HEWLETT PACKARD

OPERATING MANUAL

HP-IB DC POWER SUPPLIES
SERIES 667xA

HP Part No. 5959-3372

OPERATING MANUAL
FOR INSTRUMENTS WITH SERIAL NUMBERS
HP Model 6671A; 3110A-00101 and Above*
HP Model 6672A; 3138A-00101 and Above*
HP Model 6673A; 3138A-00101 and Above*
HP Model 6674A; 3111A-00101 and Above*
HP Model 6675A; 3138A-00101 and Above*

***For instruments with higher serial numbers, a change page may be included.**

Microfiche Part No. 5959-3373 **Printed: September, 1991**

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard hardware product is warranted against defects in material and workmanship for a period of three years from date of delivery. HP software and firmware products, which are designated by HP for use with a hardware product and when properly installed on that hardware product, are warranted not to fail to execute their programming instructions due to defects in material and workmanship for a period of 90 days from date of delivery. During the warranty period Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective. HP does not warrant that the operation for the software firmware, or hardware shall be uninterrupted or error free.

For warranty service, with the exception of warranty options, this product must be returned to a service facility designated by HP. Customer shall prepay shipping charges by (and shall pay all duty and taxes) for products returned to HP for warranty service. Except for products returned to Customer from another country, HP shall pay for return of products to Customer.

Warranty services outside the country of initial purchase are included in HP's product price, only if Customer pays HP international prices (defined as destination local currency price, or U.S. or Geneva Export price).

If HP is unable, within a reasonable time to repair or replace any product to condition as warranted, the Customer shall be entitled to a refund of the purchase price upon return of the product to HP.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Customer, Customer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation and maintenance. NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

The above statements apply only to the standard product warranty. Warranty options, extended support contacts, product maintenance agreements and customer assistance agreements are also available. Contact your nearest Hewlett-Packard Sales and Service office for further information on HP's full line of Support Programs.

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

BEFORE APPLYING POWER.

Verify that the product is set to match the available line voltage.

GROUND THE INSTRUMENT.

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument 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. For instruments designed to be hard-wired to the ac power lines (supply mains), connect the protective earth terminal to a protective conductor before any other connection is made. 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 the instrument is to be energized via an external autotransformer for voltage reduction, be certain that the autotransformer common terminal is connected to the neutral (earthed pole) of the ac power lines (supply mains).

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

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 instrument may be equipped with a 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 data plate may cause leakage currents in excess of 5.0 mA peak.

SAFETY SYMBOLS.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).

Indicates earth (ground) terminal.

Indicates chassis (signal) ground.

WARNING or

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 or **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 a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

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

Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät/System HP 6671A, 6672A, 6673A, 6674A, and 6675A in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

Zusatzinformation fur Meß- und Testgeräte

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

Manufacturer's declaration

This is to certify that the equipment HP 6671A, 6672A, 6673A, 6674A, and 6675A is in accordance with the Radio Interference Requirements of Directive FTZ 1046/84. The German Bundespost was notified that this equipment was put into circulation, the right to check the series for compliance with the requirements was granted.

Additional Information for Test- and Measurement Equipment

If Test- and Measurement Equipment is operated with unscreened cables and/or used for measurements on open set-ups, the user has to assure that under operating conditions the Radio Interference Limits are still met at the border of his premises.

Herstellerbescheinigung

Diese Information steht im Zusammenhang mit den Anforderungen der Maschinenlärminformationsverordnung vom 18 Januar 1991.

* Schalldruckpegel Lp < 70 dB(A) * Am Arbeitsplatz * Normaler Betrieb
* Nach DIN 45635 T. 19 (Typprüfung)

Manufacturer's Declaration

This statement is provided to comply with the requirements of the German Sound Emission Directive, from 18 January 1991.

This product has a sound pressure emission (at the operator position) < 70 dB.

* Sound Pressure Lp < 70 dB(A) * At Operator Position * Normal Operation
* According to ISO 7779 (Type Test).

PRINTING HISTORY

The current edition of this manual is indicated below. Reprints of this manual containing minor corrections and updates may have the same printing date. New editions are identified by a new printing date (and, in some cases, a new part number). A new edition will incorporate all new or corrected material since the previous edition. Changes to the manual occurring between editions are covered by change sheets shipped with the manual. Also, if the serial number on your power supply is higher than those listed on the title page of this manual, then the manual may include a change sheet applicable to your supply.

Edition 1...September, 1991

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General Information 1

INTRODUCTION

This is the operating manual for your HP Series 667xA power supply. Unless otherwise stated, the information in this manual applies to all models in the series.

This chapter has a general description of power supplies as well as performance specifications and operating characteristics. Information about options, cables, and accessories is also included.

SAFETY CONSIDERATIONS

This power supply is a Safety Class 1 instrument, which means that is has a protective earth terminal. That terminal must be connected to earth ground through a power source equipped with a 3-wire ground receptacle.

Refer to the Safety Summary page at the beginning of this manual for general safety information. Before installation or operation, check the power supply and review this manual for safety markings and instructions. Safety information for specific procedures is located at the appropriate places in this manual.

INSTRUMENT IDENTIFICATION

Hewlett-Packard power supplies are identified by a unique two-part serial number, such as 3110A-08145. The first part of the number (the prefix) is a number-letter combination that provides the following information:

3110 The year and week of manufacture or last significant design change. Add 1960 to the first two digits to determine the year. For example, 31 = 1991, 32 = 1992, etc. The last two digits specify the week of the year (10 = the 10th week).

A The letter indicates the country of manufacture (A = U.S.A.).

OPTIONS

Option	Description
200	Input power 200 Vac, nominal
908	Rack Mount Kit (HP 5062-3977)
909	Rack Mount Kit with Handles (HP 5062-3983)
910	HP Series 667xA Service Manual with extra Operating Manual
931	UL listed, CSA certified 12 AWG power cord without plug
941	UL listed, CSA certified 12 AWG power cord with NEMA 6-20P, 20A/250 V plug
943	UL listed, CSA certified 12 AWG power cord with JIS C8303 20A/250 V plug
932	Harmonized 4 mm^2 wire size power cord without plug
942	Harmonized 4 mm^2 wire size power cord with IEC 309, 32 A plug
934	UL listed, CSA certified 10 AWG power cord without plug
944	UL listed, CSA certified 10 AWG power cord with NEMA L6-30P, 30A/250V locking plug

ACCESSORIES

HP No.	Description
10833D	HP-IB cable, 0.5 meters (1.6 ft)
10833A	HP-IB cable, 1.0 meter (3.3 ft)
10833B	HP-IB cable, 2 meters (6.6 ft)
10833C	HP-IB cable, 4 meters (13.2 ft)
10834A	HP-IB connector adapter
5080-2148	Serial-link cable, 2 meters (6.6 ft)
1494-0058	Heavy duty slide mount kit

DESCRIPTION

The HP Series 667xA power supplies are a family of unipolar HP-IB programmable system supplies. Each supply is programmable locally from the front panel or remotely over the HP-IB bus and/or a rear analog voltage control port. By means of a serial HP-IB link, up to 16 supplies may be connected together and individually controlled from a single primary HP-IB address.

Operational features include:

- Constant voltage (CV) or constant current (CC) output over the rated output voltage or current
- Overvoltage (OV), overcurrent (OC), and overtemperature (OT) protection
- Front panel LCD includes output metering, text messages, and annunciators
- Front panel function control and numerical entry keypads
- Five nonvolatile storage locations (0 to 4) that:
  - Allow storage of up to five user-defined operating states
  - Determine the power-on state (in location 0)
  - Initially contain the factory-default operating state (in location 0)
- Automatic turn-on selftest
- Analog port for:
  - connections for remote sensing of load voltage
  - external monitoring of output current
  - remote voltage programming of voltage and/or current output
  - auto parallel operation with other Series 667xA supplies

- Digital port for DFI (discrete fault indicator)/RI (remote inhibit) functions and alternately configurable for:
  - Output relay control option or,
  - Digital I/O control option
- Telephone-style jacks for serial-link operation with other HP Series 667xA and with Series 665xA and Series 603xA power supplies
- User calibration from the front panel or over the HP-IB bus

Front Panel Programming

The power supply voltage and current can be programmed from the front panel, permitting checkout independently of the HP-IB. Front panel operation also permits:

- Enabling or disabling the output
- Setting the OVP trip voltage
- Enabling or disabling OCP
- Saving and recalling operating states
- Setting the HP-IB address
- Reading HP-IB error message codes
- Calibrating the supply, including changing the calibration protective password

Remote Programming

The HP Series 667xA power supplies may be remotely programmed via the HP-IB bus and/or an analog input port. HP-IB programming is with SCPI (Standard Commands for Programmable Instruments) commands that make power supply programs compatible with those of other HP-IB instruments. (A software-controlled Compatibility Mode also permits programming in the command set of the HP 603xA Autoranging Series.) In addition to control functions, SCPI programming permits writing to the front panel LCD and complete calibration functions. Power supply status registers can monitor the following conditions:

- Overvoltage, overcurrent, overtemperature and unregulated states
- Operating mode (CV or CC)
- RI (remote inhibit) input signal state
- PON (Power-on) status
- Output queue status (QYE)
- Pending triggers (WTG)
- HP-IB interface programming errors (CME, DDE, and EXE)
- Calibration state (enabled or disabled)

In addition, the status registers can be programmed to generate an output fault (FLT) signal upon the occurrence of one or more selected events.

Output Characteristic

The power supply can operate in either CV (constant voltage) or CC (constant current) over its voltage and current output ratings (see Table 1-1). The operating locus is shown by the Output Characteristic Curve in Table 1-2. The operating point is determined by the voltage setting (V_S), the current setting (I_S), and the load resistance. Two operating points are shown. Point 1 is defined by the load line cutting the operating locus in the constant-voltage region. This region defines the CV mode. Point 2 is defined by the load line cutting the operating locus in the constant- current region. This region defines the CC mode. Not shown in the Characteristic Curve is a limited downprogrmaming capabiity in the second quadrant ($-Is$) that provides an uncharacterizied area of current sinking capacity.

SPECIFICATIONS AND SUPPLEMENTAL CHARACTERISTICS

Table 1-1 lists the specifications of the power supply. Specifications are warranted in the temperature range of 0 to 55°C. Table 1-2 lists the supplemental characteristics, which are not warranted but are descriptions of performace determined either by design or type testing.

Table 1-1. Performance Specifications

Parameter		HP Model 6671A	6672A	6673A	6674A	6675A
Specifications are warranted over the temperature range 0 to 55°C with a resistive load and the output connected for local sensing.						
Output Ratings						
Voltage:		0-8 V	0-20 V	0-35 V	0-60 V	0-120 V
Current:		0-220 A	0-100 A	0-60 A	0-35 A	0-18 A
Programming Accuracy (@ calibration temperature ±5°C)*						
Voltage:	0.04% +	8 mV	20 mV	35 mV	60 mV	120 mV
Current:	0.1% +	125 mA	60 mA	40 mA	25 mA	12 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	650 µV	750 µV	800 µV	1.25 mV	1.9 mV
Constant Voltage	p-p	5 mV	9 mV	9 mV	11 mV	16 mV
Constant Current:**	rms	200 mA	100 mA	40 mA	25 mA	12 mA
** With minimum 2-ft load lead.						

Table 1-1. Performance Specifications (continued)

Parameter	HP Model 6671A	6672A	6673A	6674A	6675A
Readback Accuracy (over HP-IB or front panel with respect to actual output @ calibration temperature ±5°C)*					
Voltage: 0.05% +	12 mV	30 mV	50 mV	90 mV	180 mV
Current: 0.1% +	150 mA	100 mA	60 mA	35 mA	18 mA
* Factory calibration temperature = 25°C					
Load Regulation (change in output voltage or current for any load change within ratings)					
Voltage: 0.002% +	300 μV	650 μV	1.2 mV	2 mV	4 mV
Current: 0.005% +	10 mA	7 mA	4 mA	2 mA	1 mA
Line Regulation (change in output voltage or current for any line change within ratings)					
Voltage: 0.002% +	300 μV	650 μV	1.2 mV	2 mV	4 mV
Current: 0.005% +	10 mA	7 mA	4 mA	2 mA	1 mA
Transient Response Time (for output to recover to within 100 mV following any step change in load current from 100% to 50% or 50% to 100% of the rated current):	<900 μs				
AC Input Ratings (selectable via internal switch—see Appendix C)					
200 Vac nominal:	174—220 Vac				
(Below 185 Vac, derate linearly to:)	7.8 V	18.0 V	31.5 V	56.5 V	108 V
230 Vac nominal:	191—250 Vac				
Frequency range:	47—63 Hz				
Output Terminal Isolation (maximum, from output signal ground):	±240 Vdc				

Table 1-2. Supplemental Characteristics

Parameter	HP Model 6671A	6672A	6673A	6674A	6675A
Output Programming Range (Maximum programmable values):					
Voltage:	8.190 V	20.5 V	35.8 V	61.425 V	123.0 V
Current:	225.23 A	102.0 A	61.5 A	35.83 A	18.5 A
OV Protection:	10.0 V	24.0 V	42.0 V	72.0 V	144.0 V
Typical Programming Resolution					
Voltage:	2 mV	5 mV	9 mV	15 mV	30 mV
Current:	55 mA	25 mA	15 mA	8.75 mA	4.5 mA
OV Protection:	15 mV	35 mV	65 mV	100 mV	215 mV
Accuracy (@ calibration temperature ±5°C)*					
OV Protection:	200 mV	500 mV	900 mV	1.15 V	3.0 V
Analog Programming (VP):	±0.3%				
Analog Programming (IP):	±7%				
Current Monitor (IM):	±7%				
*Factory calibration temp = 25°C					
Analog Programming (IP & VP)					
Input signal (source must be isolated):					
VP input signal:*	0 to −4.72V	0 to −4.24V	0 to −4.25V	0 to −4.24V	0 to −3.97V
VP input impedance:	60 kΩ				
+IP to −IP differential input signal:	0 to +7.97V	0 to +6.81V	0 to +6.81V	0 to +7.01V	0 to +6.34 V
IP Input impedance:	52 kΩ				
*Referenced to output signal common					
Current Monitor (IM)					
Output Signal*:	−0.6 to +10.0V	−1.07 to +8.53V	−1.02 to +8.53V	−1.13 to +8.80V	−1.41 to +7.94 V
Output Impedance:	490 Ω				
*Corresponds to 0% to 100% output current					

Table 1-2. Supplemental Characteristics (continued)

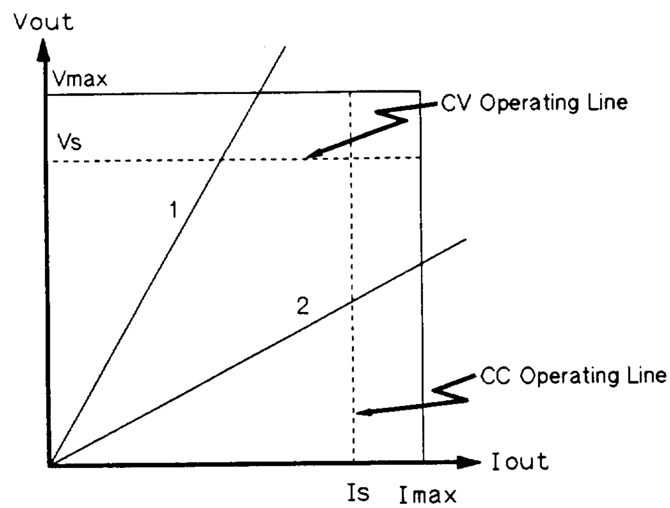
Parameter		HP Model				
		6671A	6672A	6673A	6674A	6675A
Drift (Temperature Stability) (following a 30-minute warmup, change in output over 8 hours under constant line, load, and ambient temperature)						
Voltage:	0.02% +	0.24 mV	0.6 mV	1 mV	1.8 mV	3.6 mV
Current:	0.02% +	69 mA	35 mA	20 mA	10 mA	6 mA
Temperature Coefficients (change in output per °C after a 30-minute warmup).						
Output Voltage:	50 ppm +	0.04 mV	0.2 mV	0.7 mV	1.2 mV	2.4 mV
Output Current:	75 ppm +	25 mA	12 mA	7 mA	4.0 mA	2 mA
Voltage Readback:	60 ppm +	0.1 mV	0.3 mV	1 mV	1.2 mV	3 mV
± Current Readback:	85 ppm +	30 mA	15 mA	9 mA	5 mA	2.5 mA
OV Protection:	200 ppm +	1.8 mV	5 mV	8 mV	13 mV	25 mV
Analog Programming (VP):	60 ppm +	0.1 mV	0.3 mV	0.5 mV	0.7 mV	1.5 mV
Analog Programming (± IP):	275 ppm +	26 mA	14 mA	9 mA	5 mA	3 mA
Current Monitor (+IM):	50 ppm +	3 mA	2 mA	1 mA	0.6 mA	0.3 mA
Maximum Reverse Diode Current) (maximum current, without damage, that supply will withstand while turned on and with the dc output reverse biased by an external dc source):		220 A	100 A	60 A	35 A	18 A
Typical Common Mode Noise Current*						
rms		500 μA				
peak-peak:		4 mA				
* Referenced to output signal ground.						
Maximum Input VA and Power:		3800 VA; 2600 W; 100 W with no load				
Maximum AC Line Current Ratings						
200 Vac nominal:		19 A (25 A internal fuse)				
230 Vac nominal:		Same as 200 Vac				
Remote Sensing Capability						
Voltage drop per lead:		Up to ½ of rated output voltage				
Load voltage:		Subtract voltage drop in load leads from specified output voltage rating				
Load regulation						
Degradation due to load lead drop in negative output:		None				
Degradation due to load lead drop in positive output:		ΔmV (regulation) = $2V_{drop}(V_{rating})/(V_{rating} + 10\ V)$				
Command Proecessing Time (average time for output to begin to change after receipt of digital data when supply is connected directly to the HP-IB):		20 ms				
Output Voltage Programming Response Time*						
Programming rise/fall time (time for output to change from 90% to 10% or 10% to 90% of its total excursion):**		30 ms	60 ms	130 ms	130 ms	195 ms
Full-load programming speed up/down (time for output to settle to within 4 LSBs of the final value when programmed from full output to zero):**		85 ms	190 ms	380 ms	380 ms	600 ms
No-load down programming discharge time (time for output to fall to 0.5 V when programmed from full output to zero volts):		130 ms	250 ms	350 ms	600 ms	600 ms
* All values exclude command processing time.						
** With full resistive load = rated output V/rated output I						
Monotonicity:		Output is monotonic over entire rated voltage, current, and temperature range				
Auto-Parallel Configuration:		Up to 5 identical models				

Table 1-2. Supplemental Characteristics (continued)

Parameter	HP Model				
	6671A	6672A	6673A	6674A	6675A
Digital Port Characteristics					
Maximum Ratings:	16.5 Vdc between terminals 1 & 2, between 3 & 4, and from 1 or 2 to chassis ground				
FLT/INH Operation					
FLT/INH Terminals 1 & 2					
Iol (low-level output current)	1.25 mA maximum				
V_{ol} (low-level output voltage)	0.5 V maximum				
FLT/INH Terminals 3 & 4					
V_{il} (low-level input voltage)	0.8 V maximum				
V_{ih} (high-level input voltage)	2.0 V minimum				
I_{il} (low-level input current)	1 mA				
tw (pulse width)	100 μs minimum				
td (time delay)	4 ms typical				
Digital I/O Operation					
Digital OUT Port 0,1,2—Open Collector:					
I_{oh} (high-level output leakage @ 16.5 V)	100 μA (ports 0,1);12.5 mA (port 2)				
I_{oh} (high-level output leakage @ 5.25 V)	100 μA (ports 0,1);250 μA (port 2)				
I_{ol} (low-level output sink current @ 0.5 V)	4 mA				
I_{ol} (low-level output sink current @ 1 V)	250 mA				
Digital IN Port 2—Internal 4.64k Pullup:					
I_{il} (low-level input current @ 0.4 V)	1.25 mA				
I_{ih} (high-level input current @ 5.25 V)	250 μA				
V_{il} (low-level input voltage)	0.8 V maximum				
V_{ih} (high-level input voltage)	2.0 V minimum				
HP-IB Interface Capabilities					
Interface Signals (see IEEE 488.1):	AH1,C0,DC1,DT1,E1,LE4,PP0, RL1,SH1,SR1,TE6				
Languages (see Appendix B):	SCPI (default); Compatibility				
Serial Link Capabilities (multiple supplies sharing one HP-IB primary address)					
Maximum number of supplies:	16				
Maximum number of linked supplies:	15				
Maximum total chain cable length:	30 m (100 ft)				
Savable States					
Nonvolatile memory locations:	5				
Nonvolatile memory write cycles:	40,000 typical				
Prestored state (factory default):	Location 0				
Recommended Calibration Interval:	1 year				
Safety Compliance (complies with):	CSA 22.2 No. 231; IEC 348				
(designed to comply with):	UL 1244; VDE 0411				
RFI Suppression (complies with):	FTZ 1046/84, Level B				
Dimensions					
Width:	425.5 mm (16.75 in.)				
Height: (excluding removable feet):	132.6 mm (5.2 in.)				
(including removable feet):	145.1 mm (5.71 in.)				
Depth: (including safety cover):	640 mm (25.2 in.)				
Weight					
Net:	27.7 kg (61 lb)				
Shipping:	31.4 kg (69 lb)				

Table 1-2. Supplemental Characteristics (continued)

Output Characteristic Curve:

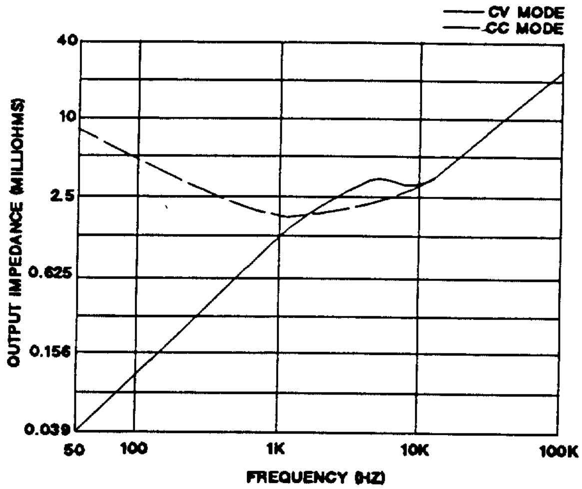


MAXIMUM RATED OUTPUT

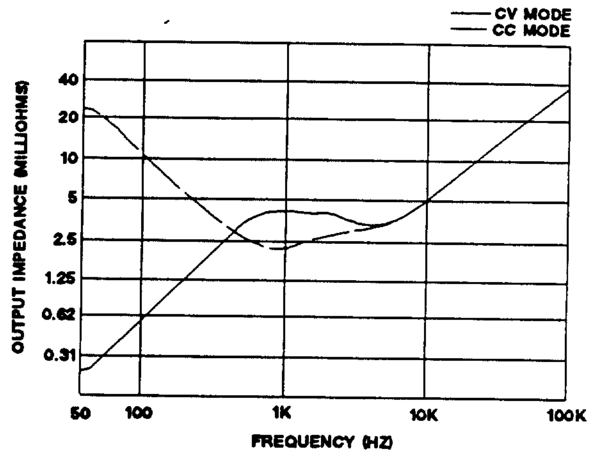
HP Model	Vout	Iout
6671A	8 V	220 A
6672A	20 V	100 A
6673A	35 V	60 A
6674A	60 V	35 A
6675A	120 V	18 A

Table 1-2. Supplemental Characteristics (continued)

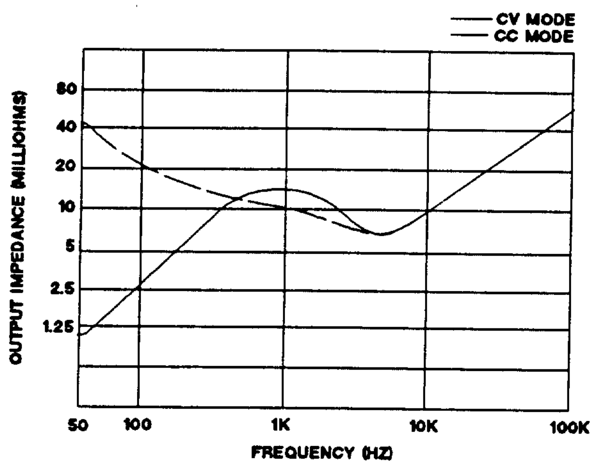
Output Impedance Curves (Typical)



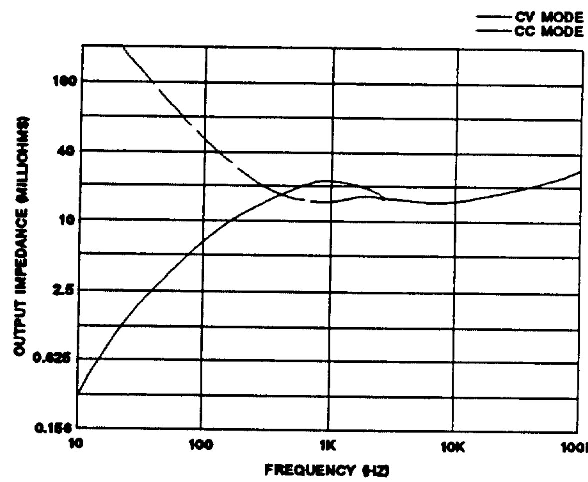
HP 6671A



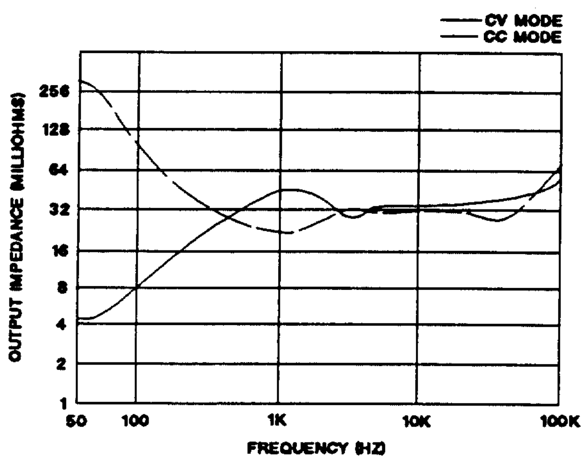
HP 6672A



HP 6673A



HP 6674A



HP 6675A

Table 1-3. Power Supply SCPI Command Parameters (See Chapter 7)[1]

Command	HP 6671A	HP 6672A	HP 6673A	HP 6674A	HP 6675A
CURR:LEV[2]	0 to 225.23	0 to 102.0	0 to 61.5	0 to 35.83	0 to 18.5
CURR:LEV MAX	225.23	102.0	61.5	35.83	18.5
CURR:LEV:TRIG[2]	Same as CURR:LEV				
*RST Value	0.88	0.40	0.24	0.14	0.07
OUTP:PROT:DEL	0 to 32.767 s				
OUTP:PROT:DEL MAX	32.767 s				
*RST Value	200 ms				
VOLT:LEV[2]	0 to 8.19	0 to 20.5	0 to 61.43	0 to 35.8	0. to 123.0
VOLT:LEV MAX	8.19	20.5	61.43	35.8	123.0
VOLT:LEV:TRIG[2]	Same as VOLT:LEV				
*RST Value	0				
VOLT:PROT	0 to 10.0	0 to 24.0	0 to 42.0	0 to 72.0	0 to 144.0
VOLT:PROT MAX	10.0	24.0	42.0	72.0	144.0
*RST Value	MAX				

[1] Unless specified otherwise, current is amperes, voltage is volts, and MIN value is 0.
[2] Levels can be uniformly programmed up to the MAX value.

Table 1-4. Operating Parts List

Description*	HP Part No.
Cable Assembly, HP-IB	(See "Accessories")
Cable Assembly, Serial Link	5080-2148
Foot, Cabinet	5041-8801
Fuse, Power, 25 A	2110-0849
Knob, Output Rotary Control	0370-1091
Lockwasher, Output Bus Bar (1/4 Spring)	3050-1690
Nut, Output Bus Bar (Hex 1/4-20 x 1/2)	2950-0084
Nut, Power Ground (Hex w/LW 3/8-32)	0590-0305
Plug, Analog Connector	1252-3698
Plug, Digital Connector	1252-1488
Power Cord Assembly	(See "Options")
Resistor, Calibration	(See Appendix A)
Safety Cover, DC Output	5040-1674
Safety Cover, AC Input with strain relief connector and rubber boot	5040-1676
Screw, Carrying Strap and Cover (M5x0.8x10 mm)	0515-1132
Screw, Output Bus Bar (1/4-20x1/2)	2940-0103
Screw, Output Sense Terminal (M3x0.5x8mm)	0515-0104
Screw, RFI Shield (M4x0.7x8 mm)	0515-0433
Manual, HP 59510A/11A, Relay Accessories	5957-6382
Manual, Operating, Series 603xA	5959-3301
Manual, Service, Series 667xA	5959-3337
Standoff, HP-IB Connector (Hex 6-32x0.255)	0380-0643
Terminal, Crimp, AC Power Cord (L,N)	0362-0681
Terminal, Crimp, AC Power Cord (Gnd)	0362-0207

*Screws require a TORX® driver. TORX is a registered trademark of Textron, Inc.

Installation 2

INSPECTION

Damage

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

Save the shipping carton and packing materials in case the supply has to be returned to Hewlett-Packard in the future. If you return the supply for service, attach a tag identifying the owner and model number. Also include a brief description of the problem.

Items Supplied

In addition to this manual, check that the following items are included with the power supply:

Power Cord In order to connect the ac power, the following items are included with the power supply:

- A power cord appropriate to your location. Depending on the power cord option chosen (see "Options" in Chapter 1), the cord may or may not be terminated in a power plug.
- A power input safety cover, strain relief connector, and rubber boot. These items secure the power cord to the power supply.

Output Hardware Screws with nuts and lockwashers are supplied for securing your load wires to the output bus bars (see Table 1-4).

CAUTION

Your power supply cannot use a standard power cord. The power cords supplied by Hewlett-Packard have heavier gauge wire.

Analog Connector A 7-terminal analog plug (see Table 1-4) that connects to the back of the supply. Analog connections are described in Chapter 4.

Digital Connector A 4-terminal digital plug (see Table 1-4) that connects to the back of the supply. Digital connections are described in Appendix D.

Serial Cable A 2-meter cable (see "Accessories" in Chapter 1) that connects to the control bus next to the HP-IB connector. This is used to serially connect multiple supplies as described under "Controller Connections" in Chapter 4.

Manual Change Sheet If applicable, change sheets may be included with this manual. If change sheets are included, make any indicated corrections to this manual.

LOCATION AND COOLING

Bench Operation

Table 1-2 in Chapter 1 gives the dimensions of your power supply. The cabinet has plastic feet that are shaped to ensure self-alignment when stacked with other HP System II cabinets. The feet may be removed for rack mounting. Your power supply must be installed in a location that allows sufficient space at the sides and rear of the supply for adequate air circulation. Minimum clearances are 1 inch (25 mm) along the sides. Do not block the fan exhaust at the rear of the supply.

Rack Mounting

The supply can be mounted in a standard 19-inch rack panel or cabinet. Rack mounting kits are available as Option 908 or 909 (with handles). Installation instructions are included with each rack mounting kit. Instrument support rails are required for non-stationary installations. These are normally supplied with the cabinet and are **not** included with the rack mounting kits.

