USER'S GUIDE

AGILENT 6010A, 6011A, 6012B, 6015A, 6023A and 6028A DC AUTORANGING POWER SUPPLY

Agilent Technologies

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CERTIFICATION

Agilent Technologies certifies that this product met its published specifications at time of shipment from the factory. Agilent Technologies 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

The 601xA/B and 602xA Agilent Technologies hardware products are warranted against defects in material and workmanship for a period of one year from date of delivery. Agilent software and firmware products, that are designated by Agilent for use with a hardware product and when properly installed on that 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 Agilent Technologies will, at its option, either repair or replace products that prove to be defective. Agilent 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 Agilent. Customer shall prepay shipping charges (and shall pay all duty and taxes) for products returned to Agilent for warranty service. Except for products returned to a Customer from another country, Agilent shall pay for return of products to the Customer.

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

If Agilent 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 Agilent.

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. AGILENT 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. AGILENT 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 Agilent Technologies Sales and Service office for further information on Agilent's full line of Support Programs.

Edition 1___January, 1999
Update 1___February, 2000
Update 2___September, 2004

Safety Summary

The following general safety precautions must be observed during all phases of operation 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. Agilent Technologies assumes no liability for the customer's failure to comply with these requirements.

GENERAL

This product is a Safety Class 1 instrument (provided with a protective earth terminal). The protective features of this product may be impaired if it is used in a manner not specified in the operating instructions.

Any LEDs used in this product are Class 1 LEDs as per IEC 825-1.

This ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada.

ENVIRONMENTAL CONDITIONS

This instrument is intended for indoor use in an installation category II, pollution degree 2 environment. It is designed to operate at a maximum relative humidity of 95% and at altitudes of up to 2000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage, the correct fuse is installed, and all safety precautions are taken. Note the instrument's external markings described under "Safety Symbols".

GROUND THE INSTRUMENT

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).

ATTENTION: Un circuit de terre continu est essentiel en vue du fonctionnement sécuritaire de l'appareil. Ne jamais mettre l'appareil en marche lorsque le conducteur de mise … la terre est d,branch,.

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.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

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

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

SAFETY SYMBOLS

	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal
	Protective earth (ground) terminal
	Frame or chassis terminal
	Terminal is at earth potential. Used for measurement and control circuits designed to be operated with one terminal at earth potential.
	Terminal for Neutral conductor on permanently installed equipment
	Terminal for Line conductor on permanently installed equipment
	On (supply)
	Off (supply)
	Standby (supply). Units with this symbol are not completely disconnected from ac mains when this switch is off. To completely disconnect the unit from ac mains, either disconnect the power cord or have a qualified electrician install an external switch.
	In position of a bi-stable push control
	Out position of a bi-stable push control
	Caution, risk of electric shock
	Caution, hot surface
	Caution (refer to accompanying documents)
WARNING	The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.
Caution	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

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

Manufacturer's Name and Address

Responsible Party
Agilent Technologies, Inc.
550 Clark Drive, Suite 101
Budd Lake, New Jersey 07828
USA

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

Declares under sole responsibility that the product as originally delivered

Product Names
a) 1 kW Single Output System dc Power Supplies
b) 1 kW Single Output dc Power Supplies
c) 200 W Single Output System dc Power Supplies

Model Numbers
a) 6030A; 6031A; 6032A; 6035A
b) 6010A; 6011A; 6012B; 6015A
c) 6033A 6038A
(and other customized products based upon the above)

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

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

EMC Information ISM Group 1 Class A Emissions

As detailed in Electromagnetic Compatibility (EMC), Certificate of Conformance Number CC/TCF/00/078 based on Technical Construction File (TCF) HPNJ5, dated Oct. 29, 1997

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

Safety Information and Conforms to the following safety standards.

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

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

January 1, 2004
Date

Bill Darcy/ Regulations Manager

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

Acoustic Noise Statement

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).

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General Information

Introduction

This manual contains specifications, installation instructions, and operating instructions for DC Power Supply Models: Agilent6010A, 6011A, 6012B, 6015A, 6023A and 6028A. Refer to "Related Documents" for other information concerning these products.

Description

These power supplies are autoranging supplies**.** Autoranging allows the power supply to deliver full output power over a higher voltage and current combination than would be possible with a rectangular output characteristic (see figure 1-1). They use a 20k Hz pulse-width modulation circuit with power MOSFETs to provide the autoranging output characteristic with laboratory performance.

Output voltage and current are continuously indicated on two 3 ½ digit displays. Front-panel controls allow the user to set output voltage, current and Overvoltage Protection (OVP) trip levels. OVP protects the load by quickly and automatically interrupting energy transfer if a preset voltage trip level is exceeded. Push button switches allow the display to alternately show the programmed values of voltage and current or the overvoltage limit. LED indicators show the operating state of the unit (CV, CC, Unregulated and Overvoltage).

