE FOR MODEL BEING CALIBRATED
490       !
```

Figure A-2. Agilent BASIC Calibration Program

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```
      500         INPUT "ENTER VALUE OF CURRENT SHUNT BEING USED",Shunt_val
      510         OUTPUT @Ps;"CAL:CURRENT:LEVEL MIN"
      520         INPUT "ENTER VOLTAGE MEASUREMENT FROM EXTERNAL VOLTMETER",Volt_read
      530         Current=Volt_read/Shunt_val
      540         OUTPUT @Ps;"CAL:CURRENT ";Current
      550         OUTPUT @Ps;"CAL:CURRENT:LEVEL MAX"
      560         INPUT "ENTER VOLTAGE MEASUREMENT FROM EXTERNAL VOLTMETER",Volt_read
      570         Current=Volt_read/Shunt_val
      580         OUTPUT @Ps;"CAL:CURRENT ";Current
      590         GOSUB Save_cal
      600         IF Err_found THEN
      610                                                 INPUT "ERRORS have occurred, REPEAT CURRENT
      CALIBRATION (Y OR N)?",Resp$
      620                                                 IF TRIM$(UPC$(Resp$[ l,l ]))="Y" THEN GOTO
      Current_cal
      630         END IF
      640         IF Err_found THEN
      650                                                 PRINT "CURRENT CALIBRATION NOT SAVED"
      660         ELSE
      670                                                 PRINT "CURRENT CALIBRATION COMPLETE"
      680         END IF
      690         STOP
700 Save_cal:       ! SAVE CALIBRATION CONSTANTS
710                 REPEAT
720                 OUTPUT @Ps;"SYSTEM:ERROR?"
730                 ENTER @Ps;Err_num,Err_msg$
740                 IF Err_num<>0 THEN
750                     PRINT "ERROR: ";Err_msg$
760                     Err_found=l
770                 END IF
780                 UNTIL Err_num=0
790                 IF NOT Err_found THEN
800                     INPUT "SAVE CALIBRATION CONSTANTS (Y OR N)?",Resp$
810                     IF TRIM$(UPC$(Resp$[1,1]))="Y" THEN
820                         OUTPUT @Ps;"CAL:SAVE"
830                     END IF
840                 END IF
850                 OUTPUT @Ps;"CAL:STATE 0"
860                 RETURN
870     END
```

Figure A-2. Agilent BASIC Calibration Program (continued)

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B

Using The Agilent 66001A MPS Keyboard

Introduction

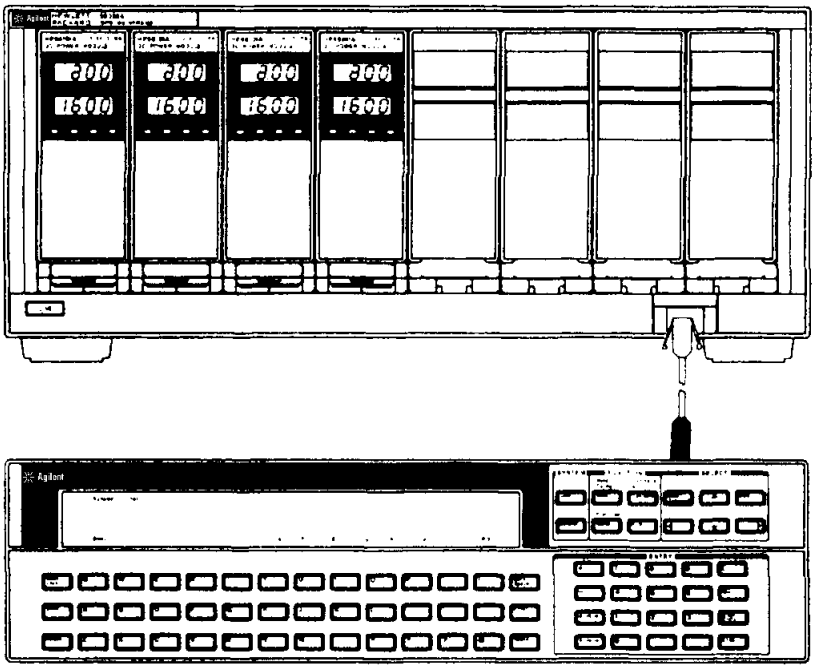
This appendix describes the Agilent 66001A Modular Power System (MPS) Keyboard, which is available as an option for the Agilent 66000A Modular Power System.