Temperature Performance

The supply can operate without loss of performance within the temperature range of 0° C to 55° C. A variable-speed fan cools the supply by drawing air through the sides and exhausting it out the back. Using HP rack mount or slide kits will not impede the flow of air.

Power Source

You can operate your supply from a nominal 200 volt or 230 volt, single-phase power source. See "AC Input Ratings " in Table 1-1 for the voltage and frequency range of each nominal line voltage.

NOTE

The power source must be a dedicated line with no other devices drawing current from it.

CAUTION

Be sure that the Line Rating label (1, Figure 2-1) corresponds to the nominal line voltage of your power source. If it does not, see Appendix C for instructions on setting the line voltage switch.

INSTALLING THE POWER CORD

The power cord supplied with your power supply may or may not include a power plug (see "Options" in Chapter 1). Terminating connectors and a ground lug are attached to one end of the cord.

WARNING

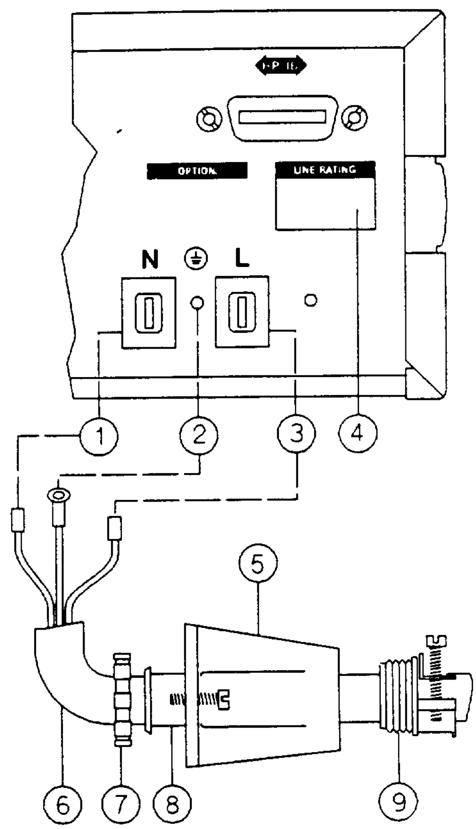
Installation of the power cord must be done by a qualified electrician and in accordance with local electrical codes.

See Figure 2-1 and proceed as follows:

1. Position the strain relief connector (9), safety cover (5), rubber boot (8), and connector nut (7) on the power cord (6).
2. Secure the ground wire (2) to the earth ground stud.
3. Connect the neutral wire (1) to the N input terminal.
4. Connect line wire (3) to the L input terminal (this line is fused inside the power supply).
5. Replace the safety cover and tighten the safety cover and strain relief connector screws.

CAUTION

Do not apply power to the power supply until directed to do so in Chapter 3.



1	NEUTRAL CONNECTION (BLUE OR WHITE)
2	GROUND CONNECTION (GREEN/YELLOW OR GREEN)
3	LINE CONNECTION (BROWN OR BLACK)
4	LINE VOLTAGE LABEL
5	POWER SAFETY COVER
6	POWER CORD
7	CONNECTOR NUT
8	RUBBER BOOT
9	STRAIN RELIEF CONNECTOR

Figure 2-1. Power Cord Installation

Turn-On Checkout 3

NOTE

This chapter provides a preliminary introduction to the power supply front panel. See Chapter 5 for more details.

INTRODUCTION

Successful tests in this chapter provide a high degree of confidence that the power supply is operating properly. For complete performance and/or verification tests, see the service manual (Option 910).

CAUTION

Do not connect the power cord to the power source until told to do so.

PRELIMINARY CHECKOUT

If required, see Figure 4-1 in Chapter 4 for terminal locations.

1. Make certain that the front panel switch is off.
2. Look at the LINE RATING label on the rear of the supply. If the rating does not agree with your power source, the position of the **line voltage selector switch** inside the supply must be changed as directed in Appendix C.
3. Remove the output safety cover (1, Figure 4-1).
4. Examine the output bus bars (3&6, Figure 4-1). They should be wired for local sensing as follows:
   - The analog connector **+S** wired to the **+LS** screw terminal.
   - The analog connector **−S** wired to the **−LS** screw terminal.
5. If the power supply is not wired for local sensing, make the above connections, using small-capacity wire (#22 AWG is sufficient).
6. Make certain there is no load connected to the bus bars.

POWER-ON CHECKOUT

1. Connect the power cord to the power source.
2. Turn the front panel power switch to ON (1).

Check that the power supply is on by placing your hand near the rear grill to feel the air flow from the fan. You may also be able to hear the fan operating.
The power supply undergoes a self-test when you turn it on. If the test is normal, the following sequence appears on the LCD:[1]

- ADDR 5 (for a few seconds)
- PWR ON INIT (for a few seconds)
- The display goes into meter mode with the **Dis** annunciator on and all others off. "Meter mode" means that the **VOLTS** digits display the output voltage and the **AMPS** digits display the output current.

Press [Output on/off] once. The **Dis** annunciator will go off and the **CV** annunciator will go on.

[1]The description assumes that the power supply has its factory default state still stored in location 0. If not, your turn-on display may be different.

NOTE

If the power supply detects an error during self-test, the display will show an error message. Go to "In Case of Trouble" at the end of this chapter.

OUTPUT CHECKOUT

Some of the front panel keys perform two functions, one labeled in black and the other in blue. You access the blue function by first pressing the blue [Shift] key, which is not labled. When the **Shift** annunciator is displayed, you will know you have access to the key's shifted (blue) function.

The [←] key is an erase key. If you make a mistake entering a number and have not yet pressed [Enter], you can delete the number by pressing [←].

Voltage Output

Perform the steps in Table 3-1 to check the basic voltage functions with no load on the power supply. **The voltages used in the table are for the HP 6671A; if you have a different model, consult Table 1-3 for the correct voltage range.** The VOLTS display will show various readings. Ignore the AMPS display.

Current Output

WARNING

The Series 667xA Power Supplies have high current capacity. To prevent overheating or possible melting of the wire, make sure the shorting wire size is sufficient for the maximum output current (see wire Table 4-1 in Chapter 4).

Perform the steps in Table 3-2 to check the basic current functions with a short across the power supply. **The currents used in the table are for the HP 6671A; if you have a**

Table 3-1. Checking the Voltage Functions (Output Terminals Open)

Action	Display	Explanation
If the **Dis** annunciator is on, turn if off by pressing [Output On/Off].		
Press [Voltage] key	VOLT 0.000	Displays default output voltage. **CV** annunciator is on. If the **CC** annunciator remains on, increase the CC current setting by pressing [Current] [·][5] [Enter].
Press [8]	VOLT 8	Set voltage to rated output (Table 1-1).
Press [Enter]	VOLT 8.000	Meter mode at rated output voltage.
Press [↓Voltage] several times		*Voltage drops about 2 millivolts each time you press the key.
Press [↑Voltage] several times		*Voltage increases about 2 millivolts each time you press the key.
Rotate the **Voltage** control first counterclockwise and then clockwise.		Control operates similarly to the [↓Voltage] and [↑Voltage] keys. Turning the control more quickly causes a more rapid change in voltage.
Press [OV]	OV 10.000	Shows default OVP trip voltage (Table 1-2).
Press [5]	OV 5	Program trip voltage to 5.
Press [Enter]		You have entered a trip voltage below the output voltage. Output drops to near zero. **CV** annuciator goes off and **Prot** annunciator comes on.
Press [Protect]	OV	Indicates the overvoltage protection circuit has tripped.
Press [←]	Meter mode	
Press [OV] [1] [0]	OV 10	Raise trip voltage up to 10.
Press [Enter]	Meter mode	Enter trip voltage.
Press [Shift] [Protect]	8.000	**Prot** annunciator goes off and full rated output is restored. (You have cleared the OV protection fault.)

Table 3-2. Checking the Current Functions (Output Terminals Shorted)

Action	Display	Explanation
Turn off the power supply. Connect a short across the (+) and (−) output bars. **Use a wire size sufficient to carry the maximum current of the supply.**		
Turn on the power supply		Meter mode with essentially zero outputs. The **Dis** annunicator is on.
Press [Voltage] [5] [Enter]	Volt 5.000	Set operating voltage
Press [Output on/off]		**Dis** annunciator goes off and **CC** annunciator comes on. AMPS display shows approximately 5 AMPS
Press [↑Current] several times		*Current increases about 60 milliamperes each time you press the key.
Press [↓Current] several times		*Current decreases about 60 milliamperes each time you press the key.
Rotate the **Current** control first counterclockwise and then clockwise.		Control operates similarly to the [↓Current] and [↑Current] keys. Turning the control more quickly causes a more rapid change in current.
Press [OCP]		**CC** annunciator goes off and **OCP** and **Prot** annunicators come on. (You have enabled the overcurrent protection circuit, which tripped because of the output short.) Output current is near zero.
Press [Protect]	OC----	Indicates the overcurrent protection circuit has tripped.
Press [←]		Returns to meter mode.
Press [Output on/off]		**Dis** annunciator comes on.
Press [OCP]		**OCP** annuciator goes off. (You have disabled the overcurrent protection circuit.)
Press [Shift] [Protect]		**Prot** annunciator goes off. (You have cleared the overcurrent protection circuit.)
Press [Output on/off]		**Dis** annunciator goes off and **CC** annunciator comes on. AMPS display indicates some output current.
Press [Current] [2] [2] [0] [Enter]	220.0	AMPS increases to 220 (maximum output)*
Press [Output on/off]		**Dis** annunciator comes on and AMPS reading drops to near zero.
Turn off the power supply and remove the short from the output.		

* For HP Model 6671A. See Table 1-2 for average resolution of other models.

different model, consult Table 1-3 for the correct current range. The AMPS display will show various readings. Ignore the VOLTS display. Before going to Table 3-2, short the output bus bars with a wire of suitable current-carrying capacity.

SAVE/RECALL CHECKOUT

The following steps check the supply save and recall function keys:

Press Voltage 5 Enter

Set voltage output. Make certain Output is on (**Dis** annunciator is Off).

Press Shift Recall 1 Enter
Save this state to location 1.

Press Recall 0 Enter
Voltage drops to near zero*.
(*This check is based on the fact that a newly shipped power supply has its default parameters stored in Location 0. If this is not true for your supply, then the voltage may be some other value.)

Press Recall 1 Enter

Output voltage returns to 5.00.

DETERMINING HP-IB ADDRESS

When the power supply is turned on, the display shows ADDR n, where "n" is the power supply HP-IB address. Any time you want to see the address:

Press Address
The display will indicate ADDR 5. (This is the factory default. If the power supply is not new, a different address may appear.)

If you need to change the address, see "Setting the HP-IB Address" in Chapter 5.

IN CASE OF TROUBLE

⚠ Power Fuse

If the power supply appears "dead" and the fan does not run, the power fuse may be blown. This fuse is located inside the supply.

WARNING

Only qualified electronics personnel should attempt to replace the power fuse.

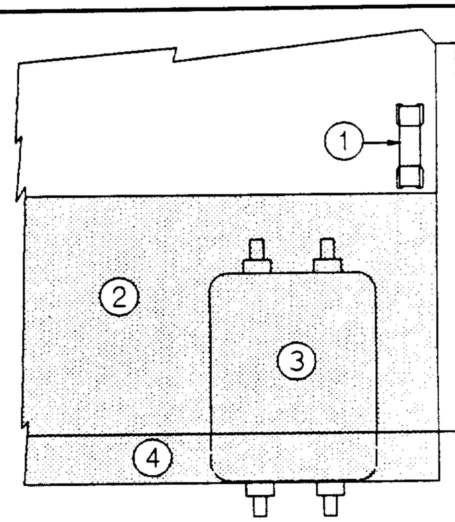
Remove the power supply cover as follows:

1. Remove the four screws that secure the two carrying straps and cover.
2. Spread the bottom rear of the cover and pull it back to disengage it from the front panel.
3. Remove the cover by sliding it back towards the rear of the supply.
4. Observe the input rail LED under the RFI shield (see Figure C-1). **If the LED is on, there is still hazardous voltage inside the supply.** Wait until it goes out (this may take several minutes) before proceeding.
5. Connect a dc voltmeter across TP1 and TP2 (It may be necessary to remove the RFI shield to reach these points. The shield is secured by four screws on each side.) When the reading is 60 volts or less, it is safe to work inside the power supply.
6. Locate the power fuse (see Figure 3-1). Replace the fuse with one of the same type and rating (for HP part number, see Table 1-4).

CAUTION

Do not use slow-blow fuses as replacements.

7. If you removed it in step 5, be sure to replace the RFI shield.
8. Replace the cover.



1	POWER FUSE
2	HP-IB BOARD
3	LINE FILTER
4	REAR OF POWER SUPPLY

Figure 3-1. Location of Power Fuse

Error Messages

Power supply failure may occur either during selftest or while operating (runtime). In either case, the power supply display may show an error message that indicates the reason for the failure.

Selftest Errors

When a selftest error occurs, it prevents all front panel operation and communication over the HP-IB. The display will show either a power-on error message or a checksum error message.

Power-On Error Messages. Power-on messages appear as:

En-- -

Where "n" is an number listed in Table 3-3. If this occurs, turn the power off and back on. It is possible to recover from EE CHKSUM errors. If any other error message persists, the power supply requires service.

Table 3-3. Power-On Selftest Errors

Error No.	Display	Failed Test
E1	FP RAM	Front panel RAM
E2	FP ROM	Front panel ROM checksum
E3	EE CHKSUM	EEPROM
E4	PRI XRAM	Primary external RAM
E5	PRI IRAM	Primary internal RAM
E6	PRI ROM	Primary ROM checksum
E7	HPIB	HP-IB R/W to serial poll
E8	SEC RAM	Secondary RAM
E9	SEC ROM	Secondary ROM checksum
E10	SEC 5V	Secondary 5V ADC reading
E11	TEMP	Secondary ambient thermistor reading
E12	DACS	Secondary VDAC/IDAC readback

Checksum Errors. If the display shows EE CHKSUM, the power supply has detected an EEPROM checksum error. A checksum error can occur due to the following operating conditions:

- Excessive number of write cyles 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 from a checksum error by writing to the EEPROM while the power supply is in the calibration mode. Proceed as follows:

- Press [Cal Enable] ([Shift] [1]). PASWD will appear on the display. Press the number keys corresponding to the password and then press [Enter] . The **Cal** annunciator will come on.

NOTE

On new equipment, the password corresponds to the four-digit model number. See Appendix A for more information about the calibration password.

- Press [Address] . The display will show the HP-IB address.
- Press [6] [Enter] .
- Turn the power off and back on.

A normal display free of error messages should appear. If not, the power supply requires service.

Runtime Error Messages

Table 3-4 lists the runtime error messages. Except for SERIAL DOWN, runtime errors halt all normal operations for about five seconds and then initiate a power-on reset. When SERIAL DOWN occurs, operation is halted until proper communications are restored with the power supply front panel. Runtime errors are hardware malfunctions that require service.

Under unusual operating conditions, the VOLT or AMPS display may show **+OL** or **-OL**. This indicates that the output voltage or current is beyond the range of the meter readback circuit.

Table 3-4. Runtime Errors

Display	Meaning
SERIAL DOWN	HP-IB not communicating with front panel
UART PARITY	UART byte parity error
UART FRAMING	UART byte framing error
UART OVERRUN	Overfilled UART receive buffer
SBUB FULL	Message too long for buffer
STK OVERFLOW	Front panel stack overflow
EE WRITE ERR	EEPROM status timeout

User Connections and Considerations 4

REAR PANEL CONNECTIONS

WARNING

Shock Hazard

Disconnect ac power before making rear panel connections.

Application connections are made to the output, analog, and digital connectors on the rear panel as shown in Figure 4-1. Controller connections (serial link and HP-IB) are discussed at the end of this chapter.

Output Connectors

Two screw-down bus bars (+ and −) connect the load wires to the power supply. Before making any connections to the bus bars, remove the four screws that secure the safety cover. Fasten a suitable terminal lug to the end of each load wire. (*Do not connect bare wires directly to the bus bars.*) Then loosen the bus bar screws, connect the load wires, and tighten the screws. Be certain to replace the safety cover after making all connections.

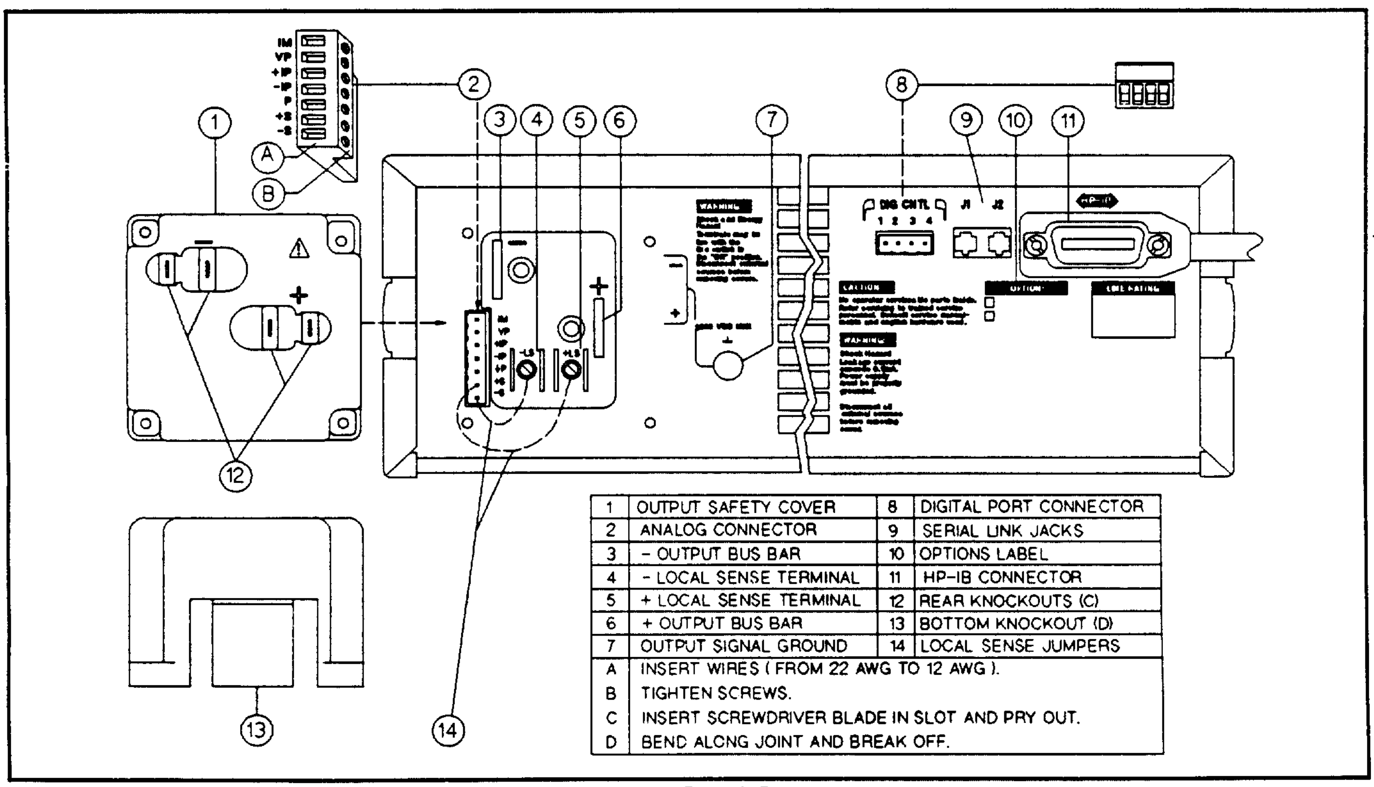
Analog Connector

A 7-pin connector and a quick-disconnect mating plug are provided for connecting remote sense leads, external current monitors, and external programming sources (see Figure 4-2).

The connector will accept wire sizes from AWG 12 to AWG 22. If you have not already done so, remove the safety cover before disconnecting the mating plug.

The analog pins are:

±IP This is a differental input that accepts a signal (see "Analog Programming" in Table 1-2) that produces a proportional output current from zero to full scale. +IP is positive with respect to −IP. −IP may be floated up to ±19 V from the Common P (P) terminal, which is approximately at the same potential as the +output. The differential input is always active and determines the output when the other (front panel and HP-IB) inputs are set to zero. If these inputs are not zero, then they are summed with the differential input to determine the output. The differential input also is used for auto-parallel operation with other HP 667xA power supplies as described later in this chapter.



1	OUTPUT SAFETY COVER	8	DIGITAL PORT CONNECTOR
2	ANALOG CONNECTOR	9	SERIAL LINK JACKS
3	- OUTPUT BUS BAR	10	OPTIONS LABEL
4	- LOCAL SENSE TERMINAL	11	HP-IB CONNECTOR
5	+ LOCAL SENSE TERMINAL	12	REAR KNOCKOUTS (C)
6	+ OUTPUT BUS BAR	13	BOTTOM KNOCKOUT (D)
7	OUTPUT SIGNAL GROUND	14	LOCAL SENSE JUMPERS
A	INSERT WIRES (FROM 22 AWG TO 12 AWG).		
B	TIGHTEN SCREWS.		
C	INSERT SCREWDRIVER BLADE IN SLOT AND PRY OUT.		
D	BEND ALONG JOINT AND BREAK OFF.		

Figure 4-1. Rear Panel Connectors

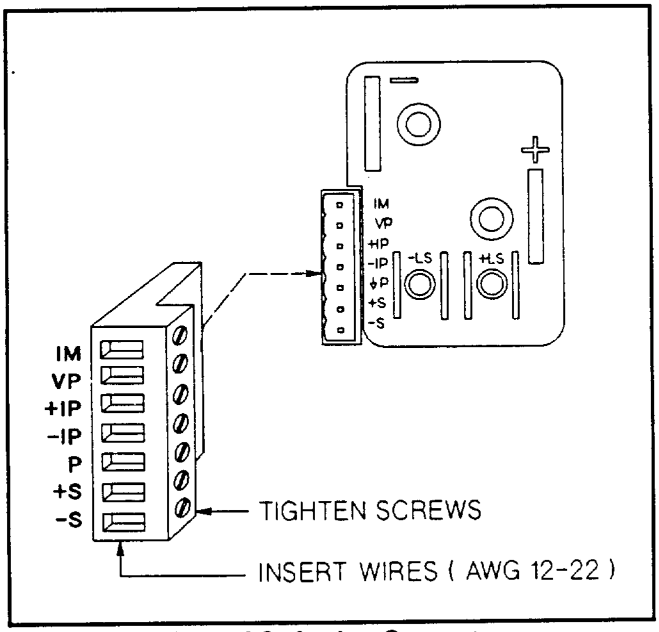


Figure 4-2. Analog Connector

VP Voltage programming input—allows an external voltage source to program constant voltage. CV mode is programmed with a signal (see "Analog Programming" in Table 1-2) that produces a proportional output voltage from zero to full scale. This input is always active; it is summed with values programmed over the HP-IB or from the front panel. The VP input can act alone if the other inputs are set to zero.

IM Current monitor output—used to monitor the power supply's output current with respect to Common P. A signal (see "Aanlog Programming" in Table 1-2) at this output indicates the zero-to-full scale source current. IM is also used when auto-paralleling with other HP 667xA power supplies for increased current output. See "Auto-Parallel Operation" for more information.

Common P (↓P) Provides the common connection for the VP voltage source inputs and the IM current monitor output.

+S and −S These are the + and − sense inputs. They are wired to the +LS and −LS terminals to achieve local sensing or to the external load for remote sensing (see "Remote Sensing"). Voltage readback is obtained from the sense inputs.

After you have finished making all wire connections, replace the mating plug in the connector and replace the safety cover.

Digital Connector

A 4-pin connector and a quick-disconnect mating plug are provided for digital input and output signals. See Appendix D for connections and operation information about this connector.

Wire Size Selection

WARNING

Fire Hazard

To satisfy safety requirements, load wires must be heavy enough not to overheat while carrying the short-circuit output current of the device connected to the load. Refer to Table 4-1 for the ampere capacity of various stranded wire sizes.

A major consideration in making load connections is the wire size. The minimum wire size required to prevent overheating may not be large enough to maintain good electrical performance. See "Remote Sensing" and "OVP Considerations" for more information. Table 4-1 gives the wire resistance for various stranded wire sizes to help you determine load lead voltage drop.

Output Isolation

The output of the power supply is isolated from earth ground. Either output terminal may be grounded, or an external voltage source may be connected between either output and ground. However, both output terminals must be kept within ±240 Vdc of ground. An earth ground terminal is provided on the rear panel for convenience, such as grounding wire shields.

WARNING

The earth ground terminal on the rear panel is a low-noise signal ground for convenience only. It is not designed to function as a safety ground.

Table 4-1. Stranded Copper Wire Ampere Capacity and Resistance

Wire Size		Ampacity Per Wire	Resistance Per Unit Length (Ω/ft)
AWG	Area in mm^2		
18	0.82	15.4	0.0064
16	1.31	19.4	0.0040
14	2.08	31.2	0.0025
12	3.31	40	0.0016
10	5.26	55	0.0010
8	8.37	75	0.0006
6	13.3	100	0.0004
4	21.1	135	0.00025
2	33.2	180	0.00016
1/0	53.0	245	0.00010

Notes:

1. AWG wire ratings derived from MIL-W-5088B.
2. Ampacity of aluminum wire is approximately 84% of copper wire.
3. With bundled wires, use the following percentages of the rated ampacity:
   2 conductors 94%   4 conductors 83%
   3 conductors 89%   5 conductors 76%
4. Maximum ambient temperature: 50° C
   Maximum conductor temperature: 105° C

LOAD CONSIDERATIONS

Capacitive Loads

In most cases, the power supply will continue to be stable with additional external load capacitors. However, large load capacitors may cause ringing in the supply's transient response. It is possible that certain combinations of load capacitance, equivalent series resistance, and load lead inductance will result in instability (see also "stability", under "Remote Sensing"). If you need help in solving a stability problem, contact an HP Service engineer through your local HP Sales and Service Office.

If the output voltage is rapidly programmed into capacitive loads, the supply may momentarily cross into constant current mode, thereby extending the CV programming time. When the supply crosses into CC mode, the maximum slew rate is limited to the programmed current divided by the internal and external capacitance. These momentary situations are communciated via the status register and may affect programming times, but will not damage the supply.

Inductive Loads

Inductive loads present no loop stability problems in constant voltage mode. However, in constant current mode, inductive loads will form a parallel resonance with the power supply's output capacitor. Generally this will not affect the stability of the supply, but it may cause ringing of the current in the load. Ringing will be minimized if the quality factor (Q) of the resonant network is ≤ 1.0. Use the following formula to determine Q:

$$Q = \frac{1}{(R_{int} + R_{ext})} \sqrt{\frac{L}{C}}$$

where:

L = load inductance

R_{ext} = load's equivalent series resistance

	HP 6671A	HP 6672A	HP 6673A	HP 6674A	HP 6675A
C =	44,000 µF	44,000 µF	12,000 µF	7,000 µF	2,100 µF
R_{int} =	1.8 mΩ	2.2 mΩ	4 mΩ	14 mΩ	30 mΩ

If the Q is greater than 0.5, inductive loads will ring with the output capacitance and be damped according to the following equation:

$$\left(e^{-t/\frac{2L}{R}}\right) \sin\omega t \sqrt{1-\left(\frac{1}{2Q}\right)^2}$$

Multiple Loads

When connecting multiple loads to the power supply using local sensing, connect each load to the output terminal using separate connecting wires (see Figure 4-3). This minimizes mutual coupling effects and takes full advantage of the supply's low output-impedance. Each pair of wires should be as short as possible and twisted or bundled to reduce lead inductance and noise pickup.

If cabling considerations require the use of distribution terminals that are located remotely from the supply, connect the output terminals to the distribution terminals by a pair of twisted or bundled wires. Connect each load to the distribution terminals separately. Remote voltage sensing is recommended in these circumstances (see "Remote Voltage Sensing"). Sense either at the remote distribution terminals or, if one load is more sensitive than the others, directly at the critical load as shown by the dashed lines in Figure 4-3. Note that voltage readback is at the sense terminals.

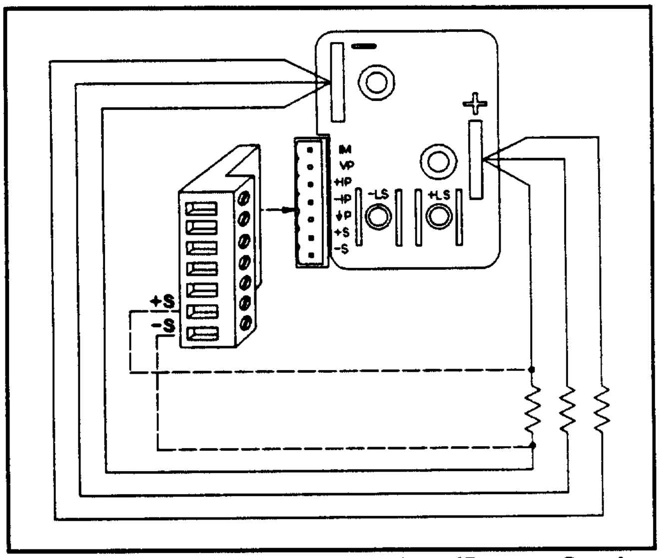


Figure 4-3. Multiple Load Connections (Remote Sensing Optional)

Local Voltage Sensing

For local sensing, the +S and −S analog connector pins must be wired to the +LS and −LS terminals (see Figure 4-1). Since local sensing does not compensate for voltage drops in the screw connections or load leads, local sensing should only be used in applications that require low output currents or where load regulation is not critical.

NOTE

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

Remote Voltage Sensing

The dashed lines in Figure 4-3 illustrate a typical power supply setup using remote voltage sensing. In this case, the remote sense terminals of the power supply are directly connected to the load rather than the output terminals. This allows the supply to automatically compensate for the voltage drop in the load leads as well as to accurately read back the voltage directly across the load.

Connect the sense leads carefully so that they do not become open-circuited. If the sense leads are left unconnected or become open during operation, the supply will regulate at the output terminals, not at the load. Remember to bundle or tie-wrap the load leads to minimize inductance and reduce noise pickup.

In remote sense applications, the voltage drop in the load leads subtracts from the available load voltage. Keep the sum of the programmed voltage and the load-lead drop within the supply's maximum voltage rating. Failure to do this may result in an unregulated output condition, especially when the ac line voltage is low.

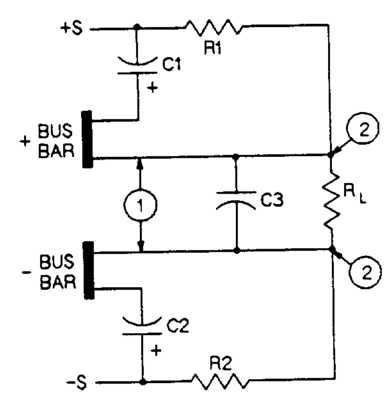
See "Remote Sensing Capability" in Table 1-2 for further characteristics and a general formula for the extra degradation in the output due to load-lead drop in the positive output lead. A voltage drop in the negative lead does not degrade voltage regulation. The sense leads are part of the supply's feedback path and must be kept at or below 0.5Ω per lead in order to maintain the above specified performance.

Output Rating. The rated output voltage and current specification in Table 1-1 applies at the output terminals of the supply. With remote sensing, any voltage dropped in the load leads causes the supply to increase the voltage at the output terminals so it can properly regulate the voltage at the remote sense points. However, if you try to operate at the full rated output voltage at the sense points, this will cause the supply's output voltage to exceed its rating at the output terminals. This will not damage the supply, but may trip the OV protection circuit, which senses the voltage at the output bus bars. When the supply is operated beyond its rated output the performance specifications are not guaranteed, although typical performance may be good. If the excessive demand on the supply forces it to lose regulation, its **Unr** annunciator will indicate that the output is unregulated.