All connections are made to rear-panel screw-on terminals.

Output voltage can be locally or remotely sensed.

A six-position MODE switch located on the rear panel is used to change from front panel control to remote voltage or remote resistance control. See section 3 for a description of remote programming, remote sensing and several methods of multiple supply operation.

Either the positive or negative output terminal may be grounded or the output may be floated (including output voltage) up to ± 240 Vdc on models 6011A, 6012B, 6023A and 6028A or ± 550 Vdc on models 6010A and 6015A from chassis ground.

The power supply is fan cooled and is packaged in an Agilent Technologies System II-compatible modular that provides easy access for servicing. A thermostat shuts down the supply if an over-temperature condition occurs and resets automatically.

Safety Considerations

This product is a Safety Class 1 instrument (provided with a protective earth terminal). The instrument and this manual should be reviewed for safety markings and instructions before operation. Refer to the Safety Summary page at the beginning of this manual for general safety information. Safety information for specific procedures is located at appropriate places in this manual.

Options

Options are standard factory modifications or accessories that are delivered with the supply. The following options are available. Note lower output power and voltage specifications for Option 100, which is described in Appendix A.

Option	Description
100	Input power: 100 Vac + 6%, -10%; 48-63 Hz single phase.
120	Input power: 120 Vac +6%, -13%. 48-63 Hz single phase.
220	Input Power: 220 Vac +6%, -13%; 48-63 Hz, single phase.
240	Input power: 240 Vac +6%, -13%; 48-63 Hz, single phase.
800	Rack mount kit for two units side by side (models 6023A and 6028A only)
908	Rack mounting kit
909	Flanges with Handles
0L2	One additional User's Guide
0B3	Service Manual

Accessories

The System-II cabinet accessories listed below may be ordered with the power supply or separately from your local Agilent Technologies Sales and Support Office (see list of addresses at rear of this manual).

For Agilent Models 6023A and 6028A

Agilent Part No	Description
5062-3989	Front handle kit for 5-1/4 inch high cabinets
1460-1345	Tilt stand (1) snaps into standard foot on; must be used in pairs
5062-3977	Rack flange kit for 5-1/4 inch high cabinet (will be shipped with supply if ordered as Option 908)
5062-3983	Rack mount flange kit with handles
1494-0060	Rack slide kit, non tilting
5060-2865	Service kit, includes extenders for control and power mesh boards, three cables to allow GP-IB and PSI boards to lie on table outside unit, and control board test connector.
5060-2866	FET service kit. Includes FETs and all components that should be replaced with FETs.
59510A	Relay Accessory
59511A	Relay Accessory (Polarity Reversing)

For Agilent Models 6023A and 6028A

For Agilent Models 6023A and 6028A

Agilent Part No	Description
5062-3960	Rack mounting adapter kit for side mounting one 7-inch high cabinet, includes one rack flange and one half-module width extension adapter. (Will be shipped with instrument if ordered as Option 908). This rack mounting adapter kit is not compatible with front handle kit Agilent P/N 5061-3990).
5062-3961	Rack mounting adapter kit for center mounting one 7-inch high cabinet, includes one rack flange and one quarter-module width extension adapter (two kits required), there will be surplus of hardware.
5062-3978	Rack flange kit for 7-inch high cabinet. Must be used with another half-module width unit of equal depth with lock link kit 5061-9694. (Will be shipped if instrument is ordered as Option 800).
5061-9694	Lock link kit for joining units of equal depth, contains hardware for three side-by-side joints (four units) and two over-under joints (three units). Locking cabinets together horizontally in a configuration wider than one full module is not recommended. 5062-3978 and 5061-9694 will be shipped if Option 800 is ordered.
5062-3990	Front handle kit for 7-inch high cabinets. Corresponding flange kit is 5061-2072. This front handle kit is not compatible with rack mounting adapter kit (Agilent PIN 5062-3960) or Option 908.
5061-2072	Flange kit to be used with front handle kit 5062-3990.
5062-3984	Rack mounting flange kit with handles for 7-inch high cabinet. Must be used with another half-module width unit of equal depth with lock link kit 5061-9694.
5062-4003	Bail handle kit for carrying 7-inch high, half-module width cabinet.
1460-1345	Tilt stand (1) snaps into standard foot on instrument, must be used in pairs.
5062-3998	Support shelf bit for mounting on or more 7-inch high cabinets of any depth to 20 inches.
5062-4027	Front filler panel, half-module width, for 7-inch high cabinet on support shelf.
1494-0065	Slide kit for 5061-0098 support shelf.
06033-60005	Service kit, includes extenders for control and power mesh boards, three cables to allow GP-IB and