The Agilent 66001A MPS Keyboard lets you program the Agilent 66000A Modular Power System without having to connect it to a computer. With the keyboard, you can:

- Access any module in the mainframe that the keyboard is plugged into.
- Display operating and status information from the selected module.
- Control the module from the fields that appear on the display.
- Program the module using SCPI commands and queries.
- Read error messages.

Connecting The Keyboard

The keyboard plugs into a jack on the front of the mainframe as indicated in the following figure. A keyboard jack is also available on the rear panel. The keyboard can be plugged in or out while the mainframe is on.

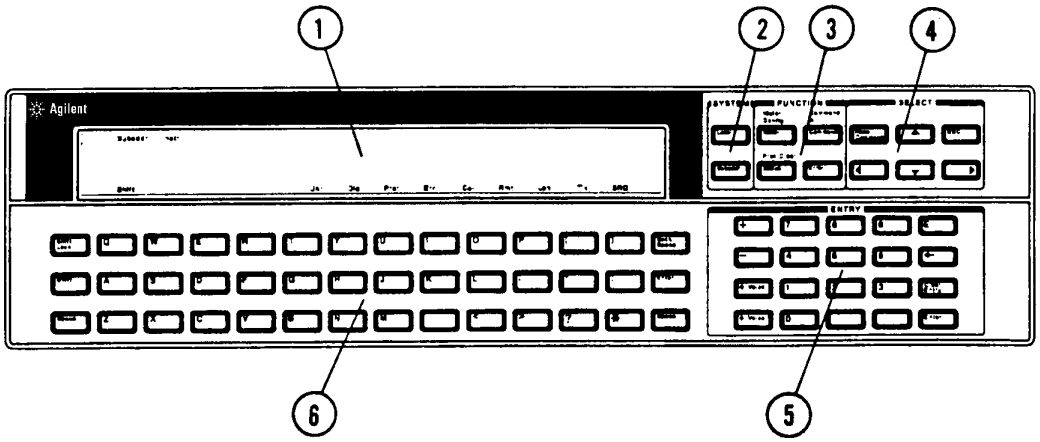


Note Do not connect more than one keyboard to a mainframe.

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Keyboard Description

This section briefly explains the various areas on the keyboard as indicated in the following figure:



① DISPLAY	
Subaddress and Instrument	The subaddress of the presently selected module appears on the left side of the display. The instrument field displays an instrument number when the module contains more than one instrument. Power supply modules do not use this field.
Meter Area	The predominant area of the display presents operating and status information about the selected module. This is referred to as the meter area of the display. Power supply modules display the output voltage and current as well as the operating mode in the meter area of the display. Refer to "Using the Display" for more information. The meter area is also used to display the SCPI commands when the Command function is active. Use the meter area to construct the SCPI command and then send the command to the module.
Annunciators	Annunciators on the bottom of the display provide additional information on the operation of the presently selected module. Active annunciators can indicate:
Shift	The Shift or Shift Lock Lock key has been pressed.
Unr	The module is unregulated.
Dis	The module's output is disabled.
Prot	One of the protection features has been activated.
Err	There is an error message in the SCPI error queue.
Cal	Calibration mode is enabled.
Rmt	The module is in remote mode (keyboard disabled).
Lsn	The module is addressed to listen over the GPIB.
Tlk	The module is addressed to talk over the GPIB.
SRQ	The module has generated a service request.