Output Noise. Any noise picked up on the sense leads may appear at the output of the supply and can adversely affect the voltage load regulation. Twist the sense leads to minimize external noise pickup and route them parallel and close to the load leads. In noisy environments it may be necessary to shield the sense leads. Ground the shield only at the power supply end, utilizing the signal ground binding post. *Do not use the shield as one of the sense conductors.*

Stability. Using remote sensing under unusual combinations of load lead lengths and large load capacitances may cause your application to form a low-pass filter, which becomes part of the voltage feedback loop. The extra phase shift created by this filter can degrade the supply's stability, resulting in poor transient response. In severe cases, it may cause oscillation. To minimize this possibility, keep the load leads as short as possible and tie wrap them together.

In most cases, following these guidelines will eliminate problems associated with load lead inductance. However, if a large bypass capacitor is required at the load and load-lead length cannot be reduced, then a sense-lead bypass network may be needed to ensure stability (see Figure 4-4). The voltage rating of the 33 μF capacitors should be about 50% greater than the anticipated load-lead drop. Addition of the 20 Ω resistors will cause a slight voltage rise at the remote sensing points. For utmost voltage programming accuracy, the supply should be recalibrated with the DVM at the remote sensing points (see Appendx A).



C1, C2	33 μF
C3	LOAD BYPASS CAPACITOR
R1, R2	20 OHM, 1%
1	LOAD LEADS
2	REMOTE SENSE POINTS

Figure 4-4. Sense Lead Bypass Network

OPERATING CONSIDERATIONS

Auto-Parallel Operation

Figure 4-5 illustrates how power supplies can be auto-paralleled for increased current output. Up to five supplies can be connected for auto-parallel operation. Use heavy enough load leads so that the absolute voltage difference between the + output terminals of the master supply and the + output terminal of the first slave supply is kept under 2 V at rated current. This also applies to the voltage difference between the + output terminals of the first and second slave supplies. If remote sensing is necessary, connect the remote sense terminals of the master supply as shown by the dashed lines in Figure 4-5. See "Remote Sensing" for more information.

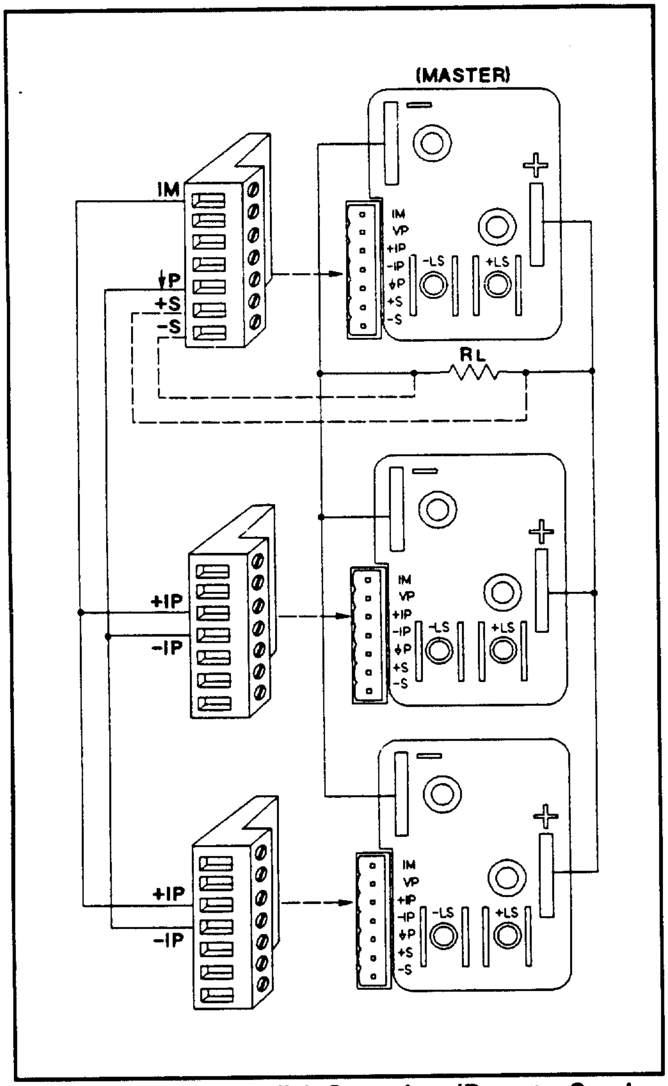


Figure 4-5. Auto-Parallel Operation (Remote Sensing Optional)

Only the first supply in the series (the "master") is programmed; the supplies that are connected to the master supply automatically track its output. However, the voltage and OVP settings of the slave supplies must be set higher than the operating voltage of the master supply. This ensures that the slave supplies will operate in CC mode when tracking the output of the master supply. Functions such as status, voltage readback, and current readback can still be read back individually for each supply.

Series Operation

CAUTION

Floating voltages must not exceed 240 Vdc. No output terminal may be more than 240 V from chassis ground.

Figure 4-6 illustrates how power supplies can be connected in series for increased voltage capability. Series connections are straightforward in this case.

Program each power supply as an independent supply. If two supplies are used in series operation, each supply can be programmed to deliver 50% of the total output voltage. Set the current limit of each power supply to the maximum that the load can handle without damage.

CAUTION

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

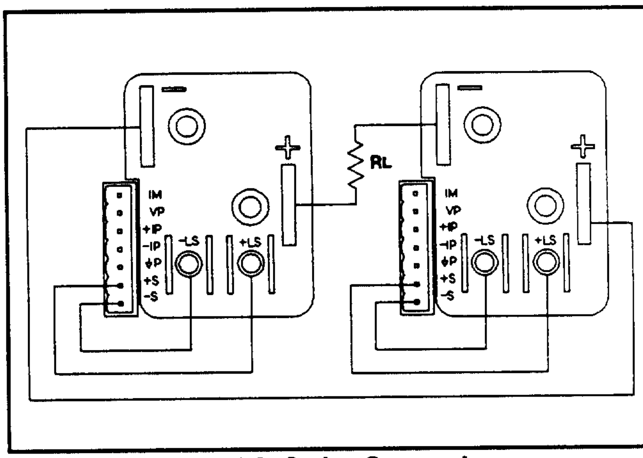
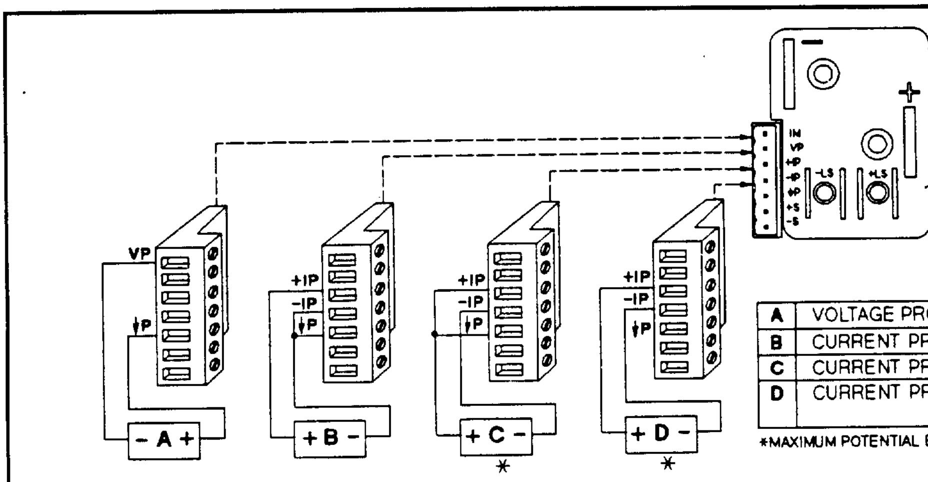


Figure 4-6. Series Connections

External Voltage Control

The setup shown in Figure 4-7 allows an external voltage to program either the output voltage or current of the supply. A zero-to-full scale voltage programming input produces a proportional zero-to-full scale output voltage. This voltage programming source is referenced to the programming Common P (↓P) terminal. A zero-to-full scale current programming input produces a proportional zero-to-full scale output current. For current programming only, this voltage can be floated up to ±19 V from Common P. The input impedance of the analog inputs is over 30 kΩ. If the output impedance of your programming source is not negligible compared to 30 kΩ, programming errors will result. Larger output impedances result in proportionately greater programming errors.

As shown in Figure 4-7, connect the voltage source between the VP terminal and Common P for voltage control. Connect the voltage source between the +IP terminal and −IP for current control.



A	VOLTAGE PROGRAMMING SOURCE	0 TO -5 V
B	CURRENT PROGRAMMING SOURCE	0 TO +10 V
C	CURRENT PROGRAMMING SOURCE	0 TO -10 V
D	CURRENT PROGRAMMING SOURCE	FLOATING 0 TO 10 V

*MAXIMUM POTENTIAL BETWEEN -IP AND IP IS ±19 V

Figure 4-7. External Voltage Programming

CAUTION

Make sure that the common connection for your voltage source is isolated from your load. Failure to do this may cause damage to the supply.

The effect of the analog programming source is always summed with the values programmed over the HP-IB or from the front panel. The voltage source can act alone if the other program sources are set to zero. Keep the total programmed setting of the supply (the analog input summed with the HP-IB or front panel setting) at or under the output ratings of the supply as specified in Table 1-1. Exceeding the output ratings will not damage the supply, but the supply may not be able to regulate its output at these levels. If this occurs, the **Unr** annunciator will come on, indicating that the output is unregulated.

OVP Considerations

Remote Sensing. The OVP circuit senses the voltage near the output terminals and not at the sense terminals. Therefore, the voltage sensed by the OVP circuit can be significantly higher than that being regulated by the supply at the load. You must program the OVP trip high enough to compensate for the expected drop between the output terminals and the load.

Battery Charging. The power supply's OVP circuit contains a down programmer FET that discharges the output of the supply whenever the OVP trips. If an external voltage source, such as a battery, is connected across the output and the OVP is triggered or the output voltage is programmed below the battery voltage, the power supply will continuously sink a large current from the source. To avoid this, insert a reverse blocking diode in series with the + output of the supply. Connect the diode's cathode to the + battery terminal and its anode to the supply's + output terminal. The diode may require a heat sink.

CONTROLLER CONNECTIONS

Figure 4-8 shows two basic ways of connecting your power supply to a controller. They are "linked" and "stand-alone" connections.

Stand-Alone Connections

See Figure 4-8a. Each stand-alone power supply has its own primary HP-IB bus address. Stand-alone power supplies may be connected to the bus in series configuration, star configuration, or a combination of the two. You may connect from 1 to 15 stand-alone power supplies to a controller HP-IB interface.

Linked Connections

See Figure 4-8b. Up to 16 power supplies may be used at a single HP-IB primary bus address by making linked connections. (*You cannot use linked connections if you intend to program power supplies with the compatibility language — see Appendix B.*)

- The first power supply in a linked connection is a "direct supply" connected to the controller via an HP-IB cable. The direct supply is the only supply connected directly to the bus and has a unique primary bus address.
- The remaining power supplies are "linked supplies" connected to the direct supply via a serial-link cable. Each linked supply has a unique secondary HP-IB bus address and derives its primary address from the direct supply. You may connect from 1 to 15 linked power supplies to each direct supply.

NOTE

See "Setting the HP-IB Address" in Chapter 5 for information about setting power supply primary and secondary addresses. See "HP-IB Interface Capabilities" in Table 1-2 for the interface functions utilized by the power supply.

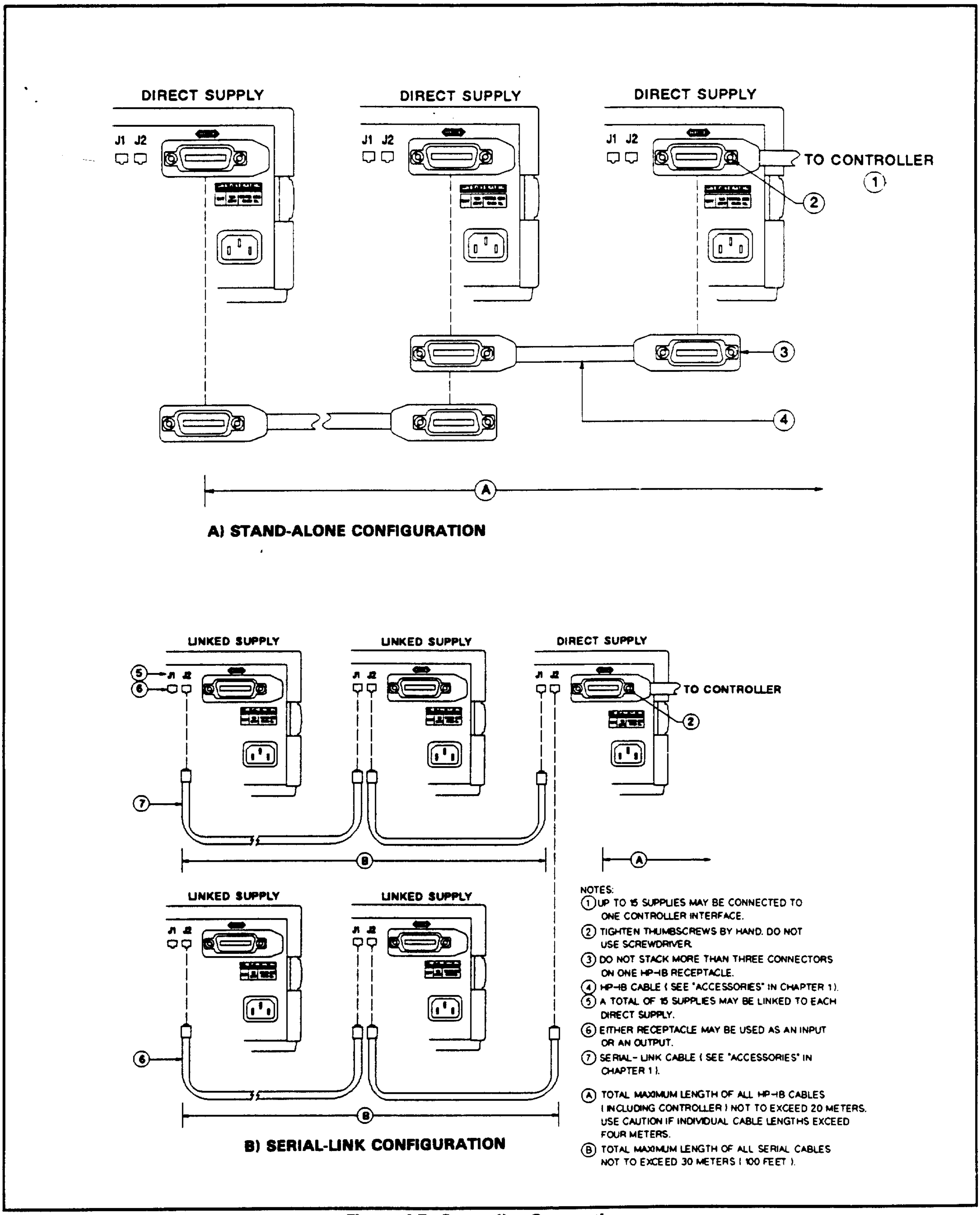


Figure 4-7. Controller Connections

Local Operation 5

INTRODUCTION

This section shows you how to operate the power supply from its front panel. It is assumed that you have performed the turn-on checkout procedures in Chapter 3. That chapter describes how to perform basic power supply functions from the control panel. Operations that you can perform are:

- Setting the output voltage and current.
- Monitoring the output voltage and current.
- Setting the overvoltage protection trip point.
- Enabling the overcurrent protection circuit.
- Enabling or disabling the power supply output.
- Saving up to 5 operating states in nonvolatile memory.
- Recalling up to 5 operating states from nonvolatile memory.
- Setting the power supply HP-IB bus address.
- Enabling local operation.
- Displaying error codes created during remote operation.

NOTE

You also can calibrate the power supply from the front panel. (See Appendix A.)

GETTING ACQUAINTED

The power supply's front panel is summarized in Figure 5-1 and Table 5-1. Note that the panel is organized as follows:

- Power On-Off (LINE) switch
- LCD display (including annunciators)
- Output rotary controls
- SYSTEM keys
- FUNCTION keys
- ENTRY keys

Some keys perform two operations. The first operation is shown **on** the key and the second (shifted) operation is shown in blue **above** the key. In order to do a shifted operation, you must first press the solid-blue key, which is unlabled but shown throughout this manual as [Shift] .

For example:

- For a recall operation, press [Recall] .
- For a save operation, press [Save] , which is really [Shift] [Recall] .

The display consists of alphanumeric data and triangular-shaped annunciators (▼) along the bottom of the display.

PROGRAMMING THE OUTPUT

IMPORTANT

These instructions show how to program a single power supply. There are special considerations when you have two or more supplies connected in series or in parallel. See "Chapter 4 — User Connections and Considerations."

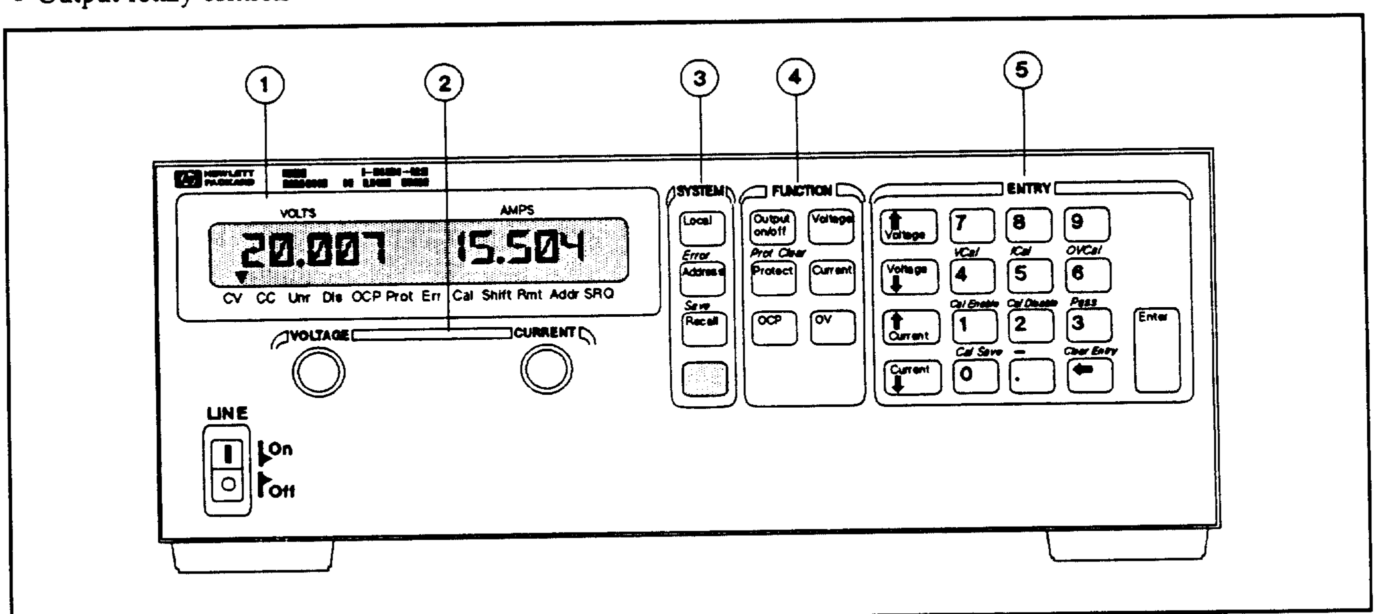


Figure 5-1. Front Panel Controls and Indicators

Table 5-1. Front Panel Controls and Indicators

Control or Indicator	Function or Indication
	1 Display
VOLTS	Shows present output voltage of the power supply.
AMPS	Shows present output current of the power supply.
	Status Annunciators
Addr	The power supply is addressed to listen or talk.
Cal	The power supply is in calibration mode.
CV	The power supply output is in constant-voltage mode.
CC	The power supply output is in constant-current mode.
Dis	The power supply output is disabled.
Err	An error has been generated as a result of remote operation. (Press [Error] to display the code.)
OCP	The overcurrent protection function is enabled.
Prot	A protection circuit has caused the supply to shut down. (Press [Protect] to determine the reason.)
Rmt	The power supply is in remote mode (control over HP-IB).
Shift	The (blue) shift key [Shift] has been pressed.
SRQ	The power supply is requesting service from the controller.
Unr	The power supply output is unregulated (output is neither CV nor CC).
	2 Output Rotary Controls
Voltage	Rotate clockwise to increase output voltage or the voltage setting. Provides the same function as the [↑ Voltage] and [↓ Voltage] keys.
Current	Rotate clockwise to increase output current or the current setting. Provides the same function as the [↑ Current] and [↓Current] keys.
	3 SYSTEM Keys
[Local]	When power supply is under remote control, press to enable local operation. *This control can be defeated by a lock-out command over the HP-IB.*
[Address]	Press to display the supply's HP-IB address. You can change the address with the ENTRY keys.
[Error]	Use to display error codes generated during remote operation. (Select by pressing [Shift] [Address].
[Save]	Use to save the power supply's present state in nonvolatile memory. (Select by pressing [Shift] [Recall].) Use the ENTRY keys to specify the location where you want to store the state. You may use locations 0 through 4. **Note: On a new power supply, location 0 holds the factory-default parameters.**
[Recall]	Press to restore a previously saved power supply state. Use the ENTRY keys [0] through [4] to specify which location to recall.
	4 FUNCTION Keys
[Output On/Off]	Press to enable or disable the power supply's output. This key toggles between the two functions. The disabled state programs the output to very low voltage and current settings. *This key cannot disable outputs set from the external voltage control port.*
[Voltage]	Press to display the output voltage setting. After pressing [Voltage], you may use the ENTRY keys to change the value.
[Current]	Press to display the output current setting. After pressing [Current], you may use the ENTRY keys to change the value.
[OV]	Press to display the OVP trip voltage setting. After pressing [OV], you may use the ENTRY keys to change the value.
[Protect]	When the **Prot** annunciator comes on, press this key to see which protection circuit caused the power supply to shut down. If no protection circuit has tripped, the display will show dashes (— — — —).
[Prot Clear]	Use to reset the protection circuit. (Select by pressing [Shift] [Protect].) If the condition that caused the the circuit to trip has been removed, the **Prot** annunciator will go off.
[OCP]	Press to enable or disable the power supply's OCP circuit. This key toggles between the two functions.

Table 5-1. Front Panel Controls and Indicators (continued)

Control or Indicator	Function or Indication
	4 FUNCTION Keys (continued)
↑ Voltage	Press to increment the output voltage in the CV mode, or the voltage setting after you have pressed the Voltage function key.[1]
↓ Voltage	Press to decrement the output voltage in the CV mode or the voltage setting after you have pressed the Voltage function key.[1]
↑ Current	Press to increment the output current in the CC mode, or the current setting after you have pressed the Current function key.[1]
↓ Current	Press to decrement the output current in the CC mode, or the current setting after you have pressed the Current function key.[1]
	5 ENTRY Keys
0 thru 9 , ·	Press to select numerical values.
-	Press to enter a minus sign. (Selected by pressing Shift ·)
←	Press to delete the last keypad entry. Use this key to correct a wrong digit before it is entered.
Clear Entry	Press to delete the entire keypad entry and return to meter mode. (Selected by pressing Shift ← .) Use this key to exit from a value before it is entered.
Enter	Press to enter a selected numeric value or to acccept an existing value and return the display to the meter mode.
	[1]The four increment keys operate in two modes. Press and release for single, uniform output change. Press and hold down for an increasingly rapid output change.

The power supply accepts values directly in volts and amperes. The power supply will round off values to the nearest multiple of its output resolution (see Table 1-2 in Chapter 1). If you attempt to enter a value not in a valid range, the entry will be ignored and OUT OF RANGE appears in the display. The Model HP 6671A is used for the examples in this chapter. Use appropriate values if you have a different model (see Table 1-2 in Chapter 1).

Figure 5-2 shows the general response of a typical power supply. Unless directed otherwise, always keep the output voltage and current within the boundaries of its operating line for the specified mode (CV or CC).

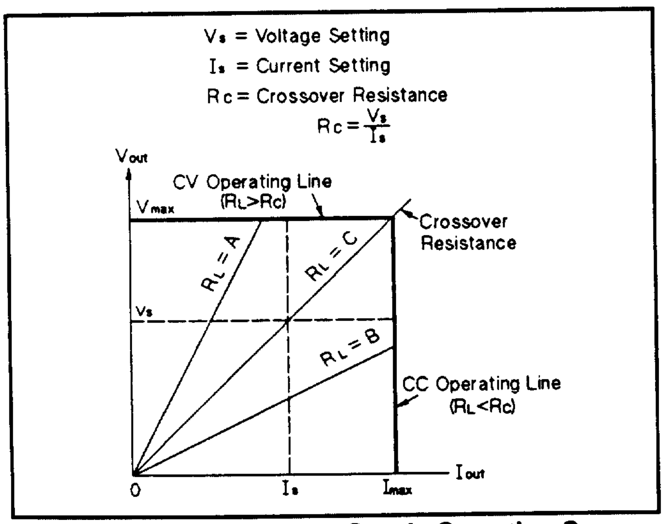


Figure 5-2. Typical Power Supply Operating Curve

Establishing Initial Conditions

If you have a new power supply that still has the default parameters in location 0 (See "Chapter 3—Turn-On Checkout"), you may omit the rest of this paragraph.

Otherwise, set up the power supply to the following conditions by pressing the specified keys where required:

Zero voltage output	Voltage 0 Enter
Minimal current output	Current · 5 Enter
Output enabled (Dis annunciator Off)	Output On/Off
OCP annunciator off	OCP
Prot annunciator off	Shift Protect

Programming Voltage

To program the output for 4.5 volts, proceed as follows:

- Press Voltage .
- The display will change from the meter mode to indicate VOLTS.
- Press 4 · 5 Enter . If you make a mistake and have not yet pressed Enter , you can erase the last keypad entry by pressing the backspace key ← .
- The display will return to the meter mode and indicate 4.500 volts.

NOTE

The power supply must be programmed for a minimal current in order to increase the output voltage beyond zero. Normally, there will be sufficient current to do this. If the power supply does not respond or the **Unr** *annunicator comes on, go to "Programming Current" and set the current to a small value (for example, 5 amperes for the HP 6671A).*

Now raise the voltage by pressing [↑ Voltage] (or by rotating the Voltage control clockwise). Note that the voltage increments each time you press the key and increases rapidly after you hold down the key. To lower the voltage back to 4.5, press [↓ Voltage] (or rotate the voltage control counterclockwise).

Try to program a voltage greater than the V_{MAX} for your supply. Note that the display shows OUT OF RANGE.

Programming Current

To program the output for 3.3 amperes, proceed as follows:

- Make certain that the voltage is not programmed to zero.
- Press [Current] .
- The display will change from the meter mode to indicate AMPS.
- Press [3] [.] [3] [Enter] . If you make a mistake and have not yet pressed [Enter] , you can erase the last keypad entry by pressing the backspace key [←].
- The display will return to the meter mode. The reading on the AMPS meter will depend upon the load current being drawn from the supply.

Now raise the current by pressing [↑Current] (or by rotating the current control clockwise). If you have a load on the power supply, note that the AMPS meter increases in equal increments each time you press the key and increases rapidly after you hold down the key. To lower the current back to 3.3, press [↓ Current] (or rotate the Current control counterclockwise).

Try to program a current greater than the I_{MAX} for your supply. Note that the display shows OUT OF RANGE.

CV Mode vs. CC Mode

In CV mode, once you program the voltage, the power supply will try to maintain that voltage over the range of the CV operating line (see Figure 5-2). In CC mode, once you program the current the power supply will try to maintain that current over the range of the CC operating line (that is, from 0 to I_{MAX}).

For the HP 6671A power supply I_{MAX} = 220 amperes. If you program the output for 220 amperes, then the CV operating line will extend from 0 to V_{MAX}, or from 0 to 8 volts. Under this condition, you can force the power supply into the CC mode only by placing a short across the output.

If you reduce the programmed current to 110 amperes, then a programmed voltage will be held constant only up to the point where the load tries to draw more than 110 amperes (this will be about 4 volts for the HP 6671A). The power supply then will switch to the CC mode and maintain the current constant at the expense of decreasing voltage for increasing load.

If a current limit is set in the CV mode and the load exceeds that limit, the speed of mode crossover response (going from CV to CC (mode) is directly proportional to the increase in required current. The larger the excess current, the faster the response.

Programming Overvoltage Protection

Overvoltage protection guards the load against voltages that reach a specified value greater than the programmed output.

Setting the OV Protection Level. Assuming that the power supply is now programmed for 7.5 volts, you can set the overvoltage protection for 8.5 volts as follows:

- Press [OV]
- The display will change from the meter mode to indicate OV, followed by the presently programmed (or default) overvoltage value.
- Press [8] [.] [5] [Enter]
- The display will return to the meter mode and indicate 7.500 volts.
- Press [OV] again.
- The display will indicate OV 8.500. To return to meter mode, press [Enter]

Checking OV Protection Operation. Now trip the OV protection circuit as follows:

- Raise the output voltage to near the trip point, such as 8.2. Then very gradually increase the output by pressing [↑Voltage] until the OV protection circuit trips.

  This will cause:
  the power supply output to drop to near zero.
  the **Prot** annunciator to go on.

- The power supply output is now disabled due to an overvoltage condition.
- To verify this, press [Protect] . The display will indicate OV.

Clearing the OV Condition. With the power supply disabled due to an OV trip, return the display to the meter mode and try to clear the condition by pressing [Prot Clear] . Nothing will appear to happen because the OV trip point is still the same. Thus, as soon as the circuit is cleared, it is tripped again. You can clear OV by:

- Lowering the output voltage below the OV trip point.
- Or, raising the OV trip voltage above the output setting.

Do either of these methods. Now when you press [Prot Clear], the **Prot** annunciator will go off and the outputs will return to normal.

Programming Overcurrent Protection

When enabled, overcurrent protection disables the power supply output whenever it goes into CC operation. This prevents the power supply from indefinitely supplying the full programmed currrent to the load. *There is no protection against currents generated by external voltage programming from the analog port.*

Setting the OCP Protection. To activate overcurrent protection, press [OCP] . The following occurs:

- The **OCP** annunciator comes on.
- The power supply will operate normally until it is forced into CC operation. If that occurs, the power supply will shut down.

Checking OCP Operation. The easiest way to check this operation at any specified current is to place a short across the load. If the supply is connected to a HP Electronic Load, press [Short On] . The following will occur:

- the power supply outputs will drop to near zero.
- the **Prot** annunciator will come on.

The power supply output is now disabled due to an overcurrent condition. To verify this, press [Protect] . The display will indicate OC. To return to meter mode, press [Enter] .

Clearing the OCP Condition. With the power supply disabled due to an OCP trip, return the display to the meter mode and try to clear the condition by pressing [Prot Clear] .

Nothing will appear to happen because the OC protection circuit will again trip as soon as it has been cleared. You can clear OCP by:

- Increasing the load resistance to lower the output current below the programmed current value.
- Or, increase the programmed current to a value equal to or greater than that required by the load.

In this example, the easiest way to clear the circuit is by removing the short from across the load. After doing this, proceed as follows:

- Clear the protection circuit by pressing [Prot Clear] .
- The **Prot** annunciator will go off and the power supply output is restored to normal.