	PSI boards to lie on table outside unit, and control board test connector.
5060-0138	GP-IB connector non-metric to metric conversion kit.
5060-2860	FET service kit, includes FETs and all components that should be replaced with FETs.
59510A	Relay Accessory
59511A	Relay Accessory (Polarity Reversing)

Instrument and Manual Identification

The serial numbers listed on the front of this guide indicate the versions of the supplies that were available when the manual was issued. If changes have been made to the instrument since the publication of this manual the manual may include a loose yellow "Manual Change" sheet. That sheet updates this manual by defining any differences between the version of your supply and the instruments described in this manual, and may also include information for correcting any manual errors. Note that because not all changes to the product require changes to the manual, there may be no update information required for your version of the supply.

Ordering Additional Manuals

One User's Guide is shipped with each power supply. Additional User's Guides and Operating and Service manuals may be purchased directly from your local Agilent Technologies Sales office. Specify the model number, serial number prefix, and the manual part number provided on the title page. (When ordered at the same time as the power supply, additional manuals may be purchased by adding Option 910 to the order. Each Option 910 includes one User's Guide and one Operating and Service Manual).

Related Documents

The following service documents can be ordered from your local Agilent Sales Office.

Agilent 6010A Operating and Service manual Agilent part number 06010-90001
Agilent 6011A Operating and Service manual Agilent part number 06011-90001
Agilent 6012B Operating and Service manual Agilent part number 06012-90004
Agilent 6015A Operating and Service manual Agilent part number 06015-90001
Agilent 6023A Operating and Service manual Agilent part number 06023-90001
Agilent 6028A Operating and Service manual Agilent part number 06010-90001

Specifications

Specifications for the power supply fall into two major categories: performance specifications and supplemental characteristics.

Performance specifications describe the power supply's warranted performance. All performance specifications are at the rear output terminals with a resistive load. Specifications apply over the full operating temperature range of 25 +/- 5°C unless otherwise specified range. The Service Manual has procedures for verifying the performance specifications.

Supplemental characteristics give typical but non-warranted performance parameters. Design or type testing determines supplemental characteristics. They are useful in understanding the power supply's operation when accessing applications for the power supply.

Table 1-1 Performance Specifications

Agilent Technologies Model			6010A	6011A
DC Output: Voltage, current and power spans indicate range over which output may be varied using front panel controls.		**Volts**	**0-200 V**	**0-20 V**
		Amps	**0-17 A**	**0-120 A**
		Maximum Power	**1000-1200 W**	**840-1072 W**
Load Effect (Load Regulation) Voltage load effect is given for a load current change equal to the current rating of the supply. Current load effect is given for a load voltage change equal to the voltage rating of the supply.		Voltage	0.01% + 5 mV	0.01% + 3 mV
		Current	0.01% + 10 mA	0.01% + 15 mA
Source Effect (Line Regulation): Given for a change within the rated line voltage for any output within the rated output voltage, current and power of the supply		Voltage	0.01% + 5 mV	0.01% + 2 mV
		Current	0.01% + 5 mA	0.01% + 25 mA
PARD (Ripple and Noise): Measured at any line voltage and under any load condition within rating (rms 10 Hz to 10 Mhz/p-p 10 Hz to 20 MHz)		Voltage	22 mV/50 mV[2]	8 mV/50 mV
		Current	15 mA/[1, 4]	120 mA/[1,4]
Load Effect Transient Recovery: Maximum time required for output voltage to recover within the specified band around the nominal output voltage following a step change (10% or 50%) in output current while operating in the constant voltage mode		Time 10%/50%	2 ms/3 ms	2 ms/3 ms
		Level 10%/50%	150 mV/500mV	100 mV/300mV