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② SYSTEM KEYS	
Local	This key switches from remote operation (over the GPIB) to local operation using the keyboard. Press Local when the **Rmt** annunciator is on to enable the keyboard.
Subaddr	This key moves the cursor to the subaddress field so you can select another module. Use the **Entry** or **Select** keys to enter another subaddress.
③ FUNCTION KEYS	
Meter	This function continuously displays operating information about the selected module. The Meter function is the turn-on default function, and is also in effect whenever the mainframe is in remote mode.
Command	This function lets you send a SCPI command or query to the selected module. Use the letter keys or the **Select** keys to select the SCPI command. Refer to the power module *Programming Guide* for a complete description of the SCPI commands. Refer to the end of this appendix for the SCPI command tree used by the keyboard.
Status	This function displays status information about the following QUEStionable and CONDition status register bits: CV, CC, OV, OC, OT, RT, WTG, and DWE. Refer to the power module *Programming Guide* for a complete description of the QUEStionable and CONDition status registers.
Error	This function displays the error messages whenever the **Err** annunciator on the display indicates that an error has occurred.
Meter Config ([Shift] [Meter])	This function lets you format the meter area of the display. Power supply modules do not use additional meter formats.
Command All ([Shift] [Command])	This function lets you send the next command entered from the keypad to all the modules in the mainframe. The subaddress field on the display indicates "**ALL**" when this function is active. You must press Command All each time you want to send a command to all modules.
Prot Clear ([Shift] [Status])	This function clears any latched protection features that have tripped.
④ SELECT KEYS	
◀ ▶	When the Meter function is active, these keys let you move across the display so that you can enter or change values in the selected fields. When the Command function is active, these keys let you move across the various levels of the command tree structure. Numeric command parameters default either to zero or the last programmed value.
▲ ▼	When the Meter function is active, these keys let you increment and decrement the numeric values in the selected field. When the Command function is active, these keys let you scroll up and down through the choices at each level of the command tree.
Recall Command	This key lets you recall up to five previous commands that were sent. You can edit any recalled command. Press Enter to send the command.
ESC	This key exits any action and returns the display to the Meter function. If the Command function is active, the displayed command is not executed (same as Meter).

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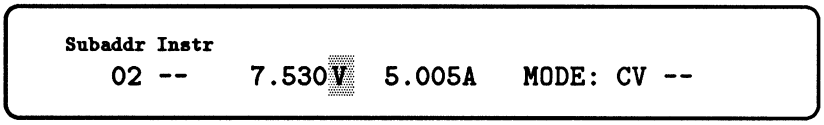
	⑤ ENTRY KEYS
0 through 9	These keys let you enter numeric values. Values can be entered directly. If the Meter function is active, the display automatically switches to the Command function with the appropriate command for programming the metered mode on the display.
.	This key enters the decimal point.
,	This key is used to separate multiple command arguments such as those used with a **List** command.
▲ Value ▼ Value	These keys let you increment and decrement the numeric values in the selected field when the Meter function is active. Note that numeric values change in larger steps the longer these keys are held down. When the Command function is active, these keys let you increment and decrement numeric command parameters.
+ −	These keys let you assign a polarity to a value that is entered with the numeric **Entry** keys. You must enter the polarity before you enter the number.
E	This key lets you enter the exponent of a value that is entered with the numeric **Entry** keys. Enter the exponent after you enter the number.
←	This key backspaces over and deletes individual digits in a numeric entry field (same as Back Space).
Clear Entry	This key clears the entire numeric entry field.
Enter	This key executes a command.
	⑥ LETTER KEYS
A through Z	These keys let you select SCPI commands when the Command function is active. Letter keys select the choices that begin with the letter that is pressed and move across the command tree when additional selections are available. Shift ed letters make selections by scrolling through the choices at the present command level that start with the shifted letter.
	Note Nothing happens if a letter is pressed that has no corresponding SCPI command.
:	This key is the prompt for the SCPI instrument commands.
*	This key is the prompt for the GPIB commands (IEEE-488.2).
?	This key is the prompt for SCPI queries. Append the prompt to the query. The result of the query appears on the display after it is entered.
Shift	This key accesses the shifted key functions. The **Shift** annunciator on the display indicates that the Shift key was depressed. The annunciator turns off when the next key is pressed.
Shift Lock	This key locks the shift key functions. The **Shift** annunciator on the display indicates when the shift functions are locked.
Back Space	This key backspaces over and deletes individual digits in a numeric entry field (same as ←).
Enter	This key executes a command.

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Using The Display

Changing or Entering Values

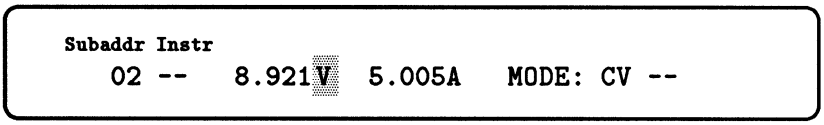
The following figure is an example of the keyboard display when a power module is addressed and the Meter function is active:



The keyboard continuously displays measured voltage and current. The blinking cursor initially highlights the voltage field, which indicates that the value in that field can be changed using the numeric **Entry** keys. You can also use the ◀ and ▶ keys to move the cursor across the display to select other fields that you want to change.