If desired, you may remove an OCP condition by disabling the function (press [OCP] to turn off the **OCP** annunciator).

NOTE

Under certain conditions, the OCP circuit may fail to clear because the load demand occurs before the supply has time to build up the required current. In this case, disable the power supply output before clearing the protection circuit. After the fault is cleared, clear the OCP circuit and then enable the output.

Unregulated Operation

Should the power supply go into a mode of operation that is neither CV nor CC, the **Unr** annunciator will come on. The unregulated condition limits the current to a value that is safe for the power supply. Some unregulated states are so brief that they will not turn on the **Unr** annunicator, but they can set the UNR status bit during remote operation (see "Chapter 8 — Status Reporting").

Operating conditions that can cause unregulated operation are:

- Low ac line voltage
- Load demand that exceeds the programmed current
- Open load circuit while in CC mode

Unregulated operation may also be caused by overdriving the analog programming port or improper remote-sense operation. See "Chapter 4 — User Connections and Considerations."

SAVING AND RECALLING OPERATING STATES

You can save programming time by storing up to 5 power supply operating states in its nonvolatile memory. The front-panel programmable parameters that you can save are:

- Output voltage
- Output current
- OV protection voltage
- OCP state
- Output On/Off state

NOTE

Many more power supply parameters are saved in remote operation. See "Chapter 7 — Language Dictionary".

As an example, set up the following state:
Voltage output = 2.5
OV protection = 5
Current output = 10
OCP = on (**OCP** annunciator on)
Output On/Off = off (**Dis** annunciator on)

To save this state in location 1, press
[Save] [1] [Enter].

Now set up the following state:
Voltage output = 5.5
OV protection = 7.0
Current output = 25
OCP = off (**OCP** annunciator off)
Output On/Off = on (**Dis** annunciator off)

To save this state in location 2, press
[Save] [2] [Enter].

Recall state 1 by pressing [Recall] [1] [Enter] and verify the parameters.

Recall state 2 and verify the parameters. Note that the **OCP** and **Dis** annunciators are on for state 1 and off for state 2.

Whenever you turn on the power supply, it automatically asserts the state it finds in location 0. If you want the power supply to always turn on in a specific state, store that state in location 0.

IMPORTANT

The factory-default state is stored in location 0. Once you overwrite it, it will be lost. You can restore the power supply to the default state by sending the ***RST** *command over the HP-IB (See "Chapter 7—Language Dictionary"). If you want to change the turn-on state without losing the default state, save the default state in another location (for example, 4).*

SETTING THE HP-IB ADDRESS

Types of Power Supply HP-IB Addresses

Figure 2-2 in Chapter 2 shows the ways the power supply can be connected to the HP-IB bus. You can set up the power supply address in one of three ways:

1. As a stand-alone supply (the only supply at the HP-IB address). It has a primary address in the range 0 to 30. For example:
   5 or 7
2. As the direct supply in a serial link. It is the only supply connected directly to the HP-IB bus. It has a unique primary address and a zero secondary address. The primary address can be from 0 to 30 and is entered as an integer followed by a decimal separator. The zero secondary address may be added after the separator but if it is omitted, it will be assumed to be zero. For example:
   5. or **7.0**
3. As a linked supply in a serial link. It has a unique secondary address and gets its primary address from the direct supply. A secondary address can be from 1 to 15 and must be preceded by the decimal separator. For example:
   .1 or **.12**

When you enter a secondary address, leading zeros between the decimal separator and the first digit are ignored. For example, .1, .01, and .001 are all accepted as secondary address 1 and displayed as 0.01. Zeros following a digit are not ignored. Thus, .10 and .010 are accepted as secondary address 10 and displayed as 0.10.

Changing the Power Supply Address

Use the [Address] key and numerical keypad for entering addresses. The power supply is shipped with stand-alone address 5 as the default. The general procedure for setting an address is:

Action	**Display Shows**
Press [Address]	Current address
Press new address keys	New address replaces old number(s) on the display
Press [Enter]	Return to meter mode

If you try to enter a forbidden number, the display will show **ADDR ERROR**.

The following examples show how to set addresses:

Set stand-alone primary address **6**
Press [Address] [6] [Enter]

Set direct primary address **6**
Press [Address] [6] [·] [Enter]

Set secondary address **1**
Press [Address] [·] [1] [Enter]

Set secondary address **12**
Press [Address] [.] [1] [2] [Enter]

NOTE

The power supply display will reset (recall the state in location 0) whenever you change between the following types of addresses:
- *a stand-alone primary address and a direct primary address.*
- *a direct primary address and a secondary address.*

Remote Programming 6

HP-IB CAPABILITIES OF THE POWER SUPPLY

All power supply functions except for setting the HP-IB address are programmable over the HP-IB. The IEEE 488.1 capabilities of the power supplies are listed in Table 1-2.

INTRODUCTION TO SCPI

IMPORTANT!

Learn the basics of power supply operation (see Chapter 5) before using SCPI.

What is SCPI?

SCPI stands for *Standard Commands for Programmable Instruments.* It is a programming language for controlling instrument functions over the HP-IB (IEEE 488) instrument bus. SCPI is intended to function with *standard* HP-IB hardware and conforms to the IEEE Standard Digital Interface for Programmable Instrumentation. SCPI is layered on top of the hardware portion of IEEE 488.2. The same SCPI commands and parameters control the same functions in different classes of instruments. For example, you would use the same DISPLay command to control the power supply display state and the display state of a SCPI-compatible multimeter.

NOTE

TMSL (Test and Measurement System Language) and HPSL (Hewlett-Packard System Language) are earlier versions of SCPI. If you have used either of these languages, then you can probably go directly to "Chapter 7 - Language Dictionary."

What You Should Already Know

This manual does not assume that you know anything about SCPI or that you are a programmer. It is assumed that you do know:

- The basics of the Hewlett-Packard Interface Bus (HP-IB), also known as the IEEE 488 bus.
- How to program I/O (input/output) statements for an IEEE 488 bus instrument. From a programming view, the power supplies are simply IEEE 488 bus instruments.
- How to format ASCII data within your I/O statements. The SCPI commands are nothing more than ASCII data strings incorporated within those statements. The language you use (GW-BASIC, IBM BASIC, HP BASIC, Pascal, etc.) makes no difference to how you program in SCPI.
- The basic operating principles of the power supply as explained in "Chapter 5 - Front Panel Programming".

References

The following documents will assist you with programming in SCPI:

- [1]*Beginner's Guide to SCPI* HP Part No. H2325-90001.
  - Highly recommended for anyone who is not a programmer and who has not had previous SCPI or TMSL programming experience.
- [1]*Tutorial Description of the Hewlett-Packard Interface Bus* HP Part No. 5952-0156.
  - Highly recommended for those not experienced with the IEEE 488.1 and 488.2 standards.
- There are two formal documents concerning the HP-IB interface:
  - [2]*ANSI/IEEE Std 488.1-1987. IEEE Standard Digital Interface for Programmable Instrumentation.* Defines the technical details of the HP-IB interface. While much of the information is beyond the need of most programmers, it can be used to clarify formal definitions of terms used in this and related documents.
  - [2]*ANSI/IEEE Std 488.2-1987. IEEE Standard Codes, Formats, Protocols, and Common Commands.* Recommended as a reference if you will do fairly sophisticated programming. Helpful for finding the precise definitions of certain types of SCPI message formats, data types, or common commands.

[1]To obtain a copy, contact your local HP Sales Office.
[2]Available from IEEE (Institute of Electrical and Electronics Engineers), 345 East 47th Street, New York, NY 10017, USA.

CONVENTIONS

The following conventions are used throughout this chapter:

Angle brackets < >	The characters inside the brackets represent something other than themselves. For example, <NR1> represents a specific form of numerical data.

Braces { }	Braces indicate one of several parameters may be entered. For example, {0|**OFF**} shows that entering either **0** or **OFF** performs the same function.
Boldface	Boldface type is used to show command syntax in the text.
Computer font	Computer font is used to show actual program lines in the text.

If you are using HP BASIC, consult the *Interfacing Techniques* manual in the BASIC documentation. It is an excellent reference on instrument I/O for programmers using HP BASIC.

SCPI MESSAGES

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

- A *program message* goes from controller to power supply and consists of one or more properly formatted SCPI commands. The message gives the power supply an instruction to perform some action. The controller may send a program message at any time.

- A *response message* goes from power supply to controller and is a collection of data in a specific SCPI format. The data can be information concerning operating parameters, power supply state, or error conditions. The power supply may send a response message only when commanded by a program special message called a "query".

OVERVIEW OF SCPI COMMANDS

SCPI has two types of commands, common and subsystem (see Figure 7-1 and Figure 7-2 in "Chapter 7 - Language Dictionary").

Common Commands

Common commands generally are not related to specific device operation but to controlling overall power supply functions, such as identification, status, and synchronization. All common commands consist of a three-letter mnemonic preceded by an asterisk:

***IDN? *OPC *RST**

Subsystem Commands

Subsystem commands correspond to specific power supply functions. They are organized into an inverted tree structure with the "root" at the top (see Figure 7-2). Commands for specific functions, such as voltage, current, display state, etc. form the "branches" of the command tree.

STRUCTURE OF A MESSAGE

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

The Message Unit

The simplest SCPI command is a single message unit consisting of a command or query word (or keyword) followed by a message terminator:

ABORT<newline>
VOLTAGE?<newline>

The message unit may include a parameter after the keyword. The parameter usually is numeric, but it can be a string:

VOLT 20<newline>
VOLT? MAX<newline>

Combining Message Units

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

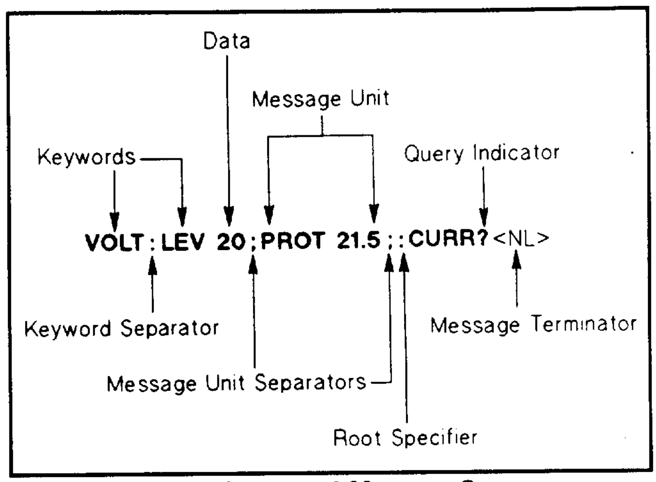


Figure 6-1. Command Message Structure

The basic parts of the above message are:

Message Component	**Example**
Keywords	VOLT LEV PROT CURR
Data	20 21.5
Message Units	VOLT:LEV 20 PROT 21.5
Message Unit Separators	The *semicolon* in VOLT:LEV 20;PROT 21.5
Keyword Separators	The *colon* in VOLT:LEV
Data Separators	The spaces in VOLT 20 and PROT 21.5
Root Specifiers	The *colon* in PROT 21.5;:CURR?
Query Indicator	The *question mark* in CURR?
Message Terminators	The <NL>(newline) indicator* * terminators are not part of SCPI syntax

THE PARTS OF A SCPI MESSAGE

Keywords

Keywords are the instructions recognized by the power supply's decoder, or "parser". Each keyword is descriptive of a command function. Figure 7-2 in Chapter 7 shows all the power supply keywords.

Forms of Keywords. Every keyword has two forms:

Long Form	The word is spelled out completely to identify its function. VOLTAGE, STATUS, DIGITAL, and TRIGGER are long-form keywords
Short Form	The word contains only the first three or four letters of the long form. VOLT, STAT, DIG, and TRIG are short-form keywords.

Short-form keywords are constructed according to the following rules:

- If the keyword consists of *four or fewer* letters, then all the letters are used.
  DATA MODE TEXT
- If the keyword consists of *five or more* letters and the fourth letter *is not* a vowel (a,e,i,o,u), then the *first four* letters are used.
  CURRent DISPlay STATus
- If the keyword consists of *five or more* letters and the fourth letter *is* a vowel (a,e,i,o,u), then only the *first three* letters are used.
  CLEar DIGital ERRor?

You must follow the above rules when using keywords. Creating an arbitrary short form, such as QUEST for QUESTIONABLE, will result in an error.

NOTE

The short form provides the fastest program execution.

Keyword Conventions. In keyword definitions and diagrams in this manual, the short-form part of each keyword is emphasized in **boldface** UPPER-CASE letters to help you remember it.

- **TRIG**ger
- **OUTP**ut
- **MEAS**ure

The SCPI parser (decoder) is **not** sensitive to case. It will accept *Trig, triG, trigger, TRIGGER, triGgER*, etc. Regardless of which form you use, you must spell out all the letters required by each form. For example, *tri* or *measur* will not be recognized.

Keyword Separator. If a command has two or more keywords, you must separate adjacent keywords with a colon(:):

- **VOLT:PROT**
- **OUTPut:RELay:POLarity**

Implied Keywords. When you look at Figure 7-2 or other examples of keywords, you will notice that some keywords are enclosed in brackets ([ ]). These are *implied* keywords because you can omit them and the power supply will respond as if they were included in the message. The following commands cause the same response from the power supply:

Syntax	*Permitted Form*
DIG:DATA[:VAL]?	DIG:DATA:VAL?
	DIG:DATA?
VOLT[:LEV][:IMM][:AMPL] 20	VOLT:LEV:IMM:AMPL 20
	VOLT:LEV:IMM 20
	VOLT:LEV 20
	VOLT:AMPL 20
	VOLT 20

IMPORTANT

*There are instances when an implied keyword **must** be included in order to properly combine two or more unit messages in a command message. This is explained under **Traversing the Command Tree**.*

Query Indicator. When a keyword is followed by a question mark (?), it becomes a query. If there is more than one keyword in the command, the query indicator follows the last keyword:

- **VOLT?**
- **CURR? MAX**
- **MEAS:CURR?**

Data

Some commands require data in numerical or character string form. Data types are explained under "SCPI Data Formats". Data always follows the last keyword of a command or query:

- **VOLT:PROT 20**
- **OUTP:PROT? MAX**

Data Separator

When a message unit includes data, you must separate it from the last keyword with a space:

- **VOLT:PROT 20**
- **OUTPut:RELay:POLarity NORMal**

Message Unit Separator

When two or more message units are combined in a command message, you must separate them with a semicolon (;)

- **VOLT 20;CURR 15**
- **DISP:STAT ON;MODE TEXT**
- **MEAS:VOLT?;CURR?**

IMPORTANT

*Only message units that are at the current path of the command tree can be combined with the semicolon. This is explained under **Traversing the Command Tree**.*

Root Specifier

When it precedes the first keyword of a message unit, the colon (:) becomes a *root specifier*. Its action places the parser (decoder) at the root or top node of the command tree. This is explained under "Traversing the Command Tree." For now, note the difference between using the colon as a root specifier and as a keyword separator:

VOLT:LEV:IMM:AMPL 8
All colons are keyword separators

:VOLT:LEV:IMM:AMPL 8
Only the first colon is a root specifier

VOLT:LEV 8;:CURR:LEV 25
Only the second colon is a root specifier

:INIT ON;:TRIG;:MEAS:CURR?;VOLT:DC?
The first three colons are root specifiers

Message Terminator

A terminator informs SCPI that it has reached the end of a message. There are three permitted message terminators:

- new line (<NL>), which is ASCII decimal 10 or hex 0A.
- end or identify (<END>), which is EOI.
- both of the above (<NL><END>).

Normally, a terminator is sent automatically by your HP-IB driver software. For example, the HP BASIC OUTPUT statement inserts <NL> after the last data byte. When binary data is exchanged, <END> must be used. The combination <NL><END> terminator is safe for all data *except* binary.

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

TRAVERSING THE COMMAND TREE

Figure 7-2 in "Chapter 7 - Language Dictionary" shows the subsystem command tree. Note the location of the root at the top node of the tree. The SCPI parser is at the root location whenever:

- The power supply is turned on.
- The power supply is reset.
- The parser encounters a message terminator.
- The parser encounters a root specifier.

Because the root-level keyword [**SOURce**] is implied, it moves the path down one level to also place **CURRent**, **DIGital**, and **VOLTage** at the root level.

Note that there are numerous paths, or "branches" starting from the root. The first keyword in each path is not preceded by a colon because that keyword is already at the root. The following are examples of root keywords:

MEASure **TRIGger** **SYSTem** **STATus**

Moving Within a Branch

There is an implied current path that moves down one level each time the parser encounters a keyword separator. As an example, look at the **DISPlay** branch. This is a root-level branch that has three sub-branches:

DISPlay[:STATe]
DISPplay:MODE
DISPplay:TEXT

Here is how the parser interprets various SCPI code:

DISP?<NL> Leaves the parser at the root because of the message terminator. Since **STAT** is implied, it may be omitted.

DISP:MODE; Moves the parser one level below **DISP**. The next command is expected at the level defined by the colon in front of **MODE**. That is why you can combine the following message units:
DISP:MODE TEXT;TEXT 'HELLO'<NL>

DISP:STAT; Leaves the parser at the same level as **DISP:MODE**. You *must* include the implied keyword in order to place the path at that position and make the following messages valid:
DISP:STAT ON;MODE TEXT<NL>
DISP:STAT ON;MODE:TEXT;TEXT 'HELLO'<NL>

Moving Among Branches

In order to access commands in different branches, you need to be aware of the current path, which is the level in the command tree where the parser expects to find the next command. This is important because the same keyword, such as **STATe**, appears in different paths.

NOTE

*The SCPI parser traverses the command tree as described in Appendix A of IEEE 488.2. The **Enhanced Tree Walking Implementation** given in that appendix is **not** implemented in the power supplies.*

To combine message units from different branches, make use of the root specifier.

VOLT:LEV 20;PROT 20.5;:CURR:LEV:IMM 15;TRIG 12.5<NL>

After **PROT 20.5**, the parser is not at the root. Placing the colon in front of the next keyword (**:CURR**) returns the current path to the top node. Note that the implied **LEV** keywords must be used in the above message.

When the parser is at the root, the following commands are both correct:

VOLT:LEV 20<NL>
:VOLT:LEV 20<NL>

You may omit the colon when you know the parser is at the root. If you are not sure, then put it in front of the root-level keyword.

Including Common Commands

You can include common commands (see Chapter 7) with subsystem commands in the same message. Treat the common command as a message unit by using the message unit separator (;). Common commands *do not affect the current path*; you may insert them anywhere in the message;

VOLT:TRIG 17;INIT;*TRG<NL>
OUTP OFF;*RCL 2;OUTP ON;MEAS:VOLT?;CURR?<NL>

SCPI QUERIES

Observe the following precautions with queries:

- Remember to set up the proper number of variables for the returned data.
- You must read back all the results of a query before sending another command message to the power supply. Otherwise, a *Query Interrupted* error will occur and the unread data will be lost.

VALUE COUPLING

Value coupling results when a command directed toward one parameter changes the value of another parameter. There is no direct value coupling among any power supply SCPI commands. However be aware that, until programmed, uninitialized trigger levels will assume the immediate levels. For example, if the power supply is powered up and **VOLT:LEV** is programmed to 30, then **VOLT:TRIG** will also be 30 until it is programmed to another value. Once you program **VOLT:TRIG**, it will remain at that level regardless of how many times you change **VOLT:LEV**.

SCPI DATA FORMATS

Each SCPI command that sends or requests parameters requires a specific format for the data. All data programmed to or returned from the power supply is ASCII. The data may be *numerical* or *character strings*.

Numeric Parameters

Numeric parameters are used with both common and subsytem commands.

Numerical Formats. SCPI recognizes the first four data types listed in Table 6-1. These are defined in *Section 7* of *IEEE 488.2*. As outlined in that document, SCPI uses the concept of forgiving listening and precise talking. Forgiving listening means that the power supply will accept the flexible <NRf> format listed in Table 6-1. Precise talking means that queries to the power supply always return data in a format specific to the query, such as <NR1>.

Extended Numerical Format. SCPI also recognizes the <NRf+> extended data type shown in Table 6-2. This allows the characters *MIN* and *MAX* to be entered for the minimum and maximum values that the parameter can be set to under the existing operating conditions. *MIN* and *MAX* are also used in query commands. The extended format cannot be used with common commands or Status Subsystem commands.

Discrete Parameters. Some program settings only have two or three finite values that are expressed with mnemonics. These discrete parameters have a long and short form, just like keywords. Some examples are:

ON **CONTinuous** **NORMal**

Numerical Data Suffixes and Multipliers. Numerical data may be followed by a suffix, or unit, that dimensions the data. A suffix may be preceded by a multiplier. *Section 7* of *IEEE 488.2* describes the approved data suffixes and multipliers. Where no suffix is entered, the dimension is implied by the syntax of the command. The power supplies make use of the suffixes and multipliers listed in Table 6-3.

Table 6-1. Numerical Data Formats

Symbol	Data Form
	Talking Formats
<NR1>	Digits with no decimal point. The decimal point is assumed to be to the right of the least-significant digit. For example, **273** , **0273**
<NR2>	Digits with a decimal point. E.g., **273.**, **27.3** , **.0273**
<NR3>	Digits with a decimal point and an exponent. E.g., **2.73E+2** , **2.73E-2**
	Listening Format
<NRf>	Extended format that includes <NR1>, <NR2> , and <NR3>. For example, **273** , **27.3**, **2.73E+2**

Table 6-2. Extended Numerical Data Format

Symbol	Data Form
<NRf+>	Expanded decimal form that includes <NRf> and **MIN** , **MAX**. For example, **273** , **27.3** , **2.73E-2** , **MIN** , **MAX**. **MIN** and **MAX** are the minimum and maximum limit values for the parameter and are implicit in the range specification for the parameter.

Table 6-3. Suffix Elements and Multipliers

Suffix Elements			
Class	**Suffix**	**Unit**	**Unit with Multiplier**
Current	A	Ampere	MA (milliampere)
Time	S	second	MS (millisecond)
Amplitude	V	Volt	MV (millivolt)
Common Multipliers			
1E3	K	kilo	
1E-3	M	milli	
1E-6	U	micro	

Boolean Parameters

Either form *{1|0}* or *{ON|OFF}* may be sent with commands. Queries always return *1* or *0*.

```
OUTPut OFF
OUTPut 0
CURRent:PROTection ON
CURRent:PROTection 1
```

Character Data Formats

For query statements, character strings may be returned in either of the forms shown in Table 6-4, depending on the length of the returned string.

Table 6-4. Query Character String Formats

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

NOTE

The IEEE 488.2 format for a string parameter requires that the string be enclosed in either single (' ') or double (" ") quotes. Be certain that your program provides these characters around the string.

EXAMPLES

The examples given here are generic, that is, without regard to the actual programming language or HP-IB interface used. That is because SCPI commands are sent as output strings within the programming language and the SCPI syntax does not change with the language or interface.

NOTE

The examples are followed by sample program code written for three popular types of BASIC-controlled HP-IB interfaces .

Controlling Output

IMPORTANT

The power supplies respond simultaneously to both HP-IB programming and local analog programming (see "External Voltage Control" in "Chapter 4 - User Connections and Considerations"). If the power supply is receiving both inputs, remember that the actual output will be the algebraic sum of the two.

Programming Voltage and Current. The following statements program voltage and current and return the actual output at the sense terminals.

VOLT 15;CURR 10	*Program the voltage and current*
VOLT?;CURR?	*Read back the programmed levels*
MEAS:VOLT?;CURR?	*Read back outputs at sense terminals*

Programming Protection Circuits. This example programs output voltage and current, an overvoltage protection value and sets the overcurrent protection to ON. It then reads back the programmed values.

Program voltage and overvoltage protection
VOLT:LEV 15;PROT 15.5

Program current and current protection
CURR:LEV 10;PROT:STAT ON

Return programmed values
VOLT:LEV?;PROT?;:CURR:LEV?;PROT:STAT?

Changing Outputs by Trigger. If you do not program trigger levels, they will default to the programmed output levels. Once programmed, the triggered level remains at that level regardless changes that you make to the output level.

Program immediate and triggered output voltage and current levels
VOLT:LEV 20;TRIG 15;:CURR:LEV 20;TRIG 15

Check programmed values
VOLT:LEV?;TRIG?;:CURR:LEV?;TRIG?

Read outputs at sense terminals
MEAS:VOLT?;CURR?

Arm the trigger circuit and send trigger
INIT;TRIG

Another way to send a trigger
INIT;*TRG

Read outputs after the trigger
MEAS:VOLT?;CURR?

If you are going to send two or more triggers, you can make the trigger function continuous.

Set continuous trigger
INIT:CONT ON

Program immediate and triggered voltage levels
VOLT:LEV 20;TRIG 10

Change output voltage to triggered level
TRIG

Restore output voltage to previous level
VOLT:TRIG 20;:TRIG

Turn off continuous trigger
INIT:CONT OFF

Saving and Recalling States

You can remotely save or recall operating states. See ***SAV** and ***RCL** in "Chapter 7 - Language Dictionary" for the parameters that are saved and recalled.

NOTE

When a power supply is delivered, location 0 stores the factory defaults.

Program the desired state
CURR:LEV 20;PROT:STAT ON
VOLT:LEV 12.5;PROT 13
OUTP:REL:STAT ON;POL REV
OUTP OFF

Save the state in location 3
*SAV 3
(Later) recall the same state
*RCL 3

Writing to the Display

You can include messages to the LCD in your programs. The description of **DISP:TEXT** in "Chapter 7 - Lanaguage Dictionary" shows the types and number of permitted characters.

Switch the display to the text mode
DISP:MODE TEXT

Send RECALLED 2 to the display
DISP:TEXT "RECALLED 2"

Return display to the normal mode
DISP:MODE NORM

Programming Status

"Chapter 8 - Status Reporting" explains the functions and bit configurations of all status registers. Refer to Figure 8-1 in that chapter while examining the following examples.

Detecting Changes via SRQ. Generally you will want the power supply to generate interrupts only on particular events. This means that you must selectively enable the required register bits. The following program statements allow the power supply to assert SRQ under selected conditions:

1. *Assert SRQ only when the power supply switches between CV and CC modes:*
   STAT:COND:ENAB 1280;PTR 1280;*SRE 128
2. *Assert SRQ only when the power supply enters or leaves calibration mode:*
   STAT:COND:ENAB 1;PTR 1;NTR 1;*SRE 128
3. *Assert SRQ only when power supply output is unregulated:*
   STAT:QUES:ENAB 1024;PTR 1024;*SRE 8
4. *Assert SRQ under any conditions in* **1.** *or* **3.**, *above.*
   COND:ENAB 1280;PTR 1280;:STAT:QUES:ENAB 1024;PTR 1024;*SRE 136

Reading Specific Registers. You can exercise program control without interrupts by reading specific registers.

Enable all conditions of the Operation Status register and read the events
STAT:OPER:PTR 32;EVEN?

Enable only CV and CC bits and read their states
STAT:OPER:PTR 1280;EVEN?

Read enabled states and events of Operation Status, Questionable Status, and Status Byte registers
STAT:QUES;ENAB?;EVEN?;:STAT:OPER:ENAB?;EVEN?;
*SRE?;*STB?

NOTE

The above query string can be handled without difficulty. If you should enter too many queries, the system will return a "Query DEADLOCKED" error (-430). In that case, break the string into smaller commands.

Controlling the Digital I/O Ports

Digital control ports 1 and 2 are TTL outputs that can be programmed either high or low. Control port 3 can be programmed to be either a TTL output or TTL input. (See **DIG:DATA;[:VAL]** in "Chapter 7- Language Dictionary" for the port bit configurations). Send a decimal value that translates into the desired straight binary code for the three ports.

Set output ports 1 and 2 high; make port 3 another output
DIG:DATA 3

Read back the port configuration
DIG:DATA?

Set output ports 1 and 2 high; make port 3 an input
DIG:DATA 7

SAMPLES

Introduction

The end of this chapter has some samples of programming code for three popular types of HP-IB interfaces controlled in the BASIC programming language. These are:

1. HP Vectra PC controller with HP 82335A HP-IB Interface Command Library
2. IBM PC controller with National Instruments GP-PCII Interface/Handler
3. HP controller with HP BASIC Language System.

Assigning the HP-IB Address in Programs

The power supply address cannot be set remotely. You must set it from the front panel. The address can be stand-alone, direct, or linked. See *HP-IB Address* in "Chapter 3- Turn-On Checkout" for the details of address setting.

The following examples assume that the HP-IB select code is 7, the power supply address is 6, and the address will be assigned to some form of the variable *PS*.

```
1055 !Stand-alone address. The supply will respond if it
1160 !is set to 6
1065 PS=706                    !HP 82335A Interface
1070 ASSIGN @PS TO 706         !HP BASIC Interface
1080 !Direct address. The supply will respond if it is set
1085 !to 6.0 or 6.
1090 PS1=70600                 !HP 82335A Interface
1095 ASSIGN @PS1 TO 70600      !HP BASIC interface
1100 !Linked address. Supply will respond if it is set to
1105 !address .1 and is serially connected to a
1110 !supply at direct address 6.0
1115 PS2=70601                 !HP 82335A Interface
1120 ASSIGN @PS2 TO 70601      !HP BASIC Interface
1130 !Linked address. Supply will respond if it is set to
1135 !address .12 and is serially connected to a
1140 !supply at direct address 6.0
1145 PS3=70612                 !HP 82335A Interface
1150 ASSIGN @PS3 TO 70612      !HP BASIC Interface
```

HP Vectra DOS Driver

For GW-BASIC programming, the HP-IB library is implemented as a series of subroutine calls. To access these subroutines, your application programs must include the file SETUP.BAS, which is part of the HP 82335A DOS Driver software. SETUP.BAS acts as a header for entry points to the subroutine calls. As provided with the interface package, SETUP.BAS starts at line 5 and can run anywhere up to line 999. Your application program must always begin at line 1000.

Error Handling. If there is no error handling code in your program, undetected errors can cause unpredictable results. With DOS systems, this can include "hanging up" the controller, forcing you to reset the system.

IMPORTANT

Use error detection after every call to a bus subroutine.

HP 82335A DOS Driver. For this system, SETUP.BAS has built-in error checking routines that provide a method to check for HP-IB errors during program execution. You can use the error-trapping code in these routines or write your own code using the same variables as used by SETUP.BAS.

National Instruments DOS Driver

The National Instruments DOS Driver software uses the header file DECL.BAS. This contains the initialization code for the interface.

You application program will not include the power supply symbolic name and HP-IB address. These must be specified during configuration (when you run IBCONF.EXE). Note that the primary address range is from 0 to 30 but any secondary address must be specified in the address range of 96 to 126. The power supply expects a message termination on EOI or line feed, so set *EOI w/last byte of Write.* It is also recommended that you set *Disable Auto Serial Polling.*

For this system, all function calls return the status word *IBSTA%*, which contains a bit (ERR) that is set if the call results in an error. When ERR is set, the appropiate error code is placed in variable *IBERR%*. Be sure to check *IBSTA%* after every function call. If it is not equal to zero, branch to an error handler that reads *IBERR%* to extract the specific error.

HP BASIC Controllers

When programming in HP BASIC, you do not have to worry about bus "hang ups" as long as your program contains a timeout statement. Since the power supply can be programmed to generate SRQ on errors, your program can use an SRQ service routine to decode the error. Some details were given under "Programming Status".

Sample Program Code

The sample code uses both long-form and short-form keywords to show they are interchangeable. The code is not a complete program, but merely shows how some of the same power supply functions can be programmed to all three of the previously mentioned interfaces.