Table 1-2. Supplemental Characteristics

Agilent Technologies Model			6010A	6011A
Programming: Given for control of the output over the GP-IB or with front panel controls		Voltage Resolution	70 mV	5 mV
		Current Resolution	7 mA	40 mA
Front Panel Voltmeter:		Range	20 V, 200 V	20 V, 200 V
		Resolution	100 mV, 1 V	10 mV, 100 mV
		Accuracy	0.65% + 3.5 counts, 0.65% + 3.5 counts	0.6% + 2 counts, 0.8% + 2 counts
		T.C. (per/°C)	80 ppm + 1 mV, 80 ppm + 1 mV	80 ppm + 1mV, 100ppm + 1 mV
Front Panel Ammeter:		Range	20 A	200 A
		Resolution	10 mA	100 mA
		Accuracy	0.6% + 4 counts	0.7% + 300 mA[4]
		T.C. (per/°C)	100 ppm + 2 mA	100 ppm + 3 mA
Display OVP:		Range	2000 V	200 V
		Resolution	1 V	100 mV
		Accuracy	2.5% + 1.1 V	2.5% + 625 mV
		T.C. (per/°C)	200 ppm + 3 mV	150 ppm + 3 mV
Maximum AC Input Current: +6% -13% (48-63) Hz		100 Vac (Opt.100)	24	24
		120 Vac (Std.)	24 A	24 A
		220 Vac (Opt.220)	15 A	15 A
		240 Vac (Opt.240)	14 A	14 A
Typical input power at rated output power: (see point P_2 on Figure 1-1)			1435 W	1375 W
Temperature Coefficient: Output change per degree Celsius change in ambient following 30 minute warm-up.		Voltage	80 ppm + 15 mV	100 ppm + 2 mV
		Current	100 ppm + 4 mA	180 ppm + 15 mA
Drift (Stability): Change in output (dc to 20 Hz) over 8-hour internal under constant line, load, and ambient following 30-minute warm-up		Voltage	0.03 % + 17 mV	0.03% + 3 mV
		Current	0.03% + 5 mA	0.1% + 25 mA
Programming Response Time: The maximum time required		Settling Band	300 mV	30 mV
to change from zero volts to full scale voltage or from full scale	Up	Full Load	300 ms (0.4Ω)	300 ms (40 Ω)
voltage to 2 volts (6 volts for Agilent 6028A and 5 volts for Agilent 6015A)		No Load	300 ms	300 ms
and settle within the specified band. Full load is defined as the	Down	Full Load	500 ms (0.4Ω)	600 ms
resistance equal to Vp1/Ip1. Light load is as specified		Light Load	3.5 s (open Ω)	1.5 s (50 Ω)
Overvoltage Protection: Trip voltage adjustable via front panel control using the Display OVP function		Range	0-214 V	0-22 V
		Resolution	600 mV	100 mV
		Accuracy	0.3% + 1.25 V	0.25% + 625 mV
Monitoring Output Accuracy: 0 to 5 V signals from rear panel terminals that indicate 0 to full scale output voltage and current. Output impedance = 10K Ω.		Voltage	0.3% + 60 mV	0.25% + 2 mV
		Current	0.36% + 10 mA	0.3% + 35 mA
Remote Analog Programming Accuracy	Resistance (0 to 4K)	Voltage	0.5% + 35 mV	0.5% + 215 mV
		Current	1% + 800 mA[3]	1% + 170 mA
	Voltage (0 to 5V)	Voltage	0.25% + 35 mA	0.3% + 215 mV
		Current	0.4% + 800 mA[3]	0.36% + 170 mA
Reverse Voltage Protection: Maximum continuous current caused by reverse voltage impressed across the output terminals.		Ac power on	17 A	50 A
		Ac power off	7 A	20 A

6012B	6015A	6023A	6028A
0-60 V	**0-500 V**	**0-20 V**	**0-60 V**
0-50 A	**0-5 A**	**0-30 A**	**0-10 A**
1000-1200 W	**1000-1050 W**	**200-242 W**	**200-242 W**
0.01% + 5 mV	0.01% + 40 mV	0.01% + 2 mV	0.01% + 3 mV
0.01% + 10 mA	0.03% + 34 mA	0.01% + 9 mA	0 01% + 5 mA
0.01% + 3 mV	0.01% + 13 mV	0.01% + 1 mV	0.01% + 2 mV
0.01% + 10 mA	0.03% + 17 mA	0 01% + 6 mA	0 01% + 2 mA
0.005% + 5 mV/40 mV[5]	50 mV/160 mV	3 mV/30 mV	3 mV/30 mV
25 mA/[1, 4]	50 mA[1, 4]	30 mA/[1, 4, 7]	5 mA/[1, 4]
2 ms/3 ms	5 ms/[6]	1 ms/2 ms	1 ms/[6]
100 mV/300 mV	200 mV/[6]	50 mV/150 mV	75 mV/[6]

NOTES.