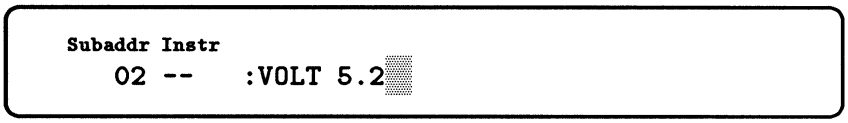
Press [▲ Value] repeatedly to increment the voltage value.

[▲ Value]
[▲ Value]

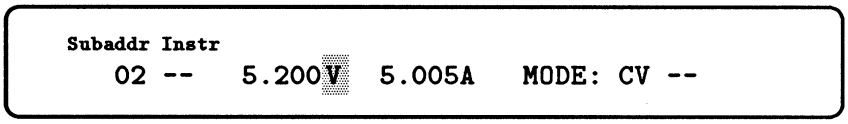


You can also use the numeric **Entry** keys to enter a new value directly into the field. The display will switch to the Command function when the numeric **Entry** keys are used. Enter the new value next to the SCPI command, and execute the command with the [Enter] key.

[5] [.] [2]



[Enter]



Displaying Status

Use the [Status] key to view the present state of the following status bits of the addressed module: CV, CC, OV, OC, OT, RT, WTG, and DWE. A Status mnemonic appears on the display only if the corresponding bit has been set in the status registers. In the following example, the display indicates that the module is in constant voltage (CV) mode and is waiting (WTG) for a trigger input.

[Status]



The status response remains on the display until you press another key to do something else, or until the module goes into remote mode. Press [ESC] or [Meter] to return to the meter function.

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Sending SCPI Commands

As described in the power module *Programming Guide*, SCPI commands are organized into message units. The keyboard can only send one message unit at a time; you cannot combine message units. Also, optional headers within a command do not appear on the display. There are two ways to construct message units using the keyboard:

- locate and append each SCPI header to the message unit with the **Select** keys, or
- directly construct the message using only the first letter of each header with the letter keys.

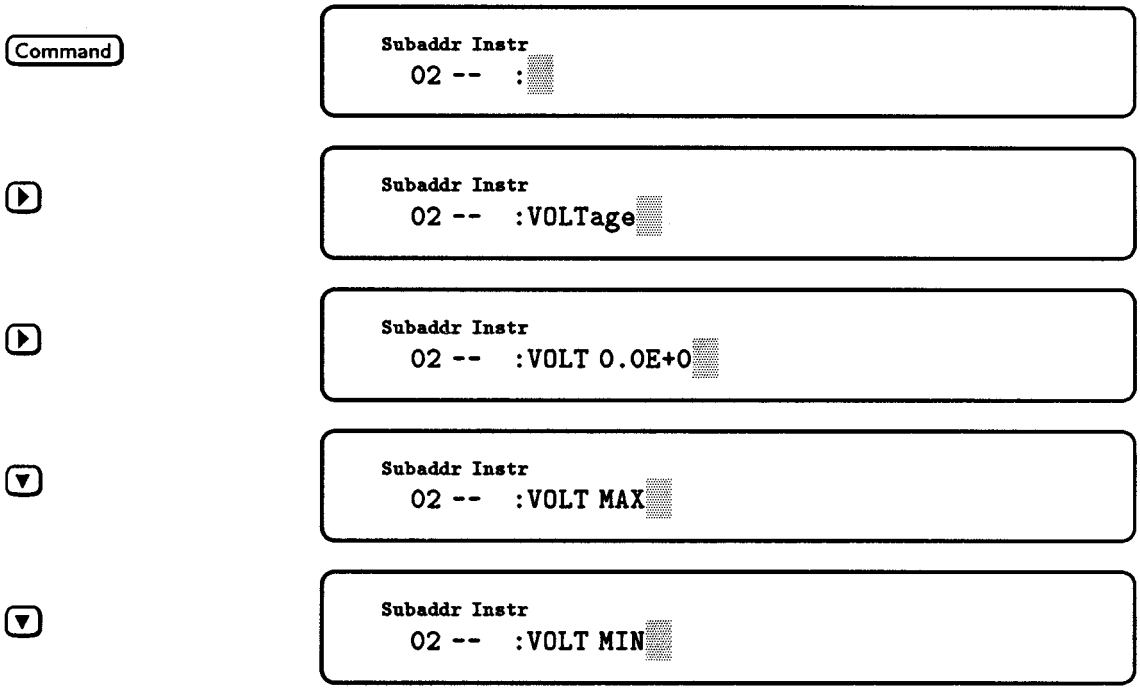
The figure at the end of this appendix shows the SCPI command tree structure that is used by the keyboard. When the command function is selected with the Command key, the **VOLTage** command appears on the display for power supply modules.