SAMPLE PROGRAMS FOR POWER SUPPLY WITH 1-OHM LOAD AT STAND-ALONE ADDRESS 6. SEQUENCE SETS UP CV MODE OPERATION, FORCES SUPPLY TO SWITCH TO CC MODE, AND DETECTS AND REPORTS MODE CHANGE.

```
     *************************************************************
            HP Vectra PC Controller Using HP 82335A Interface
     *************************************************************
5     ' <--------------- Merge SETUP.BAS here ------------------->
595   ' <-------------------------------------------------------->
1000  MAX.ELEMENTS=2 :ACTUAL.ELEMENTS=0 :MAX.LENGTH=80 :ACT.LENGTH=0
1005  DIM OUTPUTS(2) :CODES$=SPACE$(40)
1010  ISC=7 :PS=706
1015  '
1020  'Set up the Power Supply Interface for DOS driver
1025  CALL IORESET (ISC)                                 'Reset the interface
1030  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1035  TIMEOUT=3
1040  CALL IOTIMEOUT (ISC, TIMEOUT)                 'Set timeout to 3 seconds
1045  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1050  CALL IOCLEAR (ISC)                                 'Clear the interface
1055  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1060  CALL IOREMOTE (ISC)                   'Set Power Supply to remote mode
1065  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1070  '
1075  'Program power supply to CV mode with following voltage and current
1080  CODES$ = "VOLTAGE 15;CURRENT 18"   :GOSUB 2000
1085  '
1090  'Query power supply outputs & print to screen
1095  CODES$ = "MEASURE:VOLTAGE?;CURRENT?"   :GOSUB 2000  :GOSUB 3000
1100  VOUT = OUTPUTS(1)
1105  IOUT = OUTPUTS(2)
1110  PRINT "The output levels are "VOUT" Volts and "IOUT" Amps"
1115  '
1120  'Program triggered current level to value insufficient to maintain
1125  'supply within its CV operating characteristic
1130  CODES$ = "CURR:TRIG 10"   :GOSUB 2000
1135  '
1140  'Set operation status mask to detect mode change from CV to CC
1145  CODES$ = "STAT:OPER:ENAB 1024;PTR 1024"    :GOSUB 2000
1150  '
1155  'Enable Status Byte OPER summary bit
1160  CODES$ = "*SRE 128"   :GOSUB 2000
1165  '
1170  'Arm trigger circuit and send trigger to power supply
1175  CODES$ = "INITIATE;TRIGGER"    :GOSUB 2000
1180  '
1185  'Wait for supply to respond to trigger
1190  FOR I= 1 to 100  :NEXT I
1195  '
1200  'Poll for interrupt caused by change to CC mode and print to screen
1205  CALL IOSPOLL (PS,RESPONSE)
1210  IF (RESPONSE AND 128)<>128 THEN GOTO 1240    'No OPER event to report
1215  CODES$ = "STATUS:OPER:EVEN?"  :GOSUB 2000 'Query status oper register
1220  CALL IOENTER (PS,OEVENT)                         'Read back event bit
1225  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1230  IF (OEVENT AND 1024) = 1024 THEN PRINT "Supply switched to CC mode."
1235  '
1240  'Clear the status circuit
1245  CODES$ = "*CLS"   :GOSUB 2000
1250  FOR I = 1 TO 100  :NEXT I                   'Wait for supply to clear
1255  '
1260  'Disable output and save present state in location 2
1265  CODES$ = "OUTPUT OFF;*SAV 2"   :GOSUB 2000
1270  END
1275  '
2000  'Send command to power supply
2005  LENGTH = LEN(CODES$)
2010  CALL IOOUTPUTS (PS,CODES$,LENGTH)           'Send command to interface
2015  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR      'SETUP.BAS error trap
2020  RETURN
```

Figure 6-2. Programming Some Power Supply Functions

```
2025  '
3000  'Get data from power supply
3005  CALL IOENTERA (PS,OUTPUTS(1),MAX.ELEMENTS,ACTUAL.ELEMENTS)
3010  IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
3015  RETURN
***************************************************************************
               IBM Controller Using National Interface
***************************************************************************
985   ' ---------------------------------------------------------------------
990   ' -------------------- Merge DECL.BAS here ----------------------------
995   ' ---------------------------------------------------------------------
1000  'Power Supply Variable = PS% ; Stand-Alone Address = 706
1005  CODES$=SPACE$(50):MODE$=SPACE$(5):OEVENT$=SPACE$(20)
1010  D$=SPACE$(60):OUTPUT$=SPACE$(40):BDNAME$="PS%"
1015  DIM OUTPUT(2)
1020  '
1025  'Set up power supply interface for DOS driver
1030  CALL IBFIND(BDNAME$,PS%)
1035  IF PS%<0 THEN PRINT "IBFIND Failed."
1040  CALL IBCLR(PS%)
1045  '
1050  'Program power supply to CV mode with following voltage and current
1055  CODES$ = "VOLTAGE 15;CURRENT 18"   :GOSUB 2000
1060  '
1065  'Query power supply outputs and print to screen
1070  CODES$ = "MEASURE:VOLTAGE?;CURRENT?"   :GOSUB 2000   :GOSUB 3000
1075  VOUT = OUTPUT(1)
1080  IOUT = OUTPUT(2)
1085  PRINT"The programmed levels are "VOUT" Volts and "IOUT" Amps"
1090  '
1095  'Program triggered current level to value insufficient to maintain
1100  'supply within its CV operating characteristic
1105  CODES$ = "CURR:TRIG 10"    :GOSUB 2000
1110  '
1115  'Set operation status mask to detect mode change from CV to CC
1120  CODES$ = "STAT:OPER:ENAB 1024;PTR 1024"   :GOSUB 2000
1125  '
1130  'Enable Status Byte OPER summary bit
1135  CODES$ = "*SRE 128"   :GOSUB 2000
1140  '
1145  'Arm trigger circuit and send trigger to power supply
1150  CODES$ = "INITIATE;TRIGGER"   :GOSUB 2000
1155  '
1160  'Wait for supply to respond to trigger
1165  FOR I= 1 to 100   :NEXT I
1170  '
1175  'Poll for interrupt caused by change to CC mode and print to screen
1180  SPOL%=0
1185  CALL IBRSP(PS%,SPOL%)
1190  IF (SPOL% AND 128) = 128 THEN POLL = 1 'Set interrupt flag on OPER bit
1195  IF POLL <> 1 THEN GOTO 1230                 'No interrupt to service
1200  "CODES$ = "STAT:OPER:EVEN?"  :GOSUB 2000   'Query status oper register
1205  CALL IBRD(PS%,OEVENT$)                             'Read back event bit
1210  IF IBSTA% <0  THEN GOTO 2100
1215  OEVENT=VAL(OEVENT$)
1220  IF (OEVENT AND 1024) = 1024 THEN PRINT "Supply switched to CC mode."
1225  '
1230  'Clear status circuit
1235  CODES$="*CLS"   :GOSUB 2000
1240  FOR I=1 TO 50   :NEXT I                     'Wait for supply to clear
1245  '
1250  'Disable output and save present state to location 2
1255  CODES$ = "OUTPUT OFF;*SAV 2"  :GOSUB 2000
1260  END
1265  '
2000 'Send command to power supply
2005  CALL IBWRT(PS%,CODES$)
2010  IF IBSTAT% < 0  THEN GOTO 2100                         'Error detected
2015  RETURN
```

Figure 6-2. Programming Some Power Supply Functions (continued)

```
2020  '
2100  'Error detection routine
2105  PRINT "GPIB error. IBSTAT% = &H";HEX$(IBSTAT%)
2110  PRINT "             IBERR%  =   ";IBERR%" in line ";ERL
2115  STOP
2120  '
3000  'Get data from power supply
3005  CALL IBRD(PS%,OUTPUT$)
3010  IF IBSTA% < 0 THEN GOTO 2100
3015  I=1                                                  'Parse data string
3020  X=1
3025  C=INSTR(I,OUTPUT$,";")
3030  WHILE C<>0
3035   D$=MID$(OUTPUT$,I,C-I)
3040   OUTPUT(X)=VAL(D$)                                        'Get values
3045   I=C+1
3050   C=INSTR(I,OUTPUT$,";")
3055   X=X+1
3060  WEND
3065  D$=RIGHT$(OUTPUT$,LEN(OUTPUT$)-(I-1))
3070  OUTPUT(X)=VAL(D$)
3075  OUTPUT$=SPACE$(40)                                     'Clear string
3080  RETURN
***************************************************************************
               Controller Using HP BASIC
***************************************************************************
1000  !Power Supply at Stand-Alone Address = 706
1005  OPTION BASE 1
1010  DIM Codes$[80],Response$[80],Mode$[32]
1015  !
1020  !Set up the power supply interface
1025  RESET Isc:CLEAR Isc:REMOTE Isc
1030  !
1035  !Program power supply to CV mode with following voltage and current
1040  OUTPUT 706;"VOLTAGE 15;CURRENT 18"
1045  !
1050  !Query power supply outputs and print to screen
1055  OUTPUT 706;"MEASURE VOLTAGE?;CURRENT?"          !Query output levels
1060  ENTER 706;Vout,Iout
1065  PRINT "The output levels are ";Vout;" Volts and ";Iout" Amps"
1070  !
1075  !Program current triggered level to value insufficient to maintain
1080  !supply within its CV operating characteristic
1085  OUTPUT 706;"CURR:TRIG 10"
1090  !
1095  !Set operation status mask to detect mode change from CV to CC
1100  OUTPUT 706;"STAT:OPER:ENAB 1280;PTR 1280"
1105  !
1110  !Enable Status Bype OPER summary bit
1115  OUTPUT 706;"*SRE 128"
1120  !
1125  !Arm trigger circuit and send trigger to power supply
1130  OUTPUT 706;"INITIATE;TRIGGER"
1135  !
1140  !Wait for supply to respond to trigger
1145  WAIT .5
1150  !
1155  !Poll for interrupt caused by change to CC mode and print to screen
1160  Response=SPOLL(706)
1165  IF NOT BIT (Response,7) THEN GOTO 1090          !No OPER event to report
1170  OUTPUT 706;"STAT:OPER:EVEN?"            !Query status operation register
1175  ENTER 706;Oevent                                  !Read back event bit
1180  IF BIT(Oevent,10) THEN PRINT "Supply switched to CC mode."
1085  !
1090  !Clear status circuit
1095  OUTPUT 706;"*CLS"
1100  WAIT .5                                       !Wait for supply to clear
1105  !
1110  !Disable output and save present state in location 2
1115  OUTPUT 706;"OUTPUT OFF;*SAV 2"
```

Figure 6-2. Programming Some Power Supply Functions (continued)

Language Dictionary 7

INTRODUCTION

This section gives the syntax and parameters for all the IEEE 488.2 common commands and SCPI commands used by the power supplies. It is assumed that you are familiar with the material in "Chapter 6—Remote Programming". That chapter explains the terms, symbols, and syntactical structures used here and gives an introduction to programming. You should also be familiar with "Chapter 5—Front Panel Programming" in order to understand how the power supply functions.

The programming examples are simple applications of the commands. A command functions the same way in all the power supplies. Since SCPI syntax remains the same for all programming languages, the examples are generic.

Keywords

Syntax definitions use the long form, but both long and short form keywords appear in the examples. If you have any concern that the meaning of a keyword in your program listing will not be obvious at some later time, then use the long form to help make your program self-documenting.

Parameters

Most commands require a parameter and all queries will return a parameter. The range for a parameter may vary according to the model of power supply. Programming parameters for all current models are listed in Table 1-3 in Chapter 1.

Related Commands

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

Order of Presentation

The dictionary is organized as follows:
- IEEE 488.2 common commands, in alphabetical order
- Subsystem commands

COMMON Commands

Common commands begin with an * and consist of three letters (command) or three letters followed by a ? (query). *Common* commands are defined by the IEEE 488.2 standard to perform some common interface functions. The power supplies respond to the 13 required common commands that control status reporting, synchronization, and internal operations. The supplies also respond to five optional common commands controlling triggers, power-on conditions, and stored operating parameters. The description for each common command or query specifies any status registers affected. In order to make use of this information, you must refer to "Chapter 8—Status Reporting", which explains how to read specific register bits and use the information that they return.

Figure 7-1 shows the common commands and queries, which are presented in alphabetical order. If a command has a corresponding query that simply returns the data or status specified by the command, then both command and query are included under the explanation for the command. If a query does not have a corresponding command or is functionally different from the command, then the query is listed separately.

Subsystem Commands

Subsystem commands are those that are specific to the power supply functions. They can be a single command or a group of commands. The groups are comprised of commands that extend one or more levels below the root. Subsystem commands are listed in alphabetical order and the commands within each subsystem are grouped alphabetically under the subsystem. Calibration commands are not included, but are in Appendix A of this manual.

Figure 7-2 is a tree diagram of the subsystem commands. Commands followed by a question mark (?) take only the query form. Except as noted in the syntax desciptions, all other commands take both command and the query form.

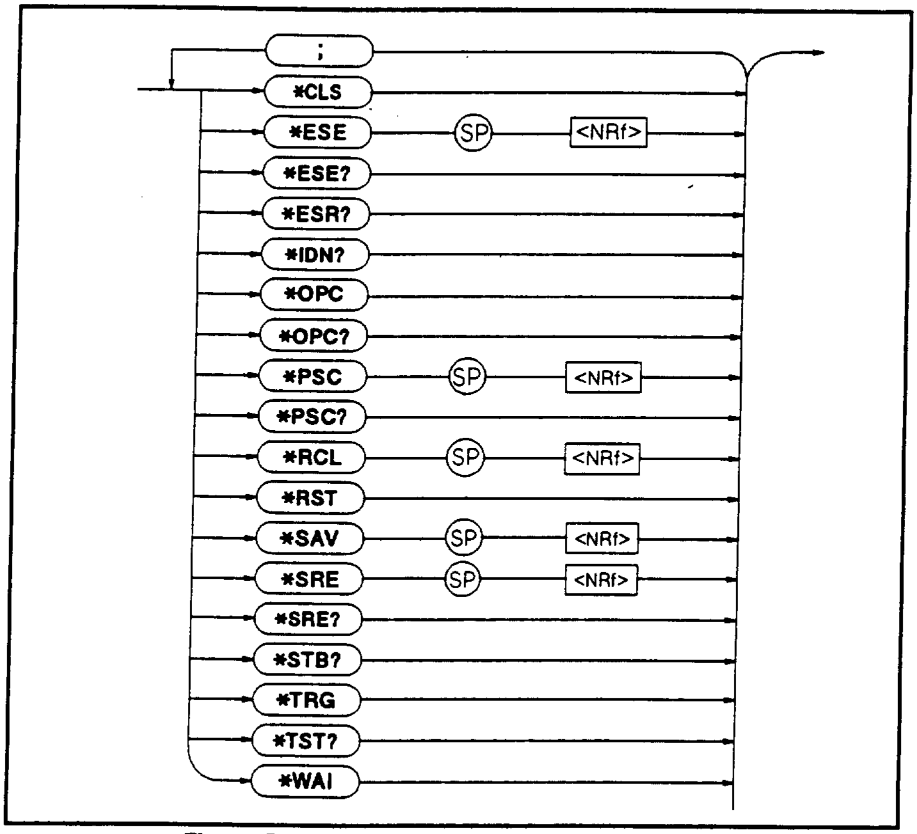


Figure 7-1. Common Commands Syntax Diagram

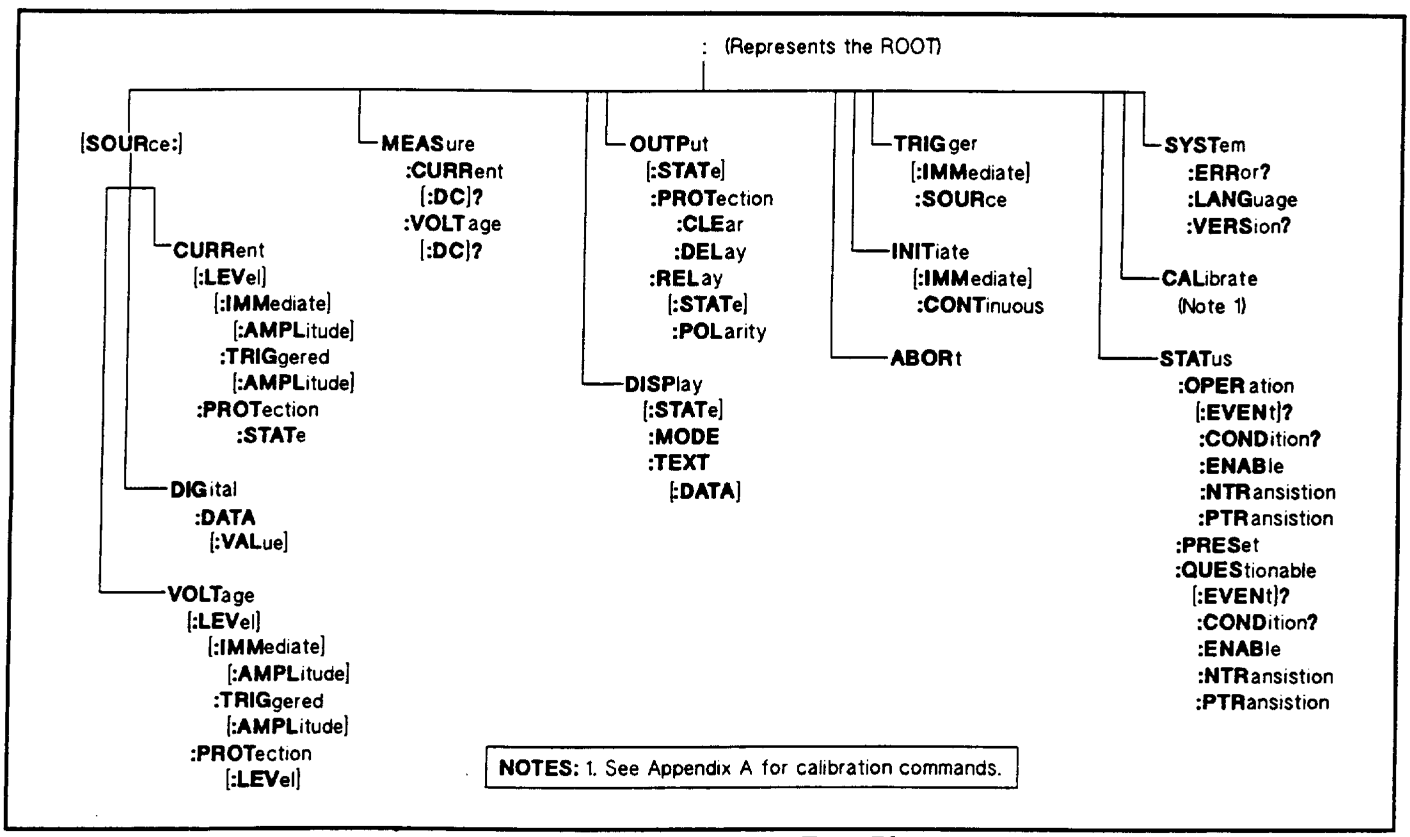


Figure 7-2. Subsystem Tree Diagram

*CLS

Meaning and Type

Clear Status Device Status

Description

This command causes the following actions (see "Chapter 8 - Status Reporting" for descriptions of all registers):

- Clears the following registers:
  - Standard Event
  - Operation Status Event
  - Questionable Status Event
  - Status Byte
- Clears the Error Queue
- Forces a previously executed ***OPC** command to appear as if it had been completed. It does *not* do this with the ***OPC?** command (see ***OPC?** for more details).
- If ***CLS** immediately follows a program message terminator (<NL>), then the output queue and the MAV bit are also cleared.

Command Syntax	*CLS
Parameters	(None)
Query Syntax	(None)
Related Commands	*OPC *OPC?

*ESE

Meaning and Type

Event Status Enable Device Status

Description

This command programs the Standard Event Status Enable register bits. The programming determines which events of the Standard Event Status Event register (see ***ESR?**) are allowed to set the ESB (Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event. All of the enabled events of the Standard Event Status Event Register are logically ORed to cause the ESB (bit 5) of the Status Byte Register to be set. See "Chapter 8 - Status Reporting" for descriptions of all three registers.

Bit Configuration of Standard Event Status Enable Register

Bit Position	7	6	5	4	3	2	1	0
Bit Name	PON	0	CME	EXE	DDE	QYE	0	OPC
Bit Weight	128	64	32	16	8	4	2	1
	CME=Command error; DDE=Device-dependent error; EXE=Execution error; OPC=Operation complete; PON=Power-on; QYE=Query error							

Command Syntax	*ESE <NRf>
Parameters	0 to 255
Power On Value	(See *PSC)
Suffix	(None)
Example	*ESE 129
Query Syntax	*ESE?
Returned Parameters	<NR1> (Register value)
Related Commands	*ESR? *PSC *STB?

Caution If PSC is programmed to *0*, then the *ESE command causes a write cycle to nonvolatile memory. The nonvolatile memory has a finite maximum number of write cycles (see "Table 1-2, Supplementary Characteristics"). Programs that repeatedly cause write cycles to nonvolatile memory can eventually exceed the maximum number of write cycles and may cause the memory to fail.

*ESR?

Meaning and Type

Event Status Register Device Status

Description

This query reads the Standard Event Status Event register. Reading the register clears it. The bit configuration of this register is the same as the Standard Event Status Enable register (*ESE). See "Chapter 8 - Status Reporting" for a detailed explanation of this register.

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

*IDN?

Identification Query

Meaning and Type

Identification System Interface

Description

This query requests the power supply to identify itself. It returns a string composed of four fields separated by commas.

Query Syntax	*IDN?	
Returned Parameters	<AARD>	
	String	**Information**
	Hewlett-Packard	Manufacturer
	xxxxA	4-digit model number followed by a letter suffix
	nnnnA-nnnnn	10-character serial number or *0*
	<R>.xx.xx	Revision levels of firmware
Example	HEWLETT-PACKARD,0,6654A,A.01.01	
Related Commands	(None)	

*OPC

Meaning and Type

Operation Complete Device Status

Description

This command causes the interface to set the OPC bit (bit 0) of the Standard Event Status register when the power supply has completed all pending operations. (See ***ESE** for the bit configuration of the Standard Event Status register.) *Pending operations* are complete when:

- all commands sent before ***OPC** have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands that affect output voltage, current or state, relays, and trigger actions are overlapped with subsequent commands sent to the power supply. The ***OPC** command provides notification that all overlapped commands have been completed.
- any change in the output level caused by previous commands has been completed (completion of settling time, relay bounce, etc.)
- all triggered actions are completed

***OPC** does not prevent processing of subsequent commands but Bit 0 will not be set until all pending operations are completed.

Command Syntax	*OPC
Parameters	(None)
Related Commands	*OPC? *WAI

*OPC?

Meaning and Type

Operation Complete Device Status

Description

This query causes the interface to place an ASCII "1" in the Output Queue when all pending operations are completed. *Pending operations* are as defined for the ***OPC** command. Unlike ***OPC**, ***OPC?** prevents processing of all subsequent commands. ***OPC?** is intended to be used at the end of a command line so that the application program can then monitor the bus for data until it receives the "1" from the power supply Output Queue.

Caution Do not follow ***OPC?** with ***TRG** or HP-IB bus triggers. Such triggers sent after ***OPC?** will be prevented from executing and will prevent the power supply from accepting further commands. If this occurs, the only programmable way to restore operation is by sending the power supply a HP-IB **DCL** (Device Clear) command.

Query Syntax	*OPC?	
Returned Parameters	<NR1>	ASCII *1* is placed in the Output Queue when the power supply has completed operations.
Related Commands	*OPC *TRIG *WAI	

*PSC

Meaning and Type
Power-on Status Clear Device Initialization

Description
This command controls the automatic clearing at power turn-on of:

- the Service Request Enable register
- the Standard Event Status Enable register

If the command parameter = *1*, then the above registers are cleared at power turn on. If the command parameter = *0*, then the above registers are not cleared at power turn on but are programmed to their last state prior to power turn on. This is the most common application for *PSC and enables the power supply to generate an SRQ (Request for Service) at power on.

Command Syntax	*PSC <bool>
Parameters	0|1|OFF|ON
Example	`*PSC 0` `*PSC 1`
Query Syntax	*PSC?
Returned Parameters	<NR1> 0|1
Related Commands	*ESE *SRE

Caution *PSC causes a write cycle to nonvolatile memory. If *PSC is programmed to *0*, then the *ESE and *SRE commands also cause a write cycle to nonvolatile memory. The nonvolatile memory has a finite number of write cycles (see "Table 1-2, Supplementary Characteristics"). Programs that repeatedly write to nonvolatile memory can eventually exceed the maximum number of write cycles and may cause the memory to fail

*RCL

Meaning and Type
Recall Device State

Warning **Recalling a previously stored state may place hazardous voltage at the power supply output.**

Description
This command restores the power supply to a state that was previously stored in memory with the *SAV command to the specified location. The following states are recalled:

CURR[:LEV][:IMM]	OUTP[:STAT]	OUTP:REL:POL
CURR:PROT:STAT	OUTP:PROT:DEL	VOLT[:LEV][:IMM]
DIG:DATA[:VAL]	OUTP:REL[:STAT]	VOLT:PROT[:LEV]

Sending ***RCL** also does the following:

- forces an **ABORt** command before resetting any parameters (this cancels any uncompleted trigger actions)
- disables the calibration function by setting **CAL:STATe** to **OFF**
- sets display functions as follows:
  - **DISP[:WIND][:STATe]** to **ON**
  - **DISP[:WIND]:MODE** to **NORMal**
  - **DISP[:WIND]:TEXT** to ' '
- sets **INIT:CONT** to **OFF**
- sets **TRIG:SOUR** to **BUS**

At power turnon, the equivalant of an ***RCL 0** is executed to restore the power supply to the state stored in location 0.

Command Syntax	***RCL <NRf>**
Parameters	0|1|2|3|4
Example	`*RCL 3`
Query Syntax	(None)
Related Commands	***PSC** ***RST** ***SAV**

*RST

Meaning and Type

Reset Device State

Description

This command resets the power supply to a factory-defined state as defined below. ***RST** also forces an **ABORt** command.

COMMAND	STATE
CAL:STAT *OFF*	**OUTP** *OFF*
CURR[:LEV][:IMM] *	**OUTP:PROT:DEL** *
CURR[:LEV]:TRIG *	**OUTP:REL** *OFF*
CURR:PROT:STAT *OFF*	**OUTP:REL:POL** *NORM*
DIG:DATA *0*	**TRIG:SOUR** *BUS*
DISP[:WIND]:STAT *ON*	**VOLT[:LEV][:IMM]** *
DISP[:WIND]:MODE *NORM*	**VOLT[:LEV][:TRIG]** *
DISP[:WIND]:TEXT *' '*	**VOLT:PROT[:LEV]** *
INIT:CONT *OFF*	

* Model-dependent value. See Table 1-3 in Chapter 1.

Command Syntax	***RST**
Parameters	(None)
Query Syntax	(None)
Related Commands	***PSC** ***SAV**

*SAV

Meaning and Type

SAVE Device State

Description

This command stores the present state of the power supply to the specified location in memory. Up to five states can be stored. Location *0* holds the device state that is automatically recalled at power turn-on. If no state has been saved to location *0*, then it will still contain its reset state (see ***RST**).

Note When a state is stored in location *0*, the reset state is written over. It can be recovered by programming ***RST** and saving the resultant state to another location.

The following power supply parameters are stored by ***SAV**:

CURR[:LEV][:IMM]	OUTP[:STAT]	OUTP:REL:POL
CURR:PROT:STAT	OUTP:PROT:DEL	VOLT[:LEV][:IMM]
DIG:DATA[:VAL]	OUTP:REL[:STAT]	VOLT:PROT[:LEV]

Command Syntax	*SAV <NRf>
Parameters	0|1|2|3|4
Example	SAV 3
Query Syntax	(None)
Related Commands	*RCL *RST

Caution The power supply uses nonvolatile memory for recording register states. Programs that repeatedly use ***SAV** for recalling states cause frequent write cycles to the memory and can eventually exceed the maximum number of write cycles for the memory (see "Table 1-2, Supplementary Characteristics").

*SRE

Meaning and Type

Service Request Enable Device Interface

Description

This command sets the condition of the Service Request Enable Register. This register determines which bits from the Status Byte Register (see ***STB** for its bit configuration) are allowed to set the Master Status Summary (MSS) bit and the Request for Service (RQS) summary bit. A *1* in any Service Request Enable Register bit position enables the corresponding Status Byte Register bit and all such enabled bits then are logically ORed to cause Bit 6 of the Status Byte Register to be set. See "Chapter 8 - Status Reporting" for more details concerning this process.

When the controller conducts a serial poll in response to SRQ, the RQS bit is cleared, but the MSS bit is not. When ***SRE** is cleared (by programming it with *0*), the cannot generate an SRQ to the controller.

Command Syntax *SRE <NRf>
Parameters 0 to 255
Default Value (See *PSC)
Example *SRE 20
Query Syntax *SRE?
Returned Paramters <NR1> (Register binary value)
Related Commands *ESE *ESR *PSC

Caution If *PSC is programmed to *0*, then the *SRE command causes a write cycle to nonvolatile memory. The nonvolatile memory has a finite number of write cycles (see "Table 1-2, Supplementary Characteristics"). Programs that repeatedly write to nonvolatile memory can eventually exceed the maximum number of write cycles and may cause the memory to fail

---

*STB?

Meaning and Type

Status Byte Device Status

Description

This query reads the Status Byte register, which contains the status summary bits and the Output Queue MAV bit. Reading the Status Byte register does not clear it. The input summary bits are cleared when the appropriate event registers are read (see "Chapter 8 - Status Reporting") for more information). The MAV bit is cleared at power on or by *CLS.

A serial poll also returns the value of the Status Byte register, except that bit 6 returns Request for Service (RQS) instead of Master Status Summary (MSS). A serial poll clears RQS, but not MSS. When MSS is set, it indicates that the power supply has one or more reasons for requesting service.

Bit Configuration of Status Byte Register

Bit Position	7	6	5	4	3	2	1	0
Bit Name	OPER	MSS	ESB	MAV	QUES	[2]	[2]	[2]
		(RQS)						
Bit Weight	128	64	32	16	8	4	2	1
ESB = Event status byte summary; MAV = Message available								
MSS = Master status summary; OPER = Operation status summary;								
QUES = Questionable status summary; RQS = Request for service								
[1]Also represents RQS. [2]These bits are always zero.								

Query Syntax *STB?
Parameters (None)
Returned Paramters <NR1> (Register binary value)
Related Commands (None)

*TRG

Meaning and Type

Trigger Device Trigger

Description

This command generates a trigger when the trigger subsystem has BUS selected as its source. The command has the same affect as the Group Execute Trigger (<GET>) command.

Command Syntax	*TRG
Parameters	(None)
Query Syntax	(None)
Related Commands	ABOR CURR:TRIG INIT TRIG[:IMM] VOLT:TRIG <GET>

*TST?

Meaning and Type

Test Device Test

Description

This query causes the power supply to do a selftest and report any errors (see "Selftest Errors" in Chapter 3).

Query Syntax	*TST?	
Parameters	(None)	
Returned Paramters	<NR1>	
	0	Indicates power supply passed selftest.
	Nonzero	Indicates an error code.
Related Commands	(None)	

*WAI

Meaning and Type

Wait to Continue Device Status

Description

This command instructs the power supply not to process any further commands until all pending operations are completed. "Pending operations" are as defined under the *OPC command. *WAI can be aborted only by sending the power supply an HP-IB DCL (Device Clear) command.