1. P-P PARD not specified
2. Initially, for each degree below 20°C the ripple increases 2.4 mV/°C. After load is applied for 15 minutes, the increase becomes 1.4 mV/°C.
3. After a five-minute wait.
4. CC PARD is specified for a 1.2 m (4 feet) length load lead
5. P-P 75mV (20 Hz to 100MHz
6. 50% change not specified
7. Typical common mode current 1 mA RMS/40 mA P-P

6012B	6015A	6023A	6028A
20 mV	15 mV	5 mV	15 mV
20 mA	2.5 mA	10 mA	10 mA
20 V, 200 V	2000 V	20 V, 200 V	20 V, 200 V
10 mV, 100 mV	1 V	10 mV, 100 mV	10 mV, 100 mV
0.65% + 3.5 counts, 0.65% + 3.5 counts	1% + 3.5 counts	0.6% + 20 mV, 0.6 + 200mV	0.6% + 20 mV, 0.6 + 200mV
80 ppm + 1mV, 80 ppm + 1mV	100 ppm + 30 mV	75 ppm + 0.25 mV	75 ppm + 0.25 mV
200 A	20 A	200 A	200 A
100 mA	10 mA	100 mA	100 mA
0.6% + 4 counts	1% + 4 counts	0.6% + 200 mA	0.6% + 70 mA
100 ppm + 2 mA	100 ppm + 7.5 mA	100 ppm + 1.5 mA	100 ppm + 1.5 mA
200 V	2000 V	200 V	200 V
100 mV	1 V	100 mV	100 mV
2.5% + 550mV	3% + 1 count	2.5% + 250mV	2.5% + 250 mV
200 ppm + 3 mV	100 ppm + 30 mV	200 ppm + 1 mV	200 ppm + 1 mV
24	24	6.0 A	6.0 A
24 A	24 A	6.5 A	6.5 A
15 A	15 A	3.8 A	3.8 A
14 A	14 A	3.6 A	3.6 A
1450 W	1256 W	340 W	325 W
80 ppm + 4 mV	100 ppm + 30 mV	70 ppm + 0.6 mV	70 ppm + 0.6 mV
100 ppm + 8 mA	100 ppm + 7 mA	100 ppm + 2 mA	100 ppm + 2 mA
0.03 % + 5 mV	0.03% + 40 mV	0.02 % + 1 mV	0.02% + 2 mV
0.03% + 10 mA	0.03% + 17 mA	0.03% + 10 mA	0.03% + 10 mA
90 mV/200 mV	750 mV	5 mV	15 mV
300 ms/120 ms (3.4 Ω)	350 ms (250 Ω)	100 ms (2 Ω)	150 ms (2 Ω)
300 ms/ 120 ms	250 ms	100 ms	120 ms
2 s/400 ms (3.4 Ω)	600 ms (250 Ω)	200 ms (2 Ω)	150 ms (2 Ω)
3 s/ 35 s (100 Ω)	7 s (100 Ω)	500 ms (50 Ω)	750 ms (50 Ω)
0-64 V	0-535 V	0-23 V	0-67 V
200 mV	1.5 V	100 mV	100 mV
0.25% + 550 mV	0.3% + 1.25 V	0.25% + 250 mV	0.25% + 250 mV
0.3% + 15 mV	1% + 150 mV	0.25% + 2 mV	0.25% + 2 mV
0.36% + 20 mA	0.5% + 100 mA	0.3% + 15 mA	0.3% + 15 mA
0.5% + 70 mV	1% + 600 mV	0.5% + 12 mV	0.5% + 36 mV
1% + 500 mA	2% + 425 mA	1% + 110 mA	1% + 40 mA
0.3% + 70 mV	0.8% + 600 mV	0.25% + 12 mV	0.25% + 36 mV
0.36% + 500 mA	0.7% + 425 mA	0.3% + 110 mA	0.3% + 40 mA
50 A	5 A	30 A	10 A
20 A	5 A	15 A	5 A

Table 1-2 Supplemental Characteristics (continued)

DC Floating Voltage: Either output terminal may be floated up to the following voltage (including the output voltage) from earth ground:
± 240 Vdc on Models 6011A, 6012B, 6023A, and 6028A
± 550 Vdc on Models 6010A and 6015A
Exceeding these voltages can result in damage to the equipment.

Efficiency (typical): 80% on maximum output boundary

Remote Sensing: The power supply maintains specifications at the load with up to 0.5 Volt per load lead with sense wire resistance less than 0.2 Ω per lead and sense lead length less than 5 metres. Operation with up to 2 volts per load lead is possible with some degradation of the load effect specification.

Multiple Operations: Up to two similar units may be connected in series, parallel or auto-parallel, to provide increased output capabilities. Mixing supplies with dissimilar output capabilities is not recommended because under certain conditions, the lower output supply may be stressed beyond its maximum voltage and or current capabilities by the higher output supply.

Reactive Loads: Stable with inductive loads up to 100 mH and capacitive loads up to 10 F. CC compensation that provides up to 10 H (with increased settling times) is available on special order.