The **Select** keys let you move up and down as well as across the various levels of the command tree. When numeric parameters are accessed with the **Select** keys, the value either defaults to zero or the last programmed value.

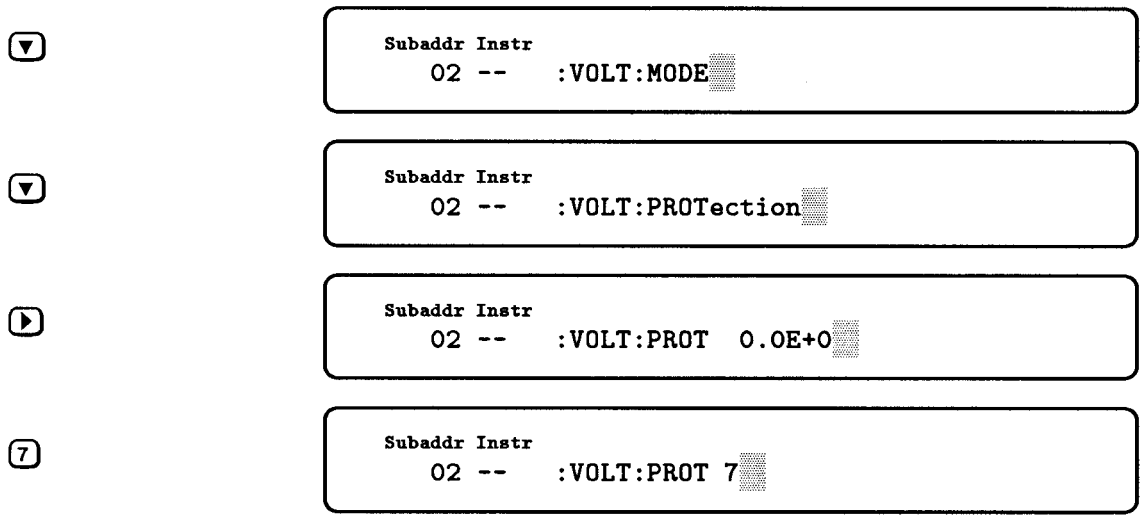
Letter keys let you directly access headers by typing the first letter of the header. Letter keys select headers by moving across the levels of the command tree. If more than one header starts with the same letter at a specific level in the command tree, the first choice in that level is selected. Use the ▲ or ▼ key to select the command you want to use. You can also use the Shift ed letters to scroll through the available choices at the present command level that start with the shifted letter.

Command Example

The following examples show you how to use the **Select** keys or the letter keys to construct and send commands to the addressed module. In this example, the voltage protection level of a power supply module is being set to 7 volts.

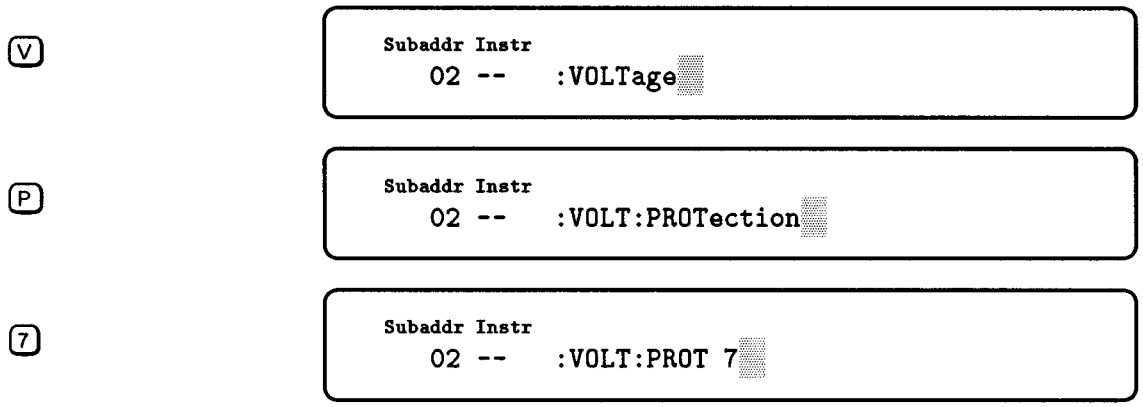


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Press Enter to execute the command.