Command Syntax	*WAI
Parameters	(None)
Query Syntax	(None)
Related Commands	*OPC *OPC?

ABOR

This command cancels any trigger actions presently in process. Pending triggered levels are reset equal to their corresponding immediate values. **ABORt** also resets the WTG bit in the Operation Condition status register (see "Chapter 8 - Status Reporting"). If **INIT:CONT ON** has been programmed, the trigger system initiates itself immediately after **ABORt**, thereby setting WTG. **ABORt** is executed at power turn on and upon execution of ***RCL** and ***RST**.

Command Syntax	ABORt
Parameters	(None)
Example	`ABOR`
Query Syntax	(None)
Related Commands	INIT *RST *TRG TRIG

Calibration Commands (See "Appendix A - Calibration")

Current Subsystem

This subsystem programs the output current of the power supply.

CURR

CURR:TRIG

These commands set the immediate current level or the pending triggered current level of the power supply. The immediate level is the current programmed for the output terminals. The pending triggered level is a stored current value that is transferred to the output terminals when a trigger occurs. A pending triggered level is unaffected by subsequent **CURR** commands and remains in effect until the trigger subsystem receives a trigger or an **ABORt** command is given. If there is no pending **CURR:TRIG** level, then the query form returns the **CURR** level. In order for **CURR:TRIG** to be executed, the trigger subsystem must be initiated (see **INITiate**).

Command Syntax	[SOURce]:CURRent[:LEVel] [:IMMediate][:AMPLitude] <NRf+> [SOURce][:CURRent[:LEVel]:TRIGgered [:AMPLitude] <NRf+>
Parameters	*See Table 1-3 in Chapter 1*
Default Suffix	*A*
***RST Value**	*See Table 1-3*

Examples	`CURR 200 MA` `CURRENT:LEVEL 200 MA`
	`CURRENT:LEVEL:IMMEDIATE:AMPLITUDE 2.5`
	`CURR:TRIG 20` `CURRENT:LEVEL:TRIGGERED 20`

Query Syntax	[SOURce]:CURRent[:LEVel] [:IMMediate][:AMPLitude]? [SOURce]:CURRent[:LEVel] [:IMMediate][:AMPLitude]? MAX [SOURce]:CURRent[:LEVel] [:IMMediate][:AMPLitude]? MIN [SOURce]:CURRent[LEVel]:TRIGgered [:AMPLitude]? [SOURce]:CURRent[LEVel]:TRIGgered [:AMPLitude]? MAX [SOURce]:CURRent[:LEVel]:TRIGgered [:AMPLitude]? MIN
Returned Parameters	<NR3> **CURR?** and **CURR:TRIG?** return presently programmed immediate and triggered levels. If not triggered level is programmed, both returned values are the same. **CURR? MAX** and **CURR? MIN** return the maximum and minimum programmable immediate current levels. **CURR:TRIG? MAX** and **CURR:TRIG? MIN** return the maximum and minimum programmable triggered current levels.

Related Commands For CURR *SAV *RCL *RST
For CURR:TRIG ABOR CURR *RST

CURR:PROT:STAT

This command enables or disables the power supply overcurrent protection (OCP) function. (*This function will not protect against overcurrents caused by programming from the external voltage control port.*) If the overcurrent protection function is enabled and the power supply goes into constant-current operation, then the output is disabled and the Questionable Condition status register OC bit is set (see "Chapter 8 - Status Reporting"). An overcurrent condition can be cleared with the **OUTP:PROT:CLE** command after the cause of the condition is removed.

Command Syntax [SOURce]:CURRent:PROTection:STATe <bool>
Parameters 0 | 1 | OFF | ON
Suffix (None)
***RST Value** OFF
Examples `CURR:PROT:STAT 0` `CURRENT:PROTECTION:STATE OFF`
`CURR:PROT:STAT 1` `CURRENT:PROTECTION:STATE ON`
Query Syntax [SOURce]:CURRent:PROTection:STATe?
Returned Parameters <NR1> *0* or *1*
Related Commands OUTP:PROT:CLE *RST

DIG:DATA

This command sets and reads the power supply digital control port when that port is configured for Digital I/O operation. Configuring of the port is done via an internal jumper (see "Appendix D - Digital Port Functions"). The port has three signal pins and a digital ground pin. Pins 1 and 2 are output pins controlled by bits 0 and 1. Pin 3 is controlled by bit 3 and can be programmed to serve either as an input or an output. Pin 4 is the digital ground.

Bit position 2 normally serves as an output. To change it to an input, it must first be programmed high. The **DIG:DATA?** query returns the last programmed value in bits 0 and 1 and the value read at pin 3 in bit 2. The bits are turned on and off in straight binary code as follows:

Digital I/O Port Programming Chart

	Bit Configuration			Pin Configuration[1]					Bit Configuration			Pin Configuration[1]			
Value	0	1	2	1	2	3	4	Value	0	1	2	1	2	3	4
0	0	0	0	Lo	Lo	Output	Gnd	4	0	0	1	Lo	Lo	Input	Gnd
1	1	0	0	Hi	Lo	Output	Gnd	5	1	0	1	Hi	Lo	Input	Gnd
2	0	1	0	Lo	Hi	Output	Gnd	6	0	1	1	Lo	Hi	Input	Gnd
3	1	1	0	Hi	Hi	Output	Gnd	7	1	1	1	Hi	Hi	Input	Gnd
[1]Pins 1 and 2 are always outputs															

Command Syntax [SOURce]:DIGital:DATA[:VALue] <NRf>
Parameters 0 to 7
Suffix (None)
***RST Value** 0
Examples `DIG:DATA 7` `DIGITAL:DATA:VALUE 7`
Query Syntax [SOURce]:DIGital:DATA?
Returned Parameters <NR1> Values from *0* to *7*
Related Commands *RST *RCL *SAV

Display Subsystem

This subsystem controls the state and output of the alphanumeric portion of the display.

DISP

Enables or disables the display. When disabled, the display characters are blank. The annunciators are not affected by this command.

Command Syntax DISPlay[:WINDow][:STATe] <bool>
Parameters 0 | 1 | OFF | ON
Suffix (None)
***RST Value** ON
Examples `DISP ON` `DISPLAY:STATE ON`
Query Syntax DISPlay[:WINDow][STATe]?
Returned Parameters <NR1> *0* or *1*
Related Commands DISP:MODE DISP:TEXT *RST

DISP:MODE

Switches the display between its normal metering mode and a mode in which it displays text sent by the user. The command uses the character data <CRD> format.

Command Syntax DISPlay[:WINDow]:MODE NORMal|TEXT
Parameters <CRD> NORMal | TEXT
***RST Value** NORM
Examples `DISP:MODE NORM` `DISPLAY:MODE NORMAL`
`DISPLAY:WINDOW:MODE TEXT`
Query Syntax DISPlay[:WINDow]:MODE?
Returned Parameters <CRD> *NORMAL* or *TEXT*
Related Commands DISP DISP:TEXT *RST

DISP:TEXT

Allows character strings to be sent to display. The characters will be displayed when the display mode is **TEXT**. The LCD has the following character set:

LCD Character Set

<table>
<tr><td>uppercase letters</td><td>A through Z (Case-sensitive entry)</td></tr>
<tr><td>digits</td><td>0 through 9</td></tr>
<tr><td>punctuation</td><td>_ | " $ < > + - / = ? . : ,</td></tr>
<tr><td>blank space</td><td></td></tr>
</table>

A display is capable of showing up to 12 characters. However, the three punctuation characters [(.)(:)(,)] do not count toward the 12- character limit when they are preceeded by an alphanumeric character. When punctuation characters are included, then the maximum number of characters (alphanumeric + punctuation) that can be displayed is 15. If it exceeds the display capacity, a message will be truncated to fit and no error message will be generated. If any character in the message is not a member of the above character set, the character will not be rejected but will be displayed as a "starburst" (all 16 segments of the character will light).

Command Syntax DISPlay[:WINDow]:TEXT [:DATA] <STR>
Parameters (See LCD character set)
***RST Value** ' '
Examples `DISP:TEXT "DEFAULT_MODE"`
`DISPLAY:WINDOW:TEXT:DATA '533.2E-1VOLTS'`
Query Syntax DISPlay[:WINDow]:TEXT?
Returned Parameters <STR> (Last programmed text string)
Related Commands DISP DISP:MODE *RST

Note *IEEE 488.2* requires that a string be enclosed in either single (') or double (") quotes.

Initiate Subsystem

This subsystem enables the trigger system. When a trigger is enabled, an event on a selected trigger source causes the specified trigging acition to occur. If the trigger subsystem is not enabled, all trigger commands are ignored. If INIT:CONT is OFF, then INIT enables the trigger subsystem only for a single trigger action. The subsystem must be enabled prior to each subsequent trigger action. If INIT:CONT is ON, then the trigger subsystem is continuously enabled and INIT is redundant.

Command Syntax INITiate[:IMMediate]
INITiate:CONTinuous <bool>
Parameters For INIT[:IMM] (None)
For INIT:CONT 0|1|OFF|ON
***RST Value** OFF
Examples `INIT INITIATE:IMMEDIATE`
`INIT:CONT 1 INITIATE:CONTINUOUS 1`
Query Syntax For INIT[:IMM] (None)
For INIT:CONT INIT:CONT?
Returned Parameters <NR1> *0|1*
Related Commands ABOR <GET> *RST TRIG *TRG

Measure Subsystem

This query subsystem returns the voltage and current measured at the power supply's sense terminals.

Query Syntax MEASure:CURRent[:DC]? MEASure:VOLTage[:DC]?
Parameters (None)
Default Suffix *A* for MEAS:CURR? *V* for MEAS:VOLT?
Examples `MEAS:CURR? MEAS:VOLT? MEASURE:VOLTAGE:DC? MV`
Returned Parameters <NR3>

Output Subsystem

This subsystem controls the power supply's voltage and current outputs and the optional HP 59510A/59511A external output relay.

OUTP

This command enables or disables the power supply output. The state of a disabled output is a condition of zero output voltage and a model-dependent minimum source current (see *Table 1-3 in Chapter 1). This command cannot disable outputs set via external voltage control port.*

If the power supply is configured to use the HP 59510A/59511A Relay Accessory, the command opens the relay contacts when the output is disabled and closes them when it is enabled. Transitions between the output ON and OFF states are sequenced so that the relay is switched while the power mesh is disabled. Use of the second (**NORelay**) parameter prevents the command from having any effect on the relay; it remains in its existing state when **OUTPut** is executed. The query form returns the output state, excluding that of the relay (see **OUTP:REL?**). -.1in>

Command Syntax	OUTPut[:STATe] <bool>[,NORelay]
Parameters	0 | OFF[,NORelay] | 1 | ON[,NORelay]
Suffix	(None)
***RST Value**	0
Examples	`OUTP 1` `OUTPUT:STATE ON,NORELAY`
Query Syntax	OUTPut[:STATe]?
Returned Parameters	<NR1> *0* or *1*
Related Commands	*RST *RCL *SAV

OUTP:PROT

There are two output protection commands that do the following:

OUTP:PROT:CLE Clears any OV (overvoltage), OC (overcurrent, unless set via external voltage control),OT (overtemperature), or RI (remote inhibit) protection features. After this command, the output is restored to the state it was in before the protection feature occurred.

OUTP:PROT:DEL Sets the time between the programming of an output change that produces a CV, CC, or UNREG condition and the recording of that condition by the Status Operation Condition register. The delay prevents the momentary changes in power supply status that can occur during reprogramming from being registered as events by the status subsystem. Since the delay applies to CC status, it also delays the OCP (overcurrent protection) feature. The OVP (overvoltage protection) feature is not affected by this delay.

Command Syntax	OUTPut:PROTection:CLEar OUTPut:PROTection:DELlay <NRf+>
Parameters	OUTP:PROT:CLE (None) OUTP:PROT:DEL 0 to 32.767 | MIN | MAX
Default Suffix	*S*
***RST Value**	200 (milliseconds)

Examples	OUTP:PROT:CLE OUTPUT:PROTECTION:CLEAR OUTPUT:PROTECTION:DELAY 75E-1 OUTP:PROT:DEL MIN OUTPUT:PROT:DELAY MAX
Query Syntax	**OUTP:PROT:CLE** (None) **OUTPut:PROTection:DELay? OUTPut:PROTection:DELay? MIN** **OUTPup:PROTection:DELay? MAX**
Returned Parameters	<NR3> **OUTP:PROT:DEL?** returns value of programmed delay. **OUTP:PROT:DEL? MIN** and **OUTP:PROT:DEL? MAX** return the minimum and maximum programmable delays.
Related Commands	**OUTP:PROT:CLE** (None) **OUTP:PROT:DEL *RST *RCL *SAV**

OUTP:REL

This command is valid only if the power supply is configured for the optional HP 59510A and HP 59511A Relay Accessory (see "Appendix D"). Programming **ON** closes the relay contacts; programming **OFF** opens them. The relay is controlled independently of the output state. If the power supply is supplying power to the load, that power will appear at the relay contacts during switching. If the power supply is not configured for either relay device, sending the command generates an error.

Command Syntax	**OUTPut:RELay[:STATe] <bool>**
Parameters	**0 | 1 | OFF | ON**
Suffix	(None)
***RST Value**	**OFF**
Examples	OUTP:REL 1 OUTPUT:RELAY OFF OUTPUT:RELAY:STATE OFF
Query Syntax	**OUTPut:RELay?**
Returned Parameters	<NR1> *0* or *1*
Related Commands	**OUTP:REL:POL *RST *RCL *SAV**

OUTP:REL:POL

This command is valid only if the power supply is configured for the HP 59511A Relay Accessory (see "Appendix D"). Programming **NORM** causes the relay output polarity to be the same as the power supply output. Programming **REV** causes the output polarity to be opposite to that of the power supply output. If **OUTP = ON** when either command is sent, the power supply output is set to 0 during the time that the relays are changing polarity. If the power supply is not configured for the HP 59511A, sending the command generates an error.

Command Syntax	**OUTPut:RELay:POLarity <CRD>**
Parameters	**NORMal | REVerse**
***RST Value**	**NORM**
Examples	OUTP:REL:POL NORM OUTPUT:RELAY:POLARITY REVERSE
Query Syntax	**OUTPut:RELay:POLarity?**
Returned Parameters	<CRD> *NORM | REV*
Related Commands	**OUTP:REL *RST *RCL *SAV**

Status Subsystem

This subsystem programs the power supply status registers. The power supply has three groups of status registers; **Operation**, **Questionable**, and **Standard Event**. The Standard Event group is programmed with Common commands as described in "Chapter 8 - Status Reporting". The Operation and Questionable status groups each consist of the Condition, Enable, and Event registers and the NTR and PTR filters.

Status Operation Registers

The bit configuration of all Status Operation registers is shown in the following table:

Bit Configuration of Operation Registers

Bit Position	15-12	11	10	9	8	7	6	5	4	3	2	1	0
Bit Name	NU	NU	CC	NU	CV	NU	NU	WTG	NU	NU	NU	NU	CAL
Bit Weight		2048	1024	512	256	128	64	32	16	8	4	2	1
CAL = Interface is computing new calibration constants; CC = The power supply is in constant-current mode.													
CV = The power supply is in constant voltage mode;NU = (Not used);WTG = The interface is waiting for a trigger.													

Note See "Chapter 8 - Status Reporting" for more explanation of these registers

STAT:OPER?

This query returns the value of the Operation Event register. The Event register is a read-only register which holds (latches) all events that are passed by the Operation NTR and/or PTR filter. Reading the Operation Event register clears it.

Query Syntax	STATus:OPERation[:EVENt]?
Parameters	(None)
Returned Parameters	<NR1> (Register Value)
Examples	STAT:OPER? STATUS:OPERATIONAL:EVENT?
Related Commands	*CLS STAT:OPER:NTR STAT:OPER:PTR

STAT:OPER:COND?

This query returns the value of the Operation Condition register. That is a read-only register which holds the real-time (unlatched) operational status of the power supply.

Query Syntax	STATus:OPERation:CONDition?
Parameters	(None)
Examples	STAT:OPER:COND? STATUS:OPERATION:CONDITION?
Returned Parameters	<NR1> (Register value)
Related Commands	(None)

STAT:OPER:ENAB

This command and its query set and read the value of the Operational Enable register. This register is a mask for enabling specific bits from the Operation Event register to set the operation summary bit (OPER) of the Status Byte register. This bit (bit 7) is the logical OR of all the Operatonal Event register bits that are enabled by the Status Operation Enable register.

Command Syntax	STATus:OPERation:ENABle <NRf>
Parameters	0 to 32727
Suffix	(None)
Default Value	0
Examples	`STAT:OPER:ENAB 1312` `STAT:OPER:ENAB 1` `STATUS:OPERATION:ENABLE?`
Query Syntax	STATus:OPERation:ENABle?
Returned Parameters	<NR1> (Register value)
Related Commands	STAT:OPER:EVEN

NTR/PTR Commands

These commands set or read the value of the Operation NTR (Negative-Transition) and PTR (Positive-Transistion) registers. These registers serve as polarity filters between the Operation Enable and Operation Event registers to cause the following actions:

- When a bit in the Operation NTR register is set to 1, then a 1-to-0 transition of the corresponding bit in the Operation Condition register causes that bit in the Operation Event register to be set.
- When a bit of the Operation PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Operation Condition register causes that bit in the Operation Event register to be set.
- If the same bits in both NTR and PTR registers are set to 1, then *any transition* of that bit at the Operation Condition register sets the corresponding bit in the Operation Event register.
- If the same bits in both NTR and PTR registers are set to 0, then *no transition* of that bit at the Operation Condition register can set the corresponding bit in the Operation Event register.

Note Setting a bit in the value of the PTR or NTR filter can of itself generate positive or negative events in the corresponding Operation Event register.

Command Syntax	STATus:OPERtion:NTRansition <NRf> STATus:OPERtion:PTRansition <NRf>
Parameters	0 to 32727
Suffix	(None)
Default Value	0
Examples	`STAT:OPER:NTR 32` `STAT:OPER:PTR 1312`
Query Syntax	STAT:OPER:NTR? STAT:OPER:PTR?
Returned Parameters	<NR1> (Register value)
Related Commands	STAT:OPER:ENAB

STAT:PRES

This command sets all defined bits in the Status Subsystem PTR registers and clears all bits in the subsytem NTR and Enable registers. STAT:OPER:PTR is set to 1313 and STAT:QUES:PTR is set to 1555.

Command Syntax	STATus:PRESet
Parameters	(None)
Examples	`STAT:PRES` `STATUS:PRESET`
Query Syntax	(None)
Related Commands	(None)

Status Questionable Registers

The bit configuration of all Status Questionable registers is as follows:

Bit Configuration of Questionable Registers

Bit Position	15-11	10	9	8	7	6	5	4	3	2	1	0
Bit Name	NU	UNR	RI	NU	NU	NU	NU	OT	NU	NU	OC	OV
Bit Weight		1024	512	256	128	64	32	16	8	4	2	1
NU = (Not used); OC = Overcurrent protection circuit has tripped.												
OT = Overtemperature status condition exists; OV = Overvoltage protection circuit has tripped												
RI = Remote inhibit is active UNR = Power supply output is unregulated.												

Note See "Chapter 8 - Status Reporting" for more explanation of these registers.

STAT:QUES?

This query returns the value of the Questionable Event register. The Event register is a read-only register which holds (latches) all events that are passed by the Questionable NTR and/or PTR filter. Reading the Questionable Event register clears it.

Query Syntax	STATus:QUEStionable[:EVENt]?
Parameters	(None)
Returned Parameters	<NR1> (Register Value)
Examples	`STAT:QUES?` `STATUS:QUESTIONABLE:EVENT?`
Related Commands	*CLS STAT:QUES:ENAB STAT:QUES:NTR STAT:QUES:PTR

STAT:QUES:COND?

This query returns the value of the Questionable Condition register. That is a read-only register which holds the real-time (unlatched) questionable status of the power supply.

Query Syntax	STATus:QUEStionable:CONDition?
Parameters	(None)
Examples	`STAT:QUES:COND?` `STATUS:QUESTIONABLE:CONDITION?`
Returned Parameters	<NR1> (Register value)
Related Commands	(None)

STAT:QUES:ENAB

This command and its query set and read the value of the Questionable Enable register. This register is a mask for enabling specific bits from the Questionable Event register to set the questionable summary bit (QUES) of the Status Byte register. This bit (bit 3) is the logical OR of all the Questionable Event register bits that are enabled by the Questionable Status Enable register.

Command Syntax	STATus:QUEStionable:ENABle <NRf>
Parameters	0 to 32727
Suffix	(None)
Default Value	0
Examples	`STAT:QUES:ENAB 20` `STAT:QUES:ENAB 16`
Query Syntax	STATus:QUEStionable:ENABle?
Returned Parameters	<NR1> (Register value)
Related Commands	STAT:QUES?

NTR/PTR Commands

These commands allow you to set or read the value of the Questionable NTR (Negative-Transition) and PTR (Positive-Transistion) registers. These registers serve as polarity filters between the Questionable Enable and Questionable Event registers to cause the following actions:

- When a bit of the Questionable NTR register is set to 1, then a 1-to-0 transition of the corresponding bit of the Questionable Condition register causes that bit in the Questionable Event register to be set.
- When a bit of the Questionable PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Questionable Condition register causes that bit in the Questionable Event register to be set.
- If the same bits in both NTR and PTR registers are set to 1, then *any transition* of that bit at the Questionable Condition register sets the corresponding bit in the Questionable Event register.
- If the same bits in both NTR and PTR registers are set to 0, then *no transition* of that bit at the Questionable Condition register can set the corresponding bit in the Questionable Event register.

Note Setting a bit in the PTR or NTR filter can of itself generate positive or negative events in the corresponding Questionable Event register.

Command Syntax	**STATus:QUEStionable:NTRansition <NRf>** **STATus:QUEStionable:PTRansition <NRf>**
Parameters	**0** to **32727**
Suffix	(None)
Default Value	**0**
Examples	`STAT:QUES:NTR 16` `STATUS:QUESTIONABLE:PTR 512`
Query Syntax	**STAT:QUES:NTR? STAT:QUES:PTR?**
Returned Parameters	**<NR1>** (Register value)
Related Commands	**STAT:QUES:ENAB**

SYST:ERR?

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

You can use the front panel (Error) key to read errors from the queue. Errors generated at the front panel are not put into the queue but appear immediately on the display.

Query Syntax	SYSTem:ERRor?
Parameters	(None)
Returned Parameters	<NR1>,<SRD>
Examples	`SYST:ERR?` `SYSTEM:ERROR?`
Related Commands	(None)

SYST:LANG

This command switches the interface between its SCPI (TMSL) command language and its compatibility language. The compatability language is provided for emulation of older power supply systems and is described in "Appendix B - Compatibility Language". Sending the command causes:

- The alternate language to become active and to be stored in nonvolatile memory.
- The power supply to reset to the state stored in Location 0.

If the power supply is shut off, it will resume operation in the last-selected language when power is restored.

Command Syntax	SYSTem:LANGuage <string> *Syntax is the same, regardless of the present language*
Parameters	TMSL | COMPatibility **Note:** Parameter *TMSL* must be used in place of *SCPI*.
Default Value	*TMSL or last selected language*
Examples	`SYST:LANG TMSL` `SYSTEM:LANGUAGE COMPATIBILITY`
Query Syntax	SYSTem:LANGuage?
Returned Paramters	<CRD> *TMSL | COMP*
Related Commands	(None)

SYST:VERS?

This query returns the SCPI version number to which the power supply complies. The returned value is of the form YYYY.V, where *YYYY* represents the year and *V* is the revision number for that year.

Query Syntax	SYSTem:VERSion?
Parameters	(none)
Returned Paramters	<NR2>
Examples	`SYST:VERS?` `SYSTEM:VERSION?`
Related Commands	(None)

Trigger Subsystem

This subsystem controls remote triggering of the power supply.

TRIG

When the trigger subsystem is enabled, **TRIG** generates a trigger signal. The trigger will then:

1. Initiate a pending level change as specified by **CURR[:LEV]:TRIG** or **VOLT[:LEV]:TRIG.**
2. Clear the WTG bit in the Status Operation Condition register.
3. If **INIT:CONT** has been given, the trigger subsystem is immediately re-enabled for subsequent triggers. As soon as it is cleared, the WTG bit is again set to 1.

Command Syntax	**TRIGger[:IMMediate]**
Parameters	(None)
Examples	`TRIG` `TRIGGER:IMMEDIATE`
Query Syntax	(None)
Related Commands	**ABOR CURR:TRIG INIT *TRG VOLT:TRIG**

TRIG:SOUR

This command selects the trigger source. Since the power supply has no other trigger source than the HP-IB bus, this command need not be used. It is included in the command set to provide programming compatibility with other instruments (such as the HP Electronic Load family) that may have more than one trigger source.

Command Syntax	**TRIGer:SOURce <CRD>**
Parameters	**BUS**
***RST Value**	**BUS**
Examples	`TRIG:SOUR BUS` `TRIGGER:SOURCE BUS`
Query Syntax	**TRIGger:SOURce?**
Returned Parameters	*BUS*
Related Commands	***RST *TRG TRIG[:IMM]**

Voltage Subsystem

This subsystem programs the output voltage of the power supply.

VOLT

VOLT:TRIG

These commands set the immediate voltage level or the pending triggered voltage level of the power supply. The immediate level is the voltage programmed for the output terminals. The pending triggered level is a stored voltage value that is transferred to the output terminals when a trigger occurs. A pending triggered level is unaffected by subsequent **VOLT** commands and remains in effect until the trigger subsystem receives a trigger or an **ABORt** command is given. If there is no pending **VOLT:TRIG** level, then the query form returns the **VOLT** level. In order for **VOLT:TRIG** to be executed, the trigger subsystem must be initiated (see **INITiate**).

Command Syntax	[SOURce]:VOLTage[:LEVel] [:IMMediate][:AMPLitude] <NRf+> [SOURce][:VOLTage[:LEVel]:TRIGgered [:AMPLitude] <NRf+>
Parameters	*See Table 1-3 in Chapter 1*
Default Suffix	*V*
***RST Value**	*See Table 1-3*

Examples	`VOLT 200 MA` `VOLTAGE:LEVEL 200 MA`
	`VOLTAGE:LEVEL:IMMEDIATE:AMPLITUDE 2.5`
	`VOLT:TRIG 20` `VOLTAGE:LEVEL:TRIGGERED 20`

Query Syntax	[SOURce]:VOLTage[:LEVel] [:IMMediate][:AMPLitude]? [SOURce]:VOLTage[:LEVel] [:IMMediate][:AMPLitude]? MAX [SOURce]:VOLTage[:LEVel] [:IMMediate][:AMPLitude]? MIN [SOURce]:VOLTage[LEVel]:TRIGgered [:AMPLitude]? [SOURce]:VOLTage[LEVel]:TRIGgered [:AMPLitude]? MAX [SOURce]:VOLTage[:LEVel]:TRIGgered [:AMPLitude]? MIN
Returned Parameters	<NR3> **VOLT?** and **VOLT:TRIG?** return presently programmed immediate and triggered levels. If not triggered level is programmed, both returned values are the same. **VOLT? MAX** and **VOLT? MIN** return the maximum and minimum programmable immediate voltage levels. **VOLT:TRIG? MAX** and **VOLT:TRIG? MIN** return the maximum and minimum programmable triggered voltage levels.
Related Commands	For **VOLT** ***SAV** ***RCL** ***RST** For **VOLT:TRIG** **ABOR** **VOLT** ***RST**

VOLT:PROT

This command sets the overvoltage protection (OVP) level of the power supply. If the output voltage exceeds the OVP level, then the power supply output is disabled and the Questionable Condition status register OV bit is set (see "Chapter 8 - Status Reporting"). An overvoltage condition can be cleared with the **OUTP:PROT:CLE** command after the condition that caused the OVP trip is removed. The OVP always trips with zero delay and is unaffected by the **OUTP:PROT:DEL** command.

Command Syntax	[SOURce]:VOLTage:PROTection [:LEVel] <NRf+>
***Alternate Syntax**	[SOURce]:VOLTage:PROTection :AMPLitude <NRf+>
Parameters	*See Table 1-3 in Chapter 1*
Default Suffix	*V*
***RST Value**	**MAX**
Examples	`VOLT:PROT 21.5` `VOLT:PROT:LEV MAX` `VOLTAGE:PROTECTION:LEVEL 145E-1`
Query Syntax	[SOURce]:VOLTage:PROTection[:LEVel]? [SOURce]:VOLTage:PROTection [:LEVel]? MIN [SOURce]:VOLTage:PROTection [:LEVel]? MAX
Returned Parameters	<NR3> **VOLT:PROT?** returns presently programmed OVP level. **VOLT:PROT? MAX** and **VOLT:PROT? MIN** return the maximum and minimum programmable OVP levels.
Related Commands	**OUTP:PROT:CLE** ***RST** ***SAV** ***RCL**

* Available to accommodate earlier power supply programs.

System Error Messages

Note Front panel error messages resulting from hardware failure are described under "In Case of Trouble" in Chapter 3. Calibration error messages are listed in Appendix A.

System error messages are obtained remotely with the **SYST:ERR?** query or by pressing the (Error) key. The error number is the value placed in the error queue. **SYST:ERR?** returns the error number into a variable and combines the number and the error message into a string. Table 7-2 lists the system errors that are associated with SCPI syntax errors and interface problems. Information inside the brackets is not part of the standard error message, but is included for clarification. When system errors occur, the Standard Event Status register (see "Chapter 8 - Status Reporting") records them as follows:

Standard Event Status Register Error Bits

Bit Set	Error Code	Error Type	Bit Set	Error Code	Error Type
5	-100 thru -199	Command	3	-300 thru -399	Device-dependent
4	-200 thru -299	Execution	2	-400 thru -499	Query

Table 7-2. Summary of System Error Messages

Error Number	Error String [Description/Explanation/Examples]
-100	Command error [generic command error]
-101	Invalid character
-102	Syntax error [unrecognized command or data type]
-103	Invalid separator [illegal character encountered in place of separator]
-104	Data type error [e.g., numeric or string expected, got block data]
-105	GET not allowed [<GET> inside a program message]
-108	Parameter not allowed [too many parameters]
-109	Missing parameter [too few parameters]
-112	Program mnemonic too long [maximum 12 characters]
-113	Undefined header [syntacticall correct but not defined for this device]
-121	Invalid character in number [e.g., alpha in decimal data, etc.]
-123	Exponent too large [numeric overflow; exponent magnitude >32000]
-124	Too many digits [number too long; more than 255 digits received]
-128	Numeric data not allowed [numeric data not accepted where positioned]
-131	Invalid suffix [unrecognized suffix, or suffix not appropriate]
-138	Suffix not allowed [numeric element does not allow suffixes]
-141	Invalid character data [bad character, or unrecognized]
-144	Character data too long [maximum length is 12 characters]
-148	Character data not allowed [character data not accepted where positioned]
-150	String data error [generic string error]
-151	Invalid string data [e.g., END received before close quote]
-158	String data not allowed [string data not accepted where positioned]
-160	Block data error [generic data block error]
-161	Invalid block data [e.g., END received before string length satisfied]
-168	Block data not allowed [block data not accepted where positioned]

Table 7-2. Summary of System Error Messages (continued)

Error Number	Error String [Description/Explanation/Examples]
-220	Parameter error
-221	Settings conflict [uncoupled parameters]
-222	Data out of range [e.g., outside the range of this device]
-223	Too much data [out of memory; block, string, or expression too long]
-240	Hardware error [device-dependent]
-241	Hardware missing [device-dependent]
-310	System error [device-dependent]
-313	Calibration memory lost [out of calibration due to memory failure]
-330	Self-test failed [more specific data after ";"]
-350	Queue overflow [errors lost due to too many errors in queue]
-400	Query error [generic query error]
-410	Query INTERRUPTED [query followed by DAB or GET before response complete]
-420	Query UNTERMINATED [addressed to talk, incomplete programming message received]
-430	Query DEADLOCKED [too many queries in command string]
-440	Query UNTERMINATED [query received after query for indefinite response]

Command Summary

This summary lists all power supply subsystem commands in alphabetical order, followed by all common commands in alphabetical order. See Table 1-3 in Chapter 1 for the command parameters accepted by each power supply model.