Voltage Overshoot (typical): The output voltage will overshoot its steady state value by less than 250 mV (1 V on Model 6015A) due to any of the following conditions:

1. Up programming
2. Crossover from CC to CV mode
3. A step change of up to 5A
4. AC power on

Temperature Rating (°C):

- Operating is 0-50 (Agilent 6010A/6011A/6012B/6015A)
  0-55 (Agilent 6023A/6028A)
- Storage is - 40 + 75 (all models)

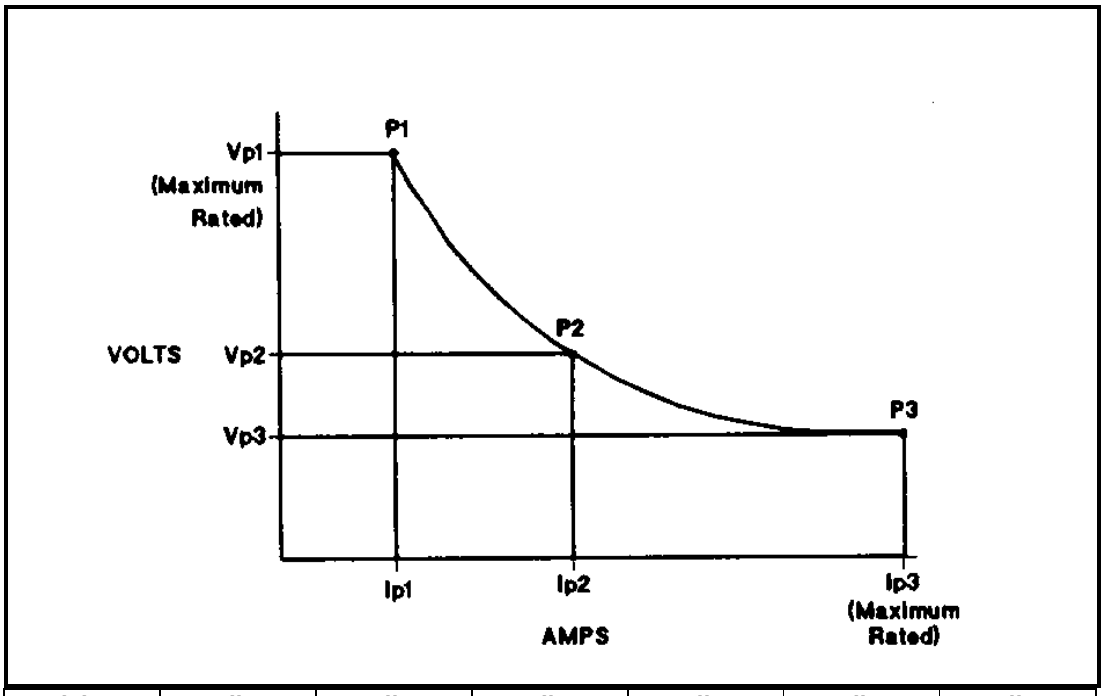
Weight kg. (Lbs.)

Model	Agilent 6010A	Agilent 6011A	Agilent6012B	Agilent 6015A	Agilent 6023A	Agilent 6028A
Net	15.9 (35)	16.8 (37)	15.9 (35)	16.3 (36)	8.6 (19)	8.6 (19)
Shipping	21.3 (47)	22.3 (49)	21.4 (47)	21.7 (48)	10.5 (23)	10.5 (23)

Dimensions: See Figure 2-1.

Certification:
The unit is designed to comply with these requirements:

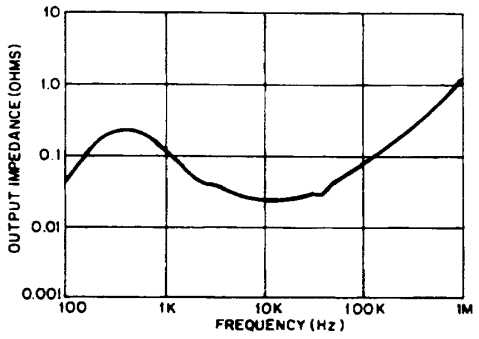
- IEC 348-Safety Requirements for Electronic Measuring Apparatus.
- CSA Electrical Bulletin 556B-Electronic Instruments and Scientific Apparatus for Special Use and Applications.
- VDE 0871.6.78 Level B-RFI Suppression of Radio Frequency Equipment for Industrial, Scientific, and Medical (ISM) and similar purposes.
- VDE 0411-Electronic Measuring Instruments and Automatic Controls.
- UL 1244-Electrical and Electronic Measuring & Testing Equipment.
- ANSI C39.5 Part 0 Draft 8-Electrical Testing, Measurement, and Control Equipment.
- Agilent Class B – Environmental Specifications