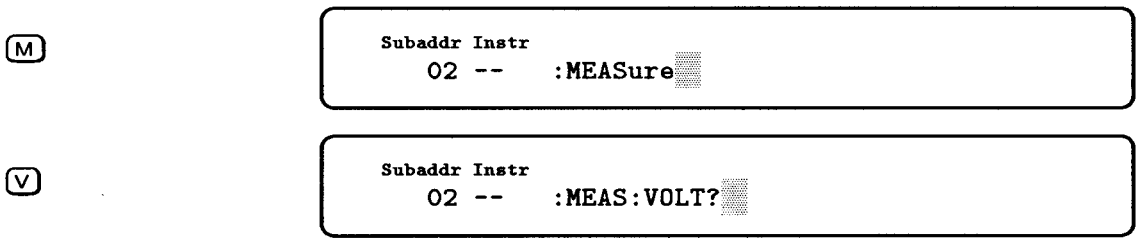
Using the letter keys to directly access and send commands is much faster than using the **Select** keys to find and then send commands. Of course, this method is faster only if you know which commands you are going to program. The following sequence shows the same example using the letter keys:



Press Enter to execute the command.

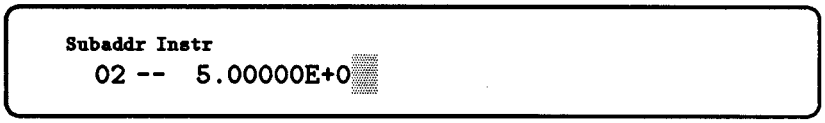
Query Example

Queries return data from the addressed module. Use the **Select** keys or the letter keys to construct and send queries to the addressed module in the same way that you send commands. When you enter the query, the display returns a value. In the following example, the power module is queried as to its actual voltage output:



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Enter



The query response remains on the display until you press another key to do something else, or until the module goes into remote mode. Press ESC or Meter to return to the meter function.

To query the programmed setting of any command parameter, use the cursor control keys to access the parameter field of the command. The value that appears is the last programmed value. In the following example, the module is queried as to its voltage protection setting:

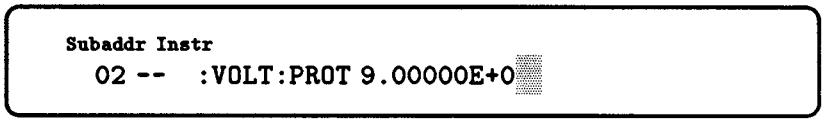
V



P



▶



You can now change the voltage protection level or press ESC or Meter to return to the meter function.

Note If a SCPI command has a corresponding query, you can also add the ? after the command to turn the command into a query. If a command does not have a corresponding query, the ? key is ignored.

Error Example

If you make an error when you are constructing a command, the display will inform you that an error has occurred when you enter the command. The following message is an example of an error that has occurred because the data entered for a parameter was out of the range of the power module.

Enter

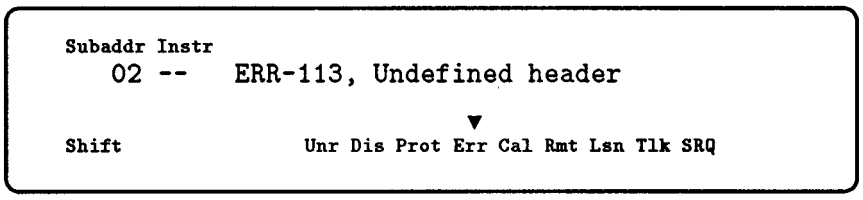


Either press Recall Command to recall and edit the command that caused the error or press ESC or Meter to clear the message and return to the meter function.