Command Summary

<table>
<tr><th>Command</th><th>Parameters</th></tr>
<tr><td colspan="2">Subsystem Commands</td></tr>
<tr><td>ABOR</td><td>(none)</td></tr>
<tr><td>CAL</td><td>(See Appendix A)</td></tr>
<tr><td>[SOUR]:CURR[:LEV][:IMM][:AMPL]</td><td><NRf+>[suffix]</td></tr>
<tr><td>[SOUR]:CURR[:LEV][:IMM][:AMPL]?</td><td>(none) |MIN|MAX</td></tr>
<tr><td>[SOUR]:CURR[:LEV]:TRIG[:AMPL]</td><td><NRf+>[suffix]</td></tr>
<tr><td>[SOUR]:CURR[:LEV]:TRIG[:AMPL]?</td><td>(none) |MIN|MAX</td></tr>
<tr><td>[SOUR]:CURR:PROT:STAT</td><td>0|1 | ON|OFF</td></tr>
<tr><td>[SOUR]:CURR:PROT:STAT?</td><td>(none)</td></tr>
<tr><td>[SOUR]:DIG:DATA[:VAL]</td><td><NRf></td></tr>
<tr><td>[SOUR]:DIG:DATA[:VAL]?</td><td>(none)</td></tr>
<tr><td>DISP[WIND]:MODE</td><td>NORM|TEXT</td></tr>
<tr><td>DISP[WIND]:MODE?</td><td>(none)</td></tr>
<tr><td>DISP[:WIND][:STAT]</td><td>0|1 | OFF|ON</td></tr>
<tr><td>DISP[:WIND][:STAT]?</td><td>(none)</td></tr>
<tr><td>DISP[:WIND]:TEXT[:DATA]</td><td><STR></td></tr>
<tr><td>DISP[:WIND]:TEXT[:DATA]?</td><td>(none)</td></tr>
<tr><td>INIT[:IMM]</td><td>(none)</td></tr>
<tr><td>INIT:CONT</td><td>0|1 | OFF|ON</td></tr>
<tr><td>INIT:CONT?</td><td>(none)</td></tr>
</table>

Command Summary (continued)

Command	*Parameters*
MEAS:CURR[:DC]?	(none)
MEAS:VOLT[:DC]?	(none)
OUTP[:STAT]	0|1[,NOR] OFF|ON[,NOR]
OUTP[:STAT?]	(none)
OUTP:PROT:CLE	(none)
OUTP:PROT:DEL	0 to 32.767|MIN|MAX
OUTP:PROT:DEL?	(none) |MIN|MAX
OUTP:REL:POL	NORM|REV
OUTP:REL:POL?	(none)
OUTP:REL[:STAT]	0|1 OFF|ON
OUTP:REL[:STAT]?	(none)
STAT:OPER:COND?	(none)
STAT:OPER:ENAB	<NRf>
STAT:OPER:ENAB?	(none)
STAT:OPER[:EVEN]?	(none)
STAT:OPER:NTR	<NRf>
STAT:OPER:NTR?	(none)
STAT:OPER:PTR	<NRf>
STAT:OPER:PTR?	(none)
STAT:PRES	(none)
STAT:QUES:COND?	(none)
STAT:QUES:ENAB	<NRf>
STAT:QUES:ENAB?	(none)
STAT:QUES[:EVEN]?	(none)
SYST:ERR?	(none)
SYST:LANG	TMSL|COMP
SYST:LANG?	(none)
SYST:VERS?	(none)
TRIG[:IMM]	(none)
TRIG:SOUR	BUS
TRIG:SOUR?	(none)
[SOUR]:VOLT[:LEV][:IMM][:AMPL]	<NRf+>[suffix]
[SOUR]:VOLT[:LEV][:IMM][:AMPL]?	(none) |MIN|MAX
[SOUR]:VOLT[:LEV]:TRIG[:AMPL]	<NRf+>[suffix]
[SOUR]:VOLT[:LEV]:TRIG?[:AMPL]?	(none) |MIN|MAX
[SOUR]:VOLT:PROT[:LEV]	<NRf+>[suffix]
[SOUR]:VOLT:PROT[:LEV]?	<NRf+>[suffix]

Common Commands

Command	*Parameters*	*Command*	*Parameters*	*Command*	*Parameters*
*CLS	(None)	*OPC?	(None)	*SRE	<NRf>
*ESE	<NRf>	*PSC	<bool>	*SRE?	(None)
*ESE?	(None)	*PSC?	(None)	*STB?	(None)
*ESR?	(None)	*RCL	<NRf>	*TRG	(None)
*IDN?	(None)	*RST	(None)	*TST?	(None)
*OPC	(None)	*SAV	<NRf>	*WAI	(None)

Status Reporting 8

POWER SUPPLY STATUS STRUCTURE

Figure 8-1 shows the status structure of the power supply. The Standard Event, Status Byte, Service Request Enable registers and the Output Queue perform standard HP-IB functions defined in the *IEEE 488.2 Standard Digital Interface for Programmable Instrumentation*. The Operation and Questionable Status registers implement the status reporting requirements of the power supply.

STATUS REGISTER BIT CONFIGURATION

Table 8-1 and Figure 8-1 shows the bit configuration of each status register.

QUESTIONABLE STATUS GROUP

Register Functions

The Questionable Status registers record signals that indicate abnormal operation of the power supply. The group consists of the following registers:

- A condition register that holds real-time status of the circuits being monitored. It is a read-only register.
- A PTR/NTR (positive transistion/negative transition) filter that functions as described under **QUES:OPER:NTR|PTR COMMANDS** in "Chapter 7 - Language Dictionary". This is a read-write register.

Table 8-1. Bit Configuration of Status Register Groups

Bit	Signal	Meaning
		Operation Status Group
0	CAL	The interface is computing new calibration constants
5	WTG	The interface is waiting for a trigger
8	CV	The power supply is in the constant-voltage mode
10	CC	The power supply is in the constant-current mode
		Questionable Status Group
0	OV	The power supply overvoltage protection circuit has tripped
1	OC	The power supply overcurrent protection circuit has tripped
4	OT	The power supply has an overtemperature condition
9	RI	The power supply remote inhibit status is active
10	UNR	The power supply output is unregulated
		Standard Event Status Group
0	OPC	Operation complete
2	QYE	Query error
3	DDE	Device-dependent error
4	EXE	Execution error
5	CME	Command error
7	PON	Power on
		Status Byte and Service Request Enable Registers
3	QUES	Questionable status summary bit
4	MAV	Message Available summary bit
5	ESB	Event Status summary bit
6	MSS	Master Status summary bit
	RQS	Request Service bit
7	OPER	Operation Status summary bit

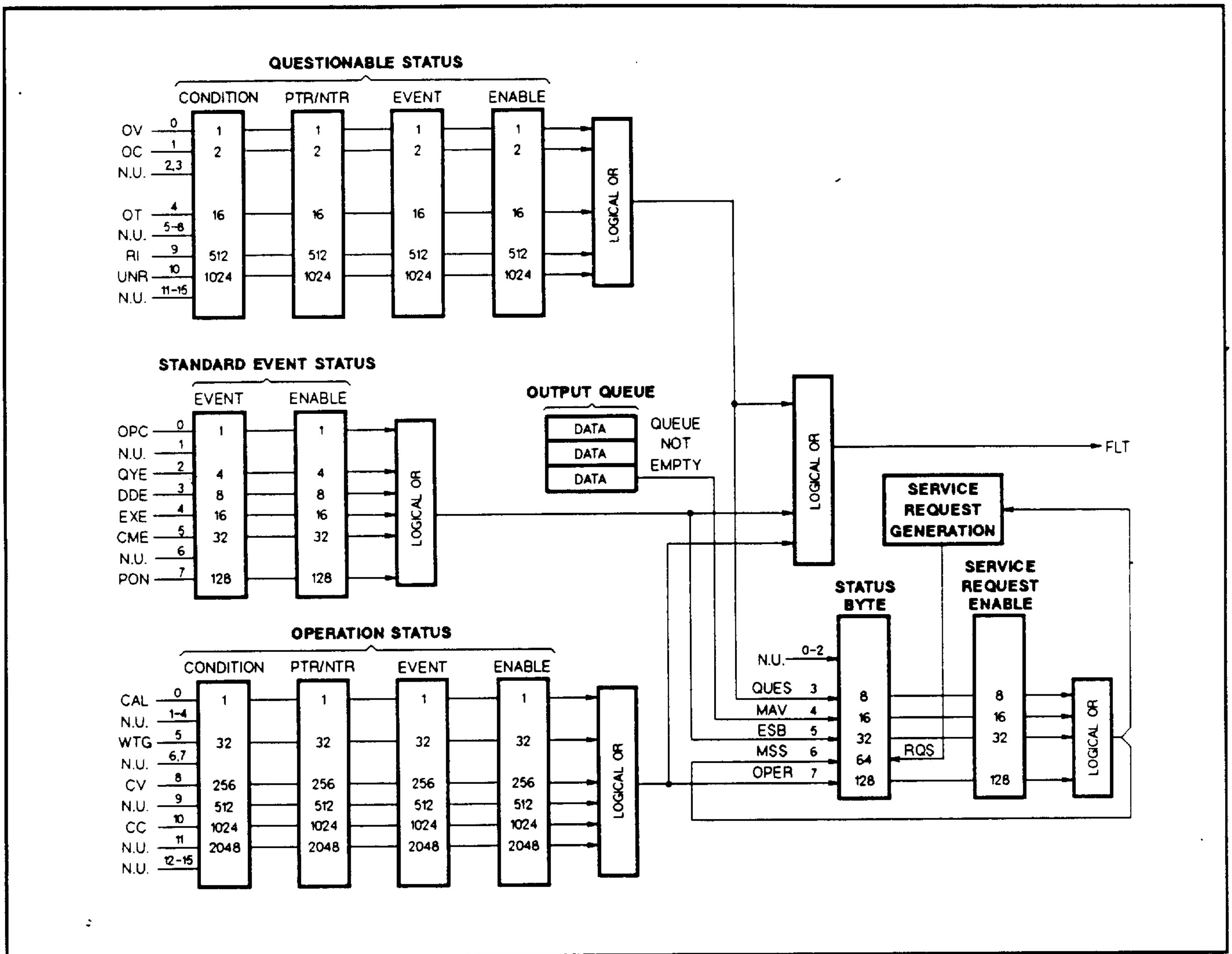


Figure 8-1. Power Supply Status Structure

- An Event register that latches any condition that is passed through the PTR or NTR filter. Reading the Event register clears it.

- An Enable register that functions as described under **QUEST:OPER:ENAB** in "Chapter 7 - Language Dictionary". This is a read/write register.

Register Programming

Programming for this group is derived from the **STAT:QUES** commands described in "Chapter 7 - Language Dictionary" and summarized in Table 8-2

OPERATION STATUS GROUP

Register Functions

The Operation Status registers record signals occur during normal operation. As shown in Figure 8-1, the group consists of a set of registers similar to the Questionable Status group. The outputs of the Operation Status group are logically-ORed into the OPER(ation) summary bit (7) of the Status Byte register.

Register Programming

Programming for this group is derived from the **STAT:OPER** commands described in "Chapter 7 - Language Dictionary" and summarized in Table 8-3.

Table 8-2. STAT:QUES Commands

Register	Command	Query	Cleared By
Condition	(None)	STAT:QUES:COND?	Cannot be cleared
PTR Filter	STAT:QUES:PTR <NRf>	STAT:QUES:PTR?	Programming *0*
NTR Filter	STAT:QUES:NTR <NRf>	STAT:QUES:NTR?	Programming *0* or STAT:PRES
Event	(None)	STAT:QUES:EVEN?	Reading or *CLS
Enable	STAT:QUES:ENAB <NRf>	STAT:QUES:ENAB?	Programming *0*

Table 8-3. STAT:OPER Commands

Register	Command	Query	Clear By
Condition	(None)	STAT:OPER:COND?	Cannot be cleared
PTR Filter	STAT:OPER:PTR <NRf>	STAT:OPER:PTR?	Programming *0*
NTR Filter	STAT:OPER:NTR <NRf>	STAT:OPER:NTR?	Programming *0* or STAT:PRES
Event	(None)	STAT:OPER:EVEN?	Reading or *CLS
Enable	STAT:OPER:ENAB <NRf>	STAT:OPER:ENAB?	Programming *0*

STANDARD EVENT STATUS GROUP

The Standard Event Status group consists of two registers (Event and Enable) that are progammed by common commands.

The Standard Event register latches events relating to interface communication status (see Table 8-1). It is a read-only register that is cleared when read.

Read Query ***ESR?**
Clear Commands ***CLS** ***ESR?**

The Standard Event Enable register is a read/write register that functions similarly to the enable registers of the Operation and Questionable status groups.

Program Command ***ESE <NRf>**
Read Query ***ESE?**
Clear Command ***ESE 0**

STATUS BYTE REGISTER

The Status Byte register summarizes the information from all other status groups as defined in the *IEEE 488.2 Standard Digital Interface for Programmable Instrumentation*. The bit configuration is shown in Table 8-1. The Status Byte can be read either by a serial poll or by the common ***STB?** query. Both methods return the same data except for bit 6. Sending ***STB?** returns MSS in bit 6, while polling returns RQS in bit 6.

The RQS Bit

When the power supply requests service, it sets the SRQ interrupt line true and latches RQS into bit 6 of the Status Byte register. When the controller services the interrupt, the RQS bit is cleared inside the register and returned in bit position 6 of the response. The remaining bits of the Status Byte register are not disturbed.

The MSS Bit

The MSS bit is real-time (unlatched) summary of all Status Byte register bits that are enabled by the Service Request Enable register. MSS is set whenever the power supply has at least one reason (and possibly more) for requesting service. Sending the power supply an ***STB?** query reads the MSS bit in position 6 of the response.None of the bits are cleared during reading of the Status Byte register.

SERVICE REQUEST ENABLE REGISTER

This register is a mask that determines which bits from the Status Byte register will be ORed to generate a service request (SRQ). It is programmed with the ***SRE** common command. When this register is cleared, no service requests can be generated to the controller.

OUTPUT QUEUE

The Output Queue is a FIFO (first-inout) data register that stores power supply-to-controller messages until the controller reads them.

Whenever the queue holds one or more bytes, it sets the MAV bit (4) in the Status Byte register. If too many unread error messages are accumulated in the queue, a system error message is generated. The Output Queue is cleared by *CLS and at power turn on.

INITIAL CONDITIONS AT POWER ON

Status Registers

When the power supply is turned on, a sequence of commands intitializes the status registers. The register states and corresponding power on commands are shown in Table 8-4.

The PON (Power On) Bit

The PON bit in the Standard Event register is set whenever the power supply is turned on. The most common use for PON is to generate an SRQ at power on following an unexpected loss of power. To do this, bit 7 of the Standard Event Enable register must be set so that a power-on event is stored in the ESB (Standard Event Summary Bit). Also, bit 5 of the Service Request Enable register must be set to permit ESB to generate an SRQ. The commands to accomplish these two conditions are:

```
*ESE 128
*SRE 32
```

If *PSC is programmed to 0, the contents of the Standard Event Enable and Service Request Enable registers are saved in nonvolatile memory and recalled at power on. This allows a PON event to generate SRQ at power on. Programming *PSC to 1 prevents these registers from being saved and they are cleared at power on. This prevents a PON event from generating SRQ at power on.

DETERMINING THE CAUSE OF A SERVICE INTERRUPT

You can determine the reason for an SRQ by the following actions:

- Use a serial poll or the *STB? query to determine which summary bits are active.
- Read the corresponding Event register for each summary bit to determine which events caused the summary bit to be set. When an Event register is read, it is cleared. This also clears the corresponding summary bit. The interrupt will recur until the specific condition that caused the each event is removed. If this is not possible, the event may be disabled by programming the corresponding bit of the status group Enable register or NTR|PTR filter. A faster way to prevent the interrupt is to disable the service request by programming the appropriate bit of the Service Request Enable register.

EXAMPLES

NOTE

These examples are generic SCPI commands. See Chapter 6 for information about encoding the commands as language strings.

Servicing an Operation Status Event

This example assumes you want a service request generated whenever the power supply switches to the CC (constant current) mode. From Figure 8-1, note that the required path is for a condition at bit 10 (CC) of the Operation Status register to set bit 6 (RQS) of the Status Byte register. The required register programming is in Table 8-5.

Table 8-4. Default Power On Register States

Register	Condition	Caused By
Operation PTR; Questionable PTR	All bits = 1	STAT:PRE
Operation NTR; Questionable NTR	All bits = 0	STAT:PRE
Operation Event; Questionable Event	All bits = 0	*CLS
Operation Enable; Questionable Enable	All bits = 0	STAT:PRE
Standard Event Status Enable	All bits = 0[1]	*ESE 0
Status Byte	All bits = 0	*CLS
Status Request Enable	All bits = 0[1]	*SRE 0
Output Queue	Cleared	*CLS

[1]If PSC = 1. If PSC = 0, then the last previous state before turn on is recalled. The value of PSC is stored in nonvolatile memory.

Table 8-5. Generating RQS from the CC Event

Register	Command	Comment
Operation PTR	STAT:OPER:PTR 1024	Allows a positive transition at the CC input (bit 10) to be latched into the Status Event register [1].
Operation Enable	STAT:OPER:ENAB 1024	Allows the latched CC event to be summed into the OPER summary bit.
Service Request Enable	*SRE 128	Enables the OPER summary bit from the Status Byte register to generate RQS
Operation Condition	STAT:OPER:EVEN?	When you service the request, read the event register to determine that bit 10 (CC) is set and to clear the register for the next event.

[1] All bits of the PTR registers bits are set to 1 at power on.

Adding Another Operation Event

To add CV (constant voltage) event to this example, it is only necessary to add the decimal value (64) for bit 8 to the programming commands of the Operation Status group. The commands to do this are:

STAT:OPER:PTR 1280;ENAB 1280

It is not necessary to change any other registers, since the programming for the operation summary bit (OPER) path has already been done.

Servicing Questionable Status Events

To add OC (overcurrent) and OT (overtemperature) events to this example, program Questionable Status group bits 1 (2) and 4 (16).

STAT:QUES:PTR 18;ENAB 18

Next, you must program the Service Request Enable register to recognize both the questionable (QUES) and the operational (OPER) summary bits.

*SRE 136

Now when there is a service request, read back both the operational and the questionable event registers.

STAT:OPER:EVEN?;QUES:EVEN?

Monitoring Both Phases of a Status Transition

You can monitor a status signal for both its positive and negative transitions. For example, to generate RQS when the power supply either enters the CC (constant current) condition or leaves that condition, program the Operational Status PTR/NTR filter as follows:

STAT:OPER:PTR 1024;NTR 1024
STAT:OPER:ENAB 1024;*SRE 128

The PTR filter will cause the OPER summary bit to set RQS when CC occurs. When the controller subsequently reads the event register (STAT:OPER:EVEN?), the register is cleared. When CC subsequently goes false, the NTR filter causes the OPER summary bit to again set RQS.

Calibration

A

INTRODUCTION

The power supply may be calibrated either from the front panel or from a controller over the HP-IB. The procedures given here apply to all models of this series.

Important

These instructions do not include verification procedures. If you need to perform verification as part of your calibration procedure, refer to the Series HP 667xA Service Manual.

EQUIPMENT

The following equipment, 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	HP 3456A or HP 3458A
HP 6671A	0.001 Ω, 0.04%, 300 A, 100 W	Guildline 9230/300
HP 6672A, 73A ,75A	0.01 Ω, 0.04%, 100 A, 100 W	Guildline 9230/100
	For HP-IB Calibration	
HP-IB Controller	HP Vectra (or IBM compatible) with HP-IB Interface; HP BASIC Series	

GENERAL PROCEDURE

WARNING

Because the power supply output must be enabled during calibration, voltages or currents hazardous to personnel and/or dangerous to equipment can appear at the output terminals.

Parameters Calibrated

You can calibrate the voltage output and readback, the current output and readback, and the OVP function. The normal procedure is to calibrate voltage first and then current. However, you do not have to do a complete calibration each time. If required, you may calibrate only the voltage or the current and then proceed to "Saving the Calibration Constants".

If you want to calibrate the OVP trip function, the power supply will do it automatically via firmware and store the OV calibration constant. *The voltage output must be in calibration before the OV trip voltage is calibrated.*

Equipment Connections

For voltage calibration:

- Disconnect all loads from the power supply
- Connect the supply for local sensing by wiring the + **LS** terminal to the + output bus bar and the − **LS** terminal to the − output bus bar.
- Connect DVM across output terminals

For current calibration:

- Disconnect all loads from the power supply
- Connect appropriate shunt (see Table A-1) across output terminals
- Connect DVM across sense terminals of shunt

For OVP Calibration

- None

(The firmware performs the calculation based on the voltage calibration constants.)

NOTE

You can exit the calibration procedure at any time without changing the existing calibration constants. To do this, press **Cal Disable** .

FRONT PANEL CALIBRATION

Seven shifted keys and the Entry keypad are used for calibration functions. (See "Chapter 5 - Local Operation" for explanations of shifted keys and the keypad.) The following steps assume you understand how to operate front panel keys and that the test equipment is connected.

Entering the Calibration Values

Use the procedure in Table A-2 for entering new calibration values.

Table A-2. Typical Calibration Procedure

Action	Display Response
Enabling the Calibration Mode	
1. Begin calibration by pressing [Cal Enable].	*PASWD*[1]
2. Enter calibration password from Entry keypad. If password is correct the **Cal** annunciator will come on. If password is incorrect, an error occurs[2]. **Note:** The initial (factory default) password is the model number of the power supply, but it can be changed (See "Changing the Password").	 *PASSWD ERROR*
Entering Voltage Calibration Values	
1. Make certain the DVM is the only load on the power supply.	(Meter mode)
2. Select the first calibration point by pressing [Vcal]. If power supply is not in CV mode, an error occurs.	*VRDG1* *WRONG MODE*
3. Read the DVM and use the Entry keypad to enter first the voltage value.	(Meter mode)
4. Select the second calibration point by pressing [Vcal] again.	*VRDG2*
5. Read the DVM and use the Entry keypad to enter the second voltage value. **Note:** If one of the entered values is not within acceptable range, an error occurs. *The power supply is now holding the new voltage calibration constants in RAM.*	(Meter mode) *CAL ERROR*
Calibrating the OVP Trip Point	
1. Make certain the voltage has been calibrated and there is no load on the power supply. If present, the optional relay accessory must be either disconnected or set to the open (off) state.	(Meter mode)
2. Select OVP calibration by pressing [OVCal].	*OVPCAL*
3. Wait for the power supply to compute the OVP calibration constant. If supply goes unregulated or into CC mode during OVP calibration, an error occurs. If computed constant is out of acceptable range, an error occurs. *The power supply is now holding the new OVP calibration constant in RAM.*	*CAL COMPLETE* *NOT CV MODE* *DOES NOT CAL*
Entering Current Calibration Values	
1. Make certain appropriate shunt (see Table A-1) is the only load on the power supply.	(Meter mode)
2. Select the first calibration point by pressing [Ical]. If power supply is not in CC mode, an error occurs.	*IRDG1* *WRONG MODE*
3. Read DVM and compute first current value (DVM reading ÷ by shunt resistance). (Wait for DVM reading to stabilize)	(Meter mode)
4. Use Entry keypad to enter first current value.	(Meter mode)
5. Select second calibration point by pressing [Ical] again.	*IRDG2*
6. Read DVM and compute second current value (DVM reading ÷ by shunt resistance). (Wait for DVM reading to stabilize)	(Meter mode)
7. Use Entry keypad to enter the second current value. **Note:** If one of the entered values is not within acceptable range, an error occurs. *The power supply is now holding the new current calibration constants in RAM.*	(Meter mode) *CAL ERROR*

[1] If *CAL DENIED* appears, then an internal jumper has been set to prevent the power supply calibration from being changed. (See the power supply *Service Manual*).

[2] If the active password is lost, the calibration function can be recovered via an internal jumper that changes the password to *0*, thereby defeating password protection. However, this also changes all calibration constants to their factory default values. (For more information, see the power supply *Service Manual*.)

Saving the Calibration Constants

CAUTION

Storing the calibration constants overwrites the existing ones in nonvolatile memory. If you are not absolutely sure that you want to store the new constants, omit this step. The power supply calibration will then remain unchanged.

To replace any existing calibration constants with ones you have just entered:

Press [Cal Save]. *CAL SAVED* then appears in the display.

Disabling the Calibration Mode

To disable the calibration mode, press [Cal Disable]. The display will return to the meter mode with the **Cal** annunciator off.

Changing the Calibration Password

You can change the calibration password only when the power supply is in the calibration mode (which requires you to enter the existing password). While in this mode, proceed as follows:

1. Press [Pass].
2. Enter the new password (up to 6 integers or 6 integers and a decimal point) in response to the prompt.
3. *AGAIN* will be displayed. Enter the new password a second time.
4. When *OK* is displayed, you have changed the password.
5. To disable the calibration mode and return to normal operation, press [Cal Disable].

NOTE

*If you want [CAL ENABLE] to operate without requiring any password, change the password to **0** (zero).*

CALIBRATION OVER THE HP-IB

In Chapter 6—"Remote Programming" you learned how to communicate with the power supply over the HP-IB. You can calibrate the power supply by using SCPI commands within your programming statements.

SCPI Calibration Commands

Be sure you are familiar with calibration from the front panel before you calibrate from a controller. The SCPI calibration commands are related to the front panel calibration controls as follows:

Front Panel Command	Corresponding SCPI Command
[Cal Enable]	CAL:STAT {ON|1},<**password**>
[Cal Disable]	CAL:STAT {OFF|0}
[Pass]	CAL:PASS <NRf>
[Vcal]	CAL:VOLT:LEV {MIN|MAX} CAL:VOLT[:DATA] <NRf>
[OVCal]	CAL:VOLT:PROT
[Ical]	CAL:CURR:LEV {MIN|MAX} CAL:CURR[:DATA] <NRf>
[Cal Save]	CAL:SAV

NOTE

See " Calibration Language Dictionary" for the complete calibration syntax.

Calibration Example

The following example shows the SCPI commands for a complete calibration. These commands can be implemented with appropriate programming language code that reads back the required DVM readings or prompts the user to enter the readings. Similarly, shunt resistance values may be entered by the user or encoded into the program where needed.

Command	Comments
	Enable Calibration Mode
	(Prompt user for password)
CAL:STAT 1,<NRf>	*<NRf>* is the password
	Calibrate Voltage
CAL:VOLT:LEV MIN	Select first calibration point (Return first DVM reading over bus or prompt user to enter the value.)
CAL:VOLT:DATA<NRf>	<NRf> is the minimum level DVM reading (VRDG1)
CAL:VOLT:LEV MAX	Select second calibration point (Return second DVM reading over bus or prompt user to enter the value.)
CAL:VOLT:DATA<NRf>	*<NRf>* is the maximum level DVM reading (VRDG2)

Command	Comments
Calibrate Overvoltage Protection	
CAL:VOLT:PROT	Wait for completion. (It takes a few seconds to make the measurements.)
Calibrate Current	(If required, prompt user for shunt resistance)
CAL:CURR:LEV MIN	Select first calibration point (Return first DVM reading over bus or prompt user to enter the value.)* Compute IRDG1 (divide DVM reading by shunt resistance)
CAL:CURR:DATA<NRf>	<*NRf*> is the minimum level current reading (IRDG1)
CAL:CURR:LEV MAX	Select second calibration point (Return second DVM reading over bus or prompt user to enter the value).* Compute IRDG2 (Divide DVM reading by shunt resistance)
CAL:CURR:DATA<NRf>	<*NRf*> is the maximum level current reading (IRDG2)

* Allow time for DVM reading to stabilize.

Save the New Calibration Constants

CAL:SAVE

Disable Calibration Mode

CAL:STAT 0

Changing the Calibration Password

You can change the calibration password only when the power supply is in the calibration mode. See the explanation of **CAL:PASS** under "Calibration Language Dictionary".

Table A-3. HP-IB Calibration Error Messages

Error No.	Meaning
1	CAL jumper prevents calibration[1]
2	CAL password is incorrect
3	CAL mode not enabled
4	Incorrect computed readback constants
5	Incorrect computed programming constants
6	Wrong CAL command sequence
7	Incorrect state (CV/CC) for this command

[1]This is a hardware disable. Refer to the power supply *Service Manual*.

CALIBRATION LANGUAGE DICTIONARY

The calibration commands are listed in alphabetical order. The format for each command follows that used in "Chapter 7 - Language Dictionary." Calibration error messages that can occur during HP-IB calibration are shown in Table A-3.

CAL:CURR[:DATA]

Enters a current calibration value that you obtain from an external meter. You must first select a calibration level (**CAL:CURR:LEV**) for the value being entered. Two successive values (one for each end of the range) must be selected and entered. (If you are entering a current value, wait for the DVM reading to stabilize.) The power supply then computes new current calibration constants. These constants are **not** stored in nonvolatile memory until saved with **CAL:SAVE**.

Command Syntax	CALibrate:CURRent[:DATA] <NRf>
Parameters	See Table 1-3 in Chapter 1
Examples	CAL:CURR 3222.3 MA CALIBRATE:CURRENT 25.0
Query Syntax	None
Related Commands	CAL:CURR:LEV

CAL:CURR:LEV

Sets the power supply to one of the two current calibration points. The calibration mode must be enabled and the lower calibration point selected first.

Command Syntax	CALibrate:CURRent:DATA {MIN|MAX}
Parameters	<CRD> *MIN* or *MAX*
Examples	CAL:CURR:LEV MIN CAL:CURR:LEV MAX CALIBRATE:CURRENT:LEVEL MIN
Query Syntax	None
Related Commands	CAL:CURR[:DATA]

CAL:PASS

Enters a new calibration password value. Command is active only if power supply is already in calibration mode. Unless it has been changed subsequent to shipment, the password is the power supply's four-digit model number. If the password is set to *0*, password protection is removed and **CAL:STAT ON** is unrestricted. A new password does not have to be saved to become permanent.

Command Syntax	CALibrate:PASScode <NRf>
Parameters	<NRf>
Examples	CAL:PASS 6652 CAL:PASSCODE 12.1776
Query Syntax	None
Related Commands	CAL:STAT

CAL:SAVE

Saves any new new calibration constant that is stored in RAM after a voltage, overvoltage, or current calibration procedure has been completed. Constants are saved in nonvolatile memory. **CAL:SAVE** functions only when the calibration mode is enabled.