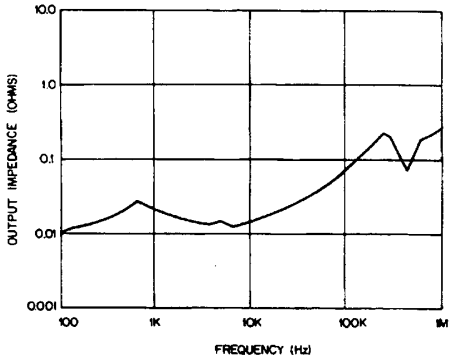
Model	Agilent 6010A	Agilent 6011A	Agilent 6012B	Agilent 6015A	Agilent 6023A	Agilent 6028A
Vp1	200 V	20 V	60 V	500 V	20 V	60 V
Ip1	5 A	50 A	17.5 A	2 A	10 A	3.3 A
Vp2	120 V	14 V	40 V	350 V	14 V	40 V
Ip2	10 A	76 A	30 A	3 A	17.2 A	6 A
Vp3	60 V	7 V	20 V	200 V	6.7 V	20 V
Ip3	17 A	120 A	50 A	5 A	30 A	10 A

Figure 1-1. Output Characteristic Curve

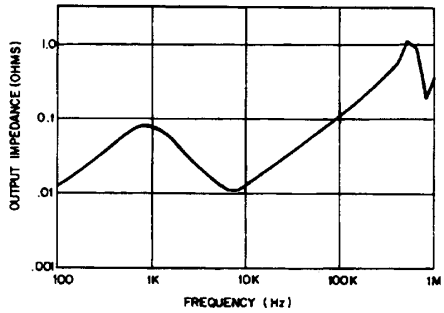
Output Impedance (typical)



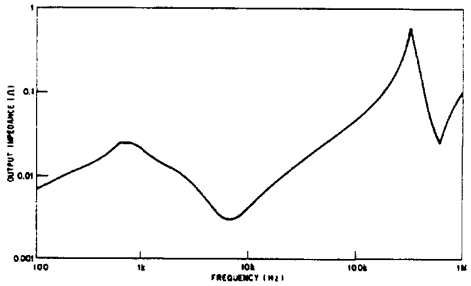
AGILENT **6010A**



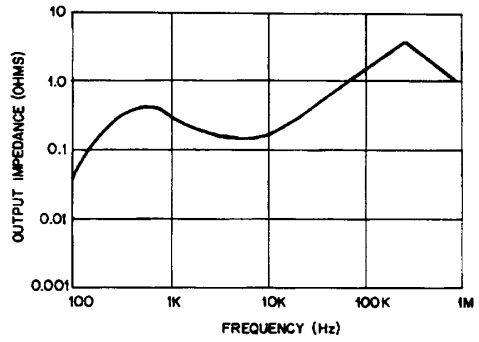
AGILENT **6011A**



AGILENT **6012B**



AGILENT **6023A** and AGILENT **6028A**



AGILENT **6015A**

Figure 1-2. Output Impedance

2

Installation

Introduction

This section contains instructions for checking and repackaging the supply; bench or rack mounting, connecting the supply to ac input power, and converting the supply from one line voltage to another if required..

Note: All power supplies generate magnetic fields that may affect the operation of other instruments. If your instrument is susceptible to operating magnetic fields, do not locate it in the immediate vicinity of the power supply. Typically, at three inches from the supply, the electromagnetic field is less than 5 gauss. **Many CRT's, such as those used in computer displays, are susceptible to magnetic fields much lower than 5 gauss. Check susceptibility before mounting any display near the power supply.**

Initial Inspection

Before shipment, this supply was inspected and found to be free of mechanical and electrical defects. As soon as the supply is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, file a claim with the carrier immediately. The Agilent Technologies Sales and Support office should be notified as soon as possible.

Mechanical Check

This check should confirm that there are no broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches, and that the meter face and rear-panel plastic covers are not scratched or cracked.

Electrical Check

Section III contains an abbreviated check that can be used quickly to place the supply into operation. Refer to the inside cover page of the manual for Certification and Warranty statements.

Preparation for Use

In order to be put into service, the power supply must be connected to an appropriate ac input power source. Also, the line voltage for which the supply is set must be checked. Additional steps may include line voltage conversion and rack mounting. Do not apply power to the supply before reading the "Input Power Requirements" section in this chapter.

Location and Cooling

The supply is fan cooled and must be installed with sufficient space in the rear and on sides for airflow. It should be used in an area where the ambient temperature does not exceed + 50 °C (55 °C for models 6023Aand 6028A).

Caution: When mounting several units in an enclosed rack, care should be taken to insure there is sufficient airflow through the enclosure. Failure to provide sufficient airflow may result in damage to the power supply or other equipment in the enclosure.

Outline Diagrams

Figure 2-1 illustrates the outline shape and dimensions of the cabinet.