With the keyboard, you can also read back any system error that has occurred when the module is operating in remote mode. The **Err** annunciator on the display indicates that there is an error in the SCPI error queue. If the module is in remote mode, you must first press Local to get out of remote mode. The following example shows how to read error messages when the module is in remote mode:

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Local Error

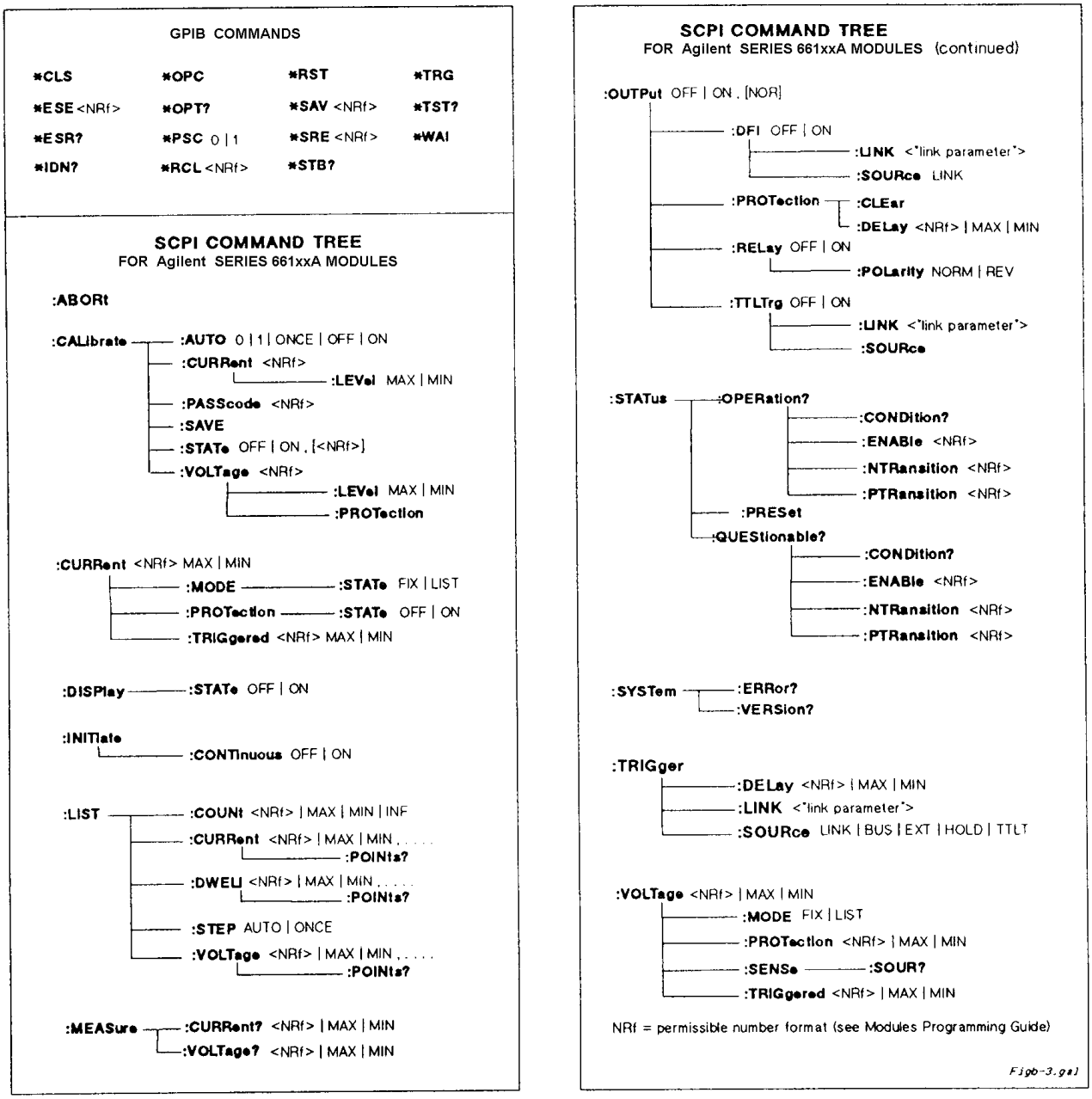


If the **Err** annunciator is still on after the error message is displayed, it means there are additional error messages in the SCPI error queue. Press Error to display the other messages. Each time you press the Error key it removes one error from the error queue.

SCPI Command Tree

The following figure illustrates the SCPI command tree used by the keyboard.

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Manual Updates

The following updates have been made to this manual since the print revision indicated on the title page.

4/15/00

All references to HP have been changed to Agilent.
All references to HP-IB have been changed to GPIB.

6/21/02

The serial number and option number information in chapter 1 has been updated.

9/21/04
The Declaration of Conformity has been updated.

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