Command Syntax:	CALibrate:SAVE
Parameters	None
Examples	CAL:SAVE CALIBRATE:SAVE
Query Syntax	None
Related Commands	None

CAL:STAT

Enables and disables the calibration mode. The first parameter specifies the state. The second is required to enable a system in which the password has not been defeated (not = 0). If the password parameter is not equal to the present password, an error occurs and the calibration mode is not enabled. The query statement returns only the present state, not the password.

Command Syntax	CALibrate:STATe <bool>[,<NRf>]
Parameters	First parameter: {*0*|*OFF*} or {*1*|*ON*} Second parameter: <NRf> present password
***RST Value**	0
Examples	CAL:STAT 1,6652 CAL:STATE ON,12.3456
Returned Parameters	*0* or *1*
Related Commands	CAL:PASS

CAL:VOLT[:DATA]

Enters a voltage calibration value that you obtain from an external meter. You must first select a calibration level (**CAL:VOLT:LEV**) for the value being entered. Two successive levels and data values (one for each end of the range) must be selected and entered. The power supply then computes new voltage calibration constants. These constants are saved in RAM and **not** stored in nonvolatile memory until saved with **CAL:SAVE**. Unsaved constants are lost when the calibration mode is disabled or the power supply is turned off.

Command Syntax:	CALibrate:VOLTage[:DATA]<NRf>
Parameters	See Table 1-3 in Chapter 1
Examples	CAL:VOLT 3222.3 MV CAL:VOLT 20.5
Query Syntax	None
Related Commands	CAL:VOLT:LEV

CAL:VOLT:LEV

Sets the power supply to one of the two voltage calibration points. The calibration mode must be enabled and the lower calibration point selected first.

Command Syntax	CALibrate:VOLTage:LEVel {MIN|MAX}
Parameters	<CRD> *MIN* or *MAX*
Examples	CAL:VOLT:LEV MIN CAL:VOLT:LEV MAX CALIBRATE:VOLTAGE:LEVEL MIN
Query Syntax	None
Related Commands	CAL:VOLT[:DATA]

CAL:VOLT:PROT

Calibrates the power supply overvoltage protection circuit. The calibration mode must be enabled and the voltage must already be calibrated. If present, the optional relay accessory must be either disconnected or set to the open (off) state. The power supply automatically performs the calibration and stores the new OV constant in nonvolatile memory.

Command Syntax:	CALibrate:VOLTage:PROTect
Parameters	None
Examples	CAL:VOLT:PROT CALIBRATE:VOLTAGE:PROTECT
Query Syntax	None
Related Commands	None

Compatibility Language B

ARPS PROGRAMMING COMMANDS

The HP 665xA and 667xA Series Power Supplies are programatically compatible with the HP 603xA Series AutoRanging Power Supplies (ARPS). This means that you can program the HP 665xA and 667xA supplies over the HP-IB using the ARPS commands. Any software that you have written for the autoranging power supplies will also program the HP 665xA and 667xA supplies.

NOTE

The HP 665xA and 667xA serial link is not supported by ARPS commands. You can use only an HP-IB primary address for the power supply.

To switch from SCPI commands to ARPS commands (and vice versa), use the **SYST:LANG** command. This is fully explained in Chapter 7.

Table B-1 summarizes the ARPS commands that program the HP 665xA and 667xA supplies. You will need to refer to the Autoranging System DC Power supply manual (see Table 1-4) for complete information on the ARPS commands. Some of the ARPS commands are similar to SCPI commands, others are unique to ARPS. There are also some SCPI commands that have no ARPS equivalent. This is not an issue because each command set works with the power supply that it has been designed for.

Table B-1. ARPS Commands

ARPS Command[1]	Description	Similar SCPI Command
VSET x VSET xV VSET xMV	These commands program output voltage. Refer to Table 1-3 for the programming ranges of these commands. Initial condition: 0 V	VOLT
ISET x ISET xA ISET xMA	These commands program output current. Refer to Table 1-3 for the programming ranges for these commands. Initial condition: 0 A	CURR
VSET? ISET?	These commands read voltage or current settings.	VOLT? CURR?
VOUT? IOUT?	These commands measure and read output voltage or current.	MEAS:VOLT? MEAS:CURR?
OVP x OVP xV OVP xMV	**Note: OVP commands do not work with HP 603xA supplies.** These commands program the overvoltage protection. The OVP setting is programmed in either volts or millivolts. Refer to Table 1-3 for the programming ranges of these commands. Initial condition: 10% above rated output.	VOLT:PROT
OVP?	This command reads the OVP setting.	VOLT:PROT?
VMAX x VMAX xV VMAX xMV	These commands program an upper limit (soft limit) on the voltage programming value that the power supply will accept. The programming ranges are the same as those used for VSET.	None
IMAX x IMAX xA IMAX xMA	These commands program an upper limit (soft limit) on the current programming value that the power supply will accept. The programming ranges are the same as those used for ISET.	None
VMAX? IMAX?	These commands read the soft voltage or current limits.	None
DLY x DLY xS DLY xMS	These commands program the delay time after a new output voltage or current is implemented or an RST, OUT ON, or CLR command is received. During the delay the CV, CC, and CR conditions cannot be reported as faults, and foldback protection is disabled.	OUTP:PROT:DEL

[1] x = any digit (within range)　MV = millivolt
MA = milliampere　MS = millisecond

Table B-1. ARPS Commands (continued)

ARPS Command[1]	Description	Similar SCPI Command
DLY?	This command reads the delay time setting.	OUTP:PROT:DEL?
OUT OFF OUT 0 OUT ON OUT 1	These commands enable or disable the power supply output. The disabled state programs the output to very low voltage and current values. The supply will be able to implement commands even while the output is disabled. Initial condition: OUT ON	OUTP:STAT
OUT?	This command reads the OUTPUT ON/OFF setting.	OUTP:STAT?
FOLD OFF FOLD 0 FOLD CV FOLD 1 FOLD CC FOLD 2	These commands enable or disable Foldback protection. Foldback protection disables the power supply output if the power supply switches to whichever mode (CV or CC) is defined as the fold (error) condition. Note that foldback protection is disabled during the DELAY period. Initial condition: FOLD OFF	None
FOLD?	This command reads the FOLDBACK setting.	None
RST	This command resets the power supply if the output is disabled by the overvoltage, remote inhibit, or foldback protection circuits. The power supply resets to the present voltage and current settings. Note that the settings can be changed while the supply is disabled.	OUTP:PROT:CLE
HOLD OFF HOLD 0 HOLD ON HOLD 1	These commands determine if certain newly received commands are acted on by the power supply immediately, or are acted on later while the supply continues to operate using previously received values. HOLD ON can be used to synchronize power supply actions with the actions of other HP-IB devices. See the TRG command. Initial condition: HOLD OFF	VOLT:TRIG CURR:TRIG
HOLD?	This command reads the HOLD setting.	VOLT:TRIG? CURR:TRIG?
T TRG	These commands cause the power supply to act on commands that have been previously sent, but are being held. The supply continues to operate using previously received values until a trigger command is received. See the HOLD command. The device trigger interface message performs the same function.	INIT ON;TRIG INIT ON;*TRG
STO RCL	These commands cause the power supply to store and recall up to 16 complete power supply states except for output on/off. Each state includes: voltage (1st and 2nd rank), current (1st and 2nd rank), soft voltage and current limit, delay time, service request on/off, foldback (1st and 2nd rank), mask (1st and 2nd rank), and hold. Initial condition: Each register is initialized to the turn-on values.	*SAV *RCL
STS?	This command reads the contents of the status register, which maintains the present status of the power supply.	STAT:OPER:COND? STAT:QUES:COND? *ESE?
ASTS?	This command reads the contents of the accumulated status register, which stores any bit condition entered in the status register since the accumulated status register was last read, regardless of whether the condition still exists.	STAT:OPER? STAT:QUES? *ESE?

Table B-1. ARPS Commands (continued)

ARPS Command[1]	Description	Similar SCPI Command
UNMASK mnemonics UNMASK xxx	These commands determine the conditions that will set bits in the fault register, allowing the operator to define the conditions that will be reported as faults. Fault conditions can be enabled by sending a string of status register mnemonics after the UNMASK command. The mnemonics must be separated by commas, and may be sent in any order, but must correspond to the condition that will be enabled. Fault conditions can also be enabled by sending the decimal equivalent of the total bit weight of all conditions to be enabled. UNMASK NONE disables all conditions from setting bits in the fault register. Initial condition: UNMASK NONE	STAT:OPER:ENAB STAT:QUES:ENAB *ESE
UNMASK?	This command reads which bits in the status register have been enabled as fault conditions. The decimal equvalent of the total bit weight of all enabled bits is returned.	STAT:OPER:ENAB? STAT:QUES:ENAB? *ESE
FAULT?	This command reads which bits have been set in the fault register. A bit is set in the fault register when the corresponding bit in the status register changes from inactive to active AND the corresponding bit in the mask register has been enabled. The fault register is reset only after it has been read. The decimal equivalent of the total bit weight of all enabled bits is returned.	STAT:OPER? STAT:QUES? *ESE
SRQ OFF SRQ 0 SRQ ON SRQ 1	These commands enable or disable the power supply's ability to request service from the controller for fault conditions. UNMASK defines which conditions are defined as faults. Initial condition: SRQ OFF	*SRE
SRQ?	This command reads the SRQ setting.	*SRE?
CLR	This command initializes the power supply to the power-on state. It also resets the PON bit, in the serial poll register. The device clear interface message performs the same function.	*RST
ERR?	This command determines the type of programming error detected by the supply. A remote programming error sets the ERR bit in the status register, which can be enabled by UNMASK to request service.	SYST:ERR?
TEST?	This command causes the power supply to run selftest and report any failures.	*TST?
ID?	This command causes the power supply to report its model number and any options that affect the supply's output.	*IDN?
SYST:LANG	This command causes the alternate language to become active and to be stored in nonvolatile memory. In this case, the commands are equivalent. When the supply is shut off, it will resume in the last-selected language when power is restored. The parameter must be either TMSL or COMP.	SYST:LANG

Note on Parallel Polling

Series 200/300 controller operated supplies programmed for Compatibility mode and parallel polling can "hang up" the HP-IB bus when the system is turned on. This can occur under the following conditions:

- the controller uses CS80 protocol for an external disk drive (e.g. HP 9133D).
- the external disk drive and the power supply have the *same select code and that code is 7 or less.*
- the external disk drive and power supply addresses are *binary complements of each other (e.g., 0 & 7, 1 & 6, etc.).*

When the system is turned on, the power supply accesses the HP-IB bus before the controller and prevents it from accessing the external disk drive. The solution is to change one of the HP-IB addresses, or to ensure that the power supply is not turned on until the controller has completed its selftest and has control of the HP-IB bus.

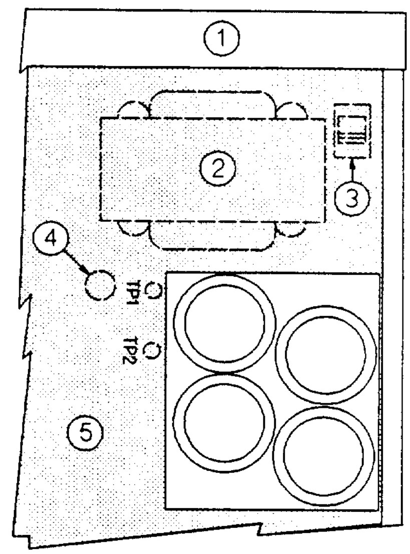
Line Voltage Conversion

C

WARNING

Hazardous voltage can remain inside the power supply even after it has been turned off. This procedure should be done only by qualified electronics service personnel.

1. Turn off the power switch and disconnect the power cord from the power source.
2. Remove the four screws that secure the two carrying straps and cover.
3. Spread the bottom rear of the cover and pull it back to disengage it from the front panel.
4. Remove the cover by sliding it back towards the rear of the supply.
5. Observe the input rail LED under the RFI shield (see Figure C-1). **If the LED is on, there is still hazardous voltage inside the supply.** Wait until it goes out (this may take several minutes) before proceeding.
6. Connect a dc voltmeter across TP1 and TP2 (It may be necessary to remove the RFI shield to reach these points. The shield is secured by four screws on each side.) When the reading is 60 volts or less, it is safe to work inside the power supply.
7. Locate the line selector switch (see Figure C-1) and slide it to the desired position.
8. If you removed it in step 6, be sure to replace the RFI shield.
9. Replace the cover.



1	FRONT OF SUPPLY
2	TRANSFORMER
3	LINE SELECTOR SWITCH
4	INPUT RAIL LED
5	RFI SHIELD

Figure C-1. Locations of Input Rail LED & Line Selector Switch

Digital Port Functions

D

DIGITAL CONNECTOR

A 4-pin connector and a quick-disconnect mating plug are provided for digital input and output signals (see Figure D-1 for wiring connections and Table 1-2 for electrical characteristics). This digital port can be configured to provide one of three functions: Fault/Inhibit, Relay Link, or Digital I/O.

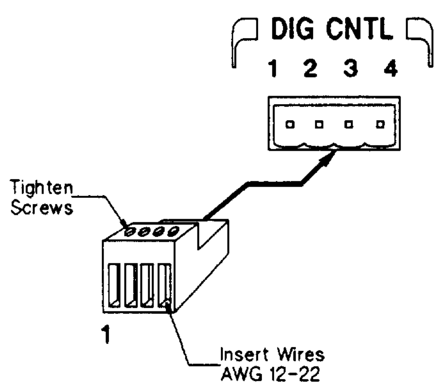
FAULT/INHIBIT OPERATION

As shipped from the factory, the digital port is configured to provide a fault indicator (FLT) output and a remote inhibit (INH) input. Disconnect the mating plug to make your wire connections.

FLT Output (pins 1 and 2) — Used to indicate that a fault has occurred in the power supply. Pins 1 and 2 are the open-collector output of an optocoupler, with pin 1 the collector and pin 2 the emitter. When a fault has occurred, pin 1 is driven low with respect to pin 2 (negative-true).

INH Input (pin 3) — Used to shut down the power supply output. Pin 3 is a high impedance input. The supply shuts down when this input is driven low (negative-true). This can be accomplished by shorting pin 3 to pin 4.

INH Common (pin 4) — Provides the common connection for the INH input.



Pin	Digital I/O	Relay Link	Fault/Inhibit
1	OUT 0	RLY SEND	FLT Output
2	OUT 1	No Connection	FLT Output
3	IN/OUT 2	RLY RTN	INH Input
4	Common	Common	INH Common

Figure D-1. Digital Connector

After you have finished making all wire connections, replace the mating plug in the connector.

Three examples are provided to show how to use the FLT/INH circuits of your power supply. Use twisted wire connections to reduce or prevent EMI in all cases. If shielded wire is used, connect only one end of the shield to the chassis signal ground binding post to prevent ground loops.

In Figure D-2, the INH input is connected to a switch that shorts pin 3 to pin 4 whenever it is necessary to externally disable the output of the supply. This will activate the remote inhibit (RI) fault protection circuit, causing the front panel **Prot** annunciator to come on. It also sets the RI event bit in the supply's Questionable Status Event register (see Chapter 8). To re-enable the supply after it has been disabled by the INH input, first open the connection between pins 3 and 4. Then clear the protection circuit either from the front panel (see Chapter 5) or over the HP-IB (see Chapter 7).

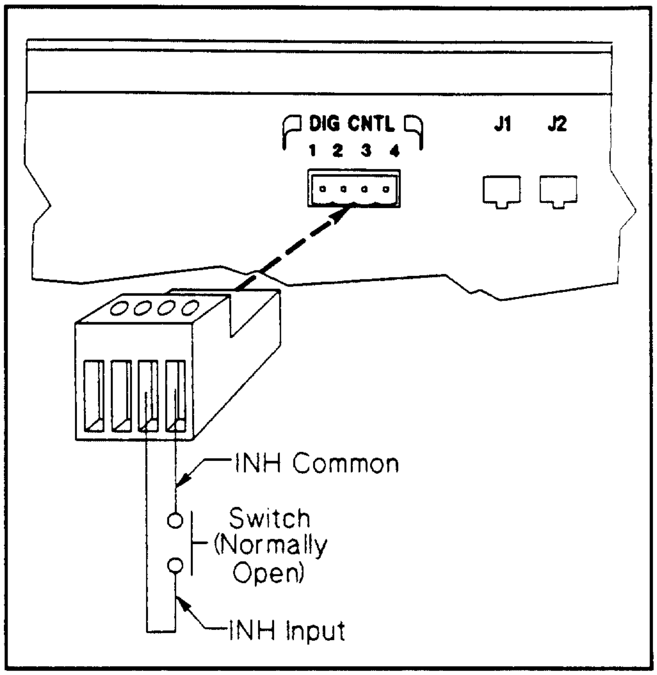


Figure D-2. INH Example

In Figure D-3, the FLT output is connected to a relay driver circuit that energizes a relay whenever a fault condition occurs on the power supply. The relay can be used to physically disconnect the output of the power supply from the load. The FLT output is generated by the logical ORing of the power supply's Operation, Questionable, and Event status summary bits. You can cause one or more events to

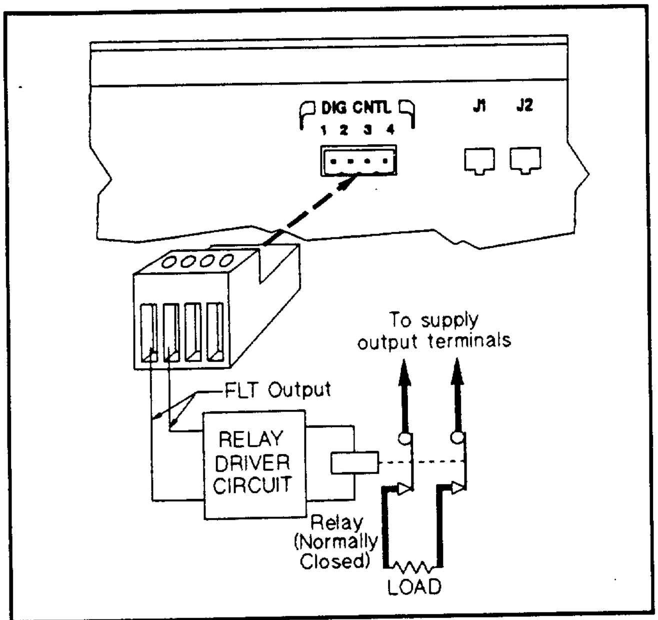


Figure D-3. FLT Example

activate the FLT output by enabling the appropriate events in these status registers. (See Chapter 8 for more information about the registers.) The fault condition is cleared by first removing the cause of the fault and then reading the appropriate status event register(s).

In Figure D-4, the FLT output of one supply is connected to the INH input of another supply. Although only two supplies are shown, it is possible to chain other supplies using this arrangement. A fault condition in any one of the power supplies will disable all of them without intervention either from the controller or by external circuitry. The controller can be made aware of the fault via a service request (SRQ) generated by the Questionable Status summary bit. (See Chapter 8 for more information on this bit.)

The INH input cannot be used to disable outputs set form the external voltage programming port.

The digital port is configured for FLT/INH operation when shipped from the factory. You can change the configuration of the port to operate as a general-purpose digital input/output port to control your custom circuitry. On the Model 6674A only, you can also change the port to operate as a relay link for use with a HP 59510A or 59511A Relay Accessory.

CHANGING THE PORT CONFIGURATION

To change the port configuration, you must move a jumper on the HP-IB board. Proceed as follows:

WARNING

Hazardous voltage can remain inside the power supply even after it has been turned off. This procedure should be done by qualified electronics service personnel.

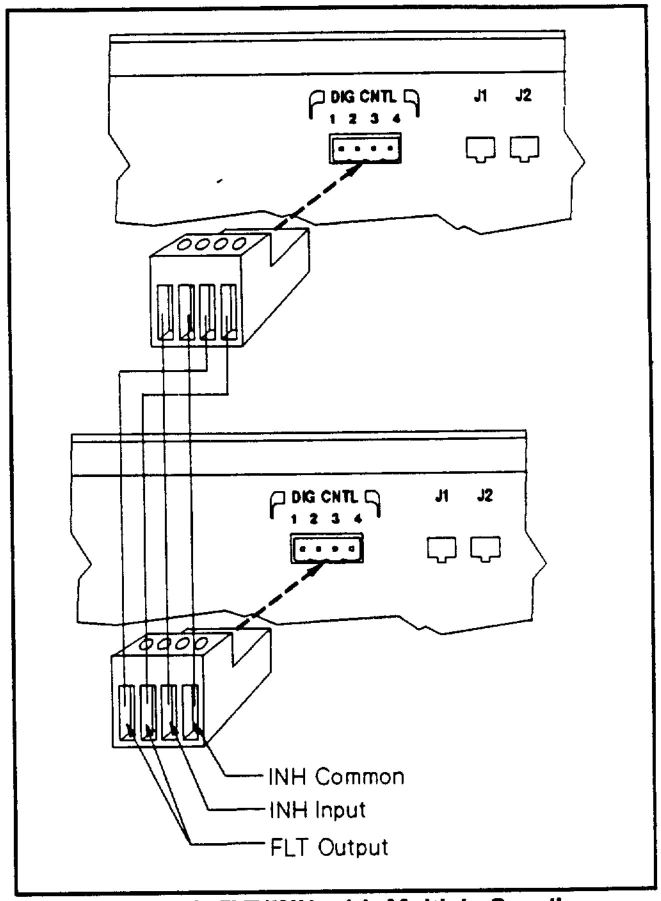


Figure D-4. FLT/INH with Multiple Supplies

1. Turn off the power switch and disconnect the power cord from the power source.
2. Remove the four screws that secure the two carrying straps (see Table 1-4).
3. Spread the bottom rear of the cover and pull it back to disengage it from the front panel.
4. Remove the cover by sliding it back towards the rear of the supply.
5. Locate the input rail LED under the shield cover (see Figure C-1). **If the LED is on, there is still hazardous voltage inside the supply. Wait until it goes out (this may take several minutes) before proceeding.**
6. Connect a dc voltmeter across TP1 and TP2. When the reading is 60 volts or less, it is safe to work inside the power supply.
7. Refer to Figure D-5 and use needle-nose pliers to move the jumper to either the Relay Link or Digital I/O position.
8. Replace the top cover, and secure the carrying straps.
9. Make the necessary wire connections to the digital connector.

RELAY LINK OPERATION

CAUTION

Do not use these accessories with the HP 6671A. Its high output exceeds their current-handling capacity.

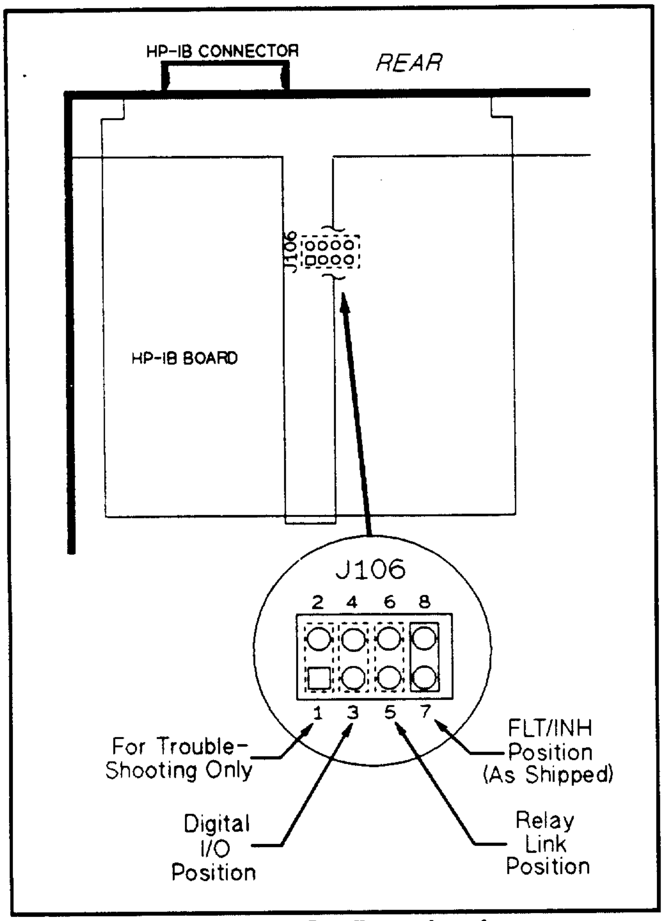


Figure D-5. Port Configuration Jumper

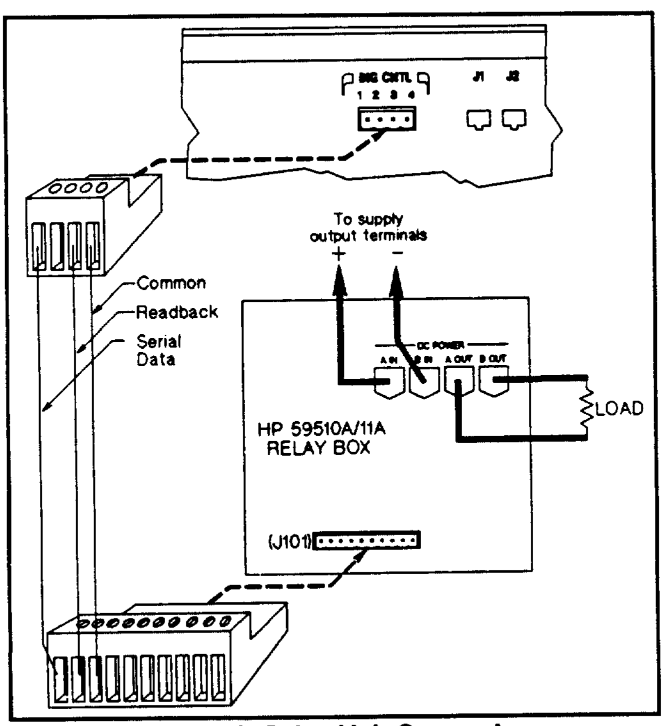


Figure D-6. Relay Link Connections

The digital port can be configured to provide relay control outputs for the HP 59510A or 59511A Relay Accessory. Refer to Figure D-1 for the pin assignments of the mating plug.

RLY SEND (pin 1) Provides the serial data to control the relays in the Relay Accessory.

(pin 2) (Not used)

RLY RTN (pin 3) Receives the data readback that indicates the status of the relays in the Relay Accessory.

Common (pin 4) Common connection for the RLY SEND and RLY RTN lines.

Figure D-6 shows how to connect your power supply to a HP 59510A or 59511A Relay Accessory when the digital port is configured for relay link operation. *An error will be generated if you attempt to program the relay box without first configuring the digital port for relay link operation.* For more information about programming the relay, refer to **OUTP:REL[:STAT]** in Chapter 7. For more information about the Relay Accessory, refer to its manual (see Table 1-4).

DIGITAL I/O OPERATION

This digital port can be configured to provide a digital input/output to be used with custom digital interface circuits or relay circuits. Some examples are shown in Figure D-7. See Figure D-1 for the pin assignments of the mating plug and Table 1-2 for the electrical charactaristics of each port. See **DIG:DATA[:VAL]** in Chapter 7 for information on programming these ports.

OUT 0 (pin 1) This port can only be used as an open-collector output. It is assigned a bit weight of 1.

OUT 1 (pin 2) This port can only be used as an open-collector output. It is assigned a bit weight of 2.

IN/OUT 2 (pin 3) This port can be programmed to be either a high impedance input or an open-collector output.

Common (pin 4) This pin is the common connection for the Digital I/O ports.

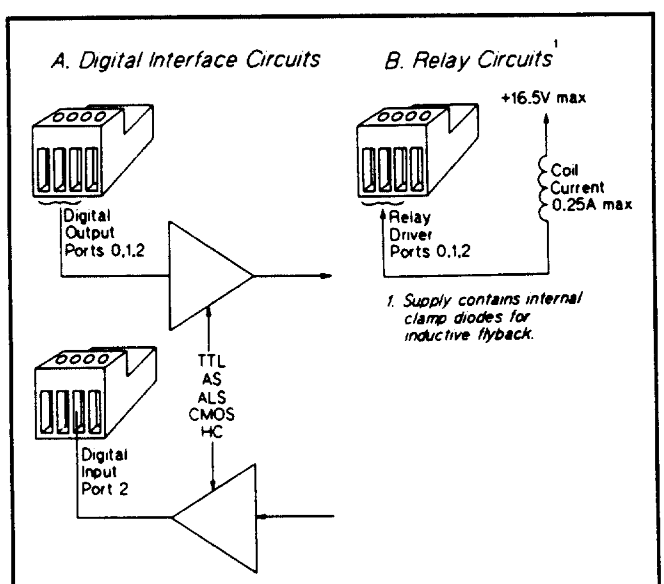


Figure D-7. Digital I/O Application

SCPI Conformance Information E

Note	See *Chapter 7 - Language Dictionary* for command syntax.

SCPI Version

This power supply conforms to Version 1990.0.

SCPI Confirmed Commands

ABOR	OUTP:PROT:DEL	TRIG[:STAR]:DEL
CAL[:STAT]	OUTP:PROT:DEL?	TRIG[:STAR]:DEL?
[SOUR]:CURR[:LEV][:IMM][:AMPL]	STAT:OPER[:EVEN?]	TRIG[:STAR]:SOUR
[SOUR]:CURR[:LEV][:IMM][:AMPL]?	STAT:OPER:COND?	TRIG[:STAR]:SOUR?
[SOUR]:CURR[:LEV]:TRIG[:AMPL]	STAT:OPER:ENAB	[SOUR]:VOLT[:LEV][:IMM][:AMPL]
[SOUR]:CURR[:LEV]:TRIG[:AMPL]?	STAT:OPER:ENAB?	[SOUR]:VOLT[:LEV][:IMM][:AMPL]?
[SOUR]:CURR:PROT:STAT	STAT:OPER:NTR	[SOUR]:VOLT[:LEV][:TRIG][:AMPL]
[SOUR]:CURR:PROT:STAT?	STAT:OPER:NTR?	[SOUR]:VOLT[:LEV][:TRIG][:AMPL]?
DISP[:WIND][:STAT]	STAT:OPER:PTR	[SOUR]:VOLT:PROT[:LEV]
DISP[:WIND][:STAT]?	STAT:OPER:PTR?	[SOUR]:VOLT:PROT[:LEV]?
DISP[:WIND]:TEXT[:DATA]	STAT:PRES	*CLS *RCL
DISP[:WIND]:TEXT[:DATA]?	STAT:QUES[:EVEN]?	*ESE *RST
INIT[:IMM]	STAT:QUES:COND?	*ESE? *SAV
INIT:CONT	STAT:QUES:ENAB	*ESR? *SRE
INIT:CONT?	STAT:QUES:ENAB?	*IDN? *SRE?
MEAS:CURR[:DC]?	SYST:ERR?	*OPC *STB?
MEAS:VOLT[:DC]?	SYST:LANG	*OPC? *TRG
OUTP[:STAT]	SYST:LANG?	*PSC *TST?
OUTP[:STAT?]	SYST:VERS?	*PSC? *WAI
OUTP:PROT:CLE	TRIG[:STAR][:IMM]	

SCPI Approved Commands

(None)

Non-SCPI Commands

CAL:CURR[:DATA]	CAL:VOLT:LEV	DISP[:WIND]:MODE?
CAL:CURR:LEV	CAL:VOLT:PROT	OUTP:REL:POL
CAL:PASS	[SOUR]:DIG:DATA[:VAL]	OUTP:REL:POL?
CAL:SAV	[SOUR]:DIG:DATA[:VAL]?	[SOUR]:VOLT:PROT[:AMPL]
CAL:VOLT[:DATA]	DISP[:WIND]:MODE	[SOUR]:VOLT:PROT[:AMPL]?

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