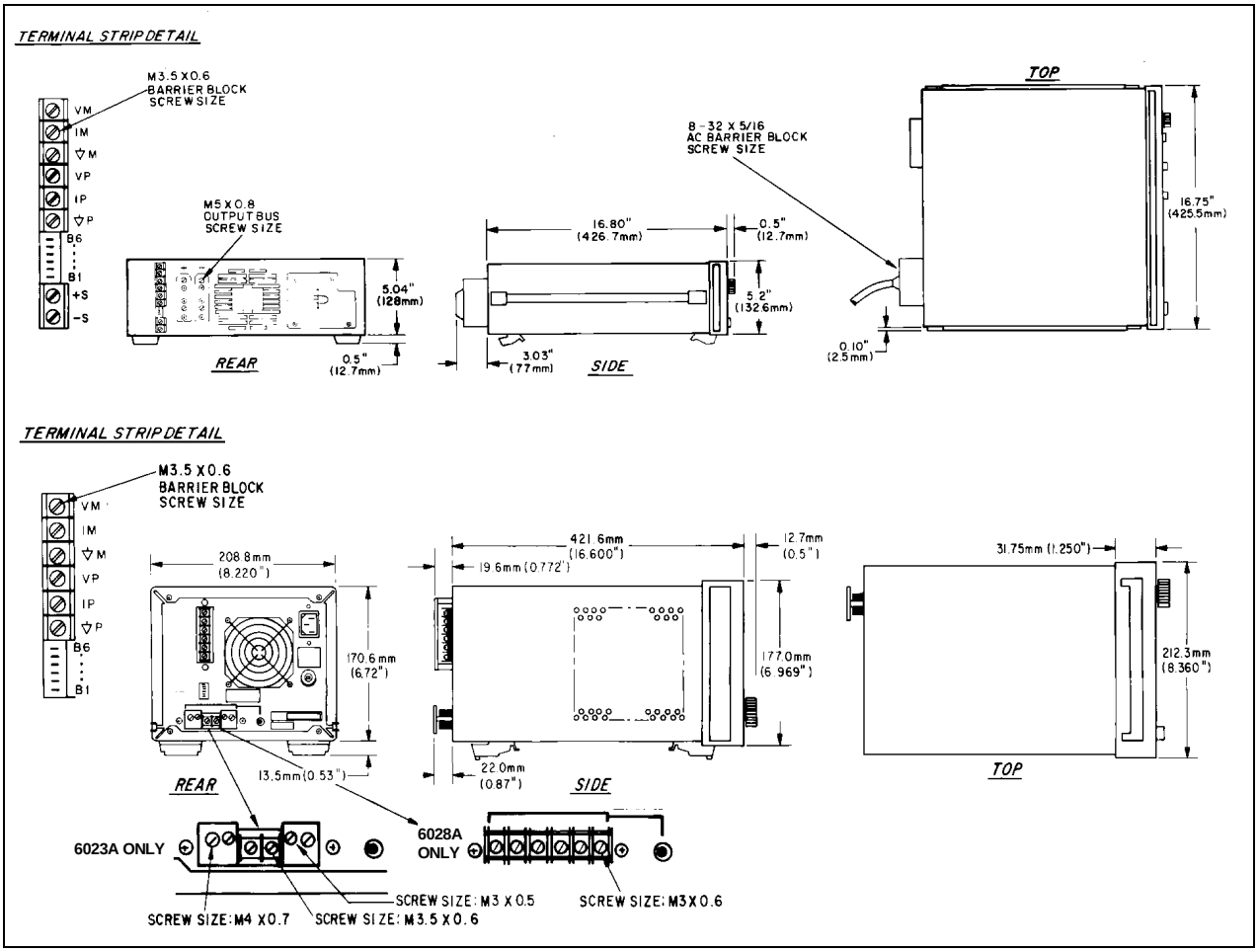


Figure 2-1. Outline Diagram

Bench Operation

The supply cabinet has plastic feet, which are shaped to ensure self-aligning when stacked with other Agilent Technologies System II cabinets.

Rack Mounting

The supply can be mounted in a standard 19-inch rack enclosure. Rack mounting accessories for these units are listed in the ACCESSORIES paragraph in Section I. Complete installation instructions are included with each rack mounting kit. Support rails are also required for rack mounting. These are usually supplied with the system cabinet.

Input Power Requirements

This supply may be operated from a nominal 120 V, 220 V or 240 V single-phase ac power source (48-63 Hz). The input voltage range and input current required for each of the nominal inputs is listed in Table 1-1. To operate from 100 Vac line, Option 100 must be installed. This is a factory-installed option. A label on the rear panel indicates the nominal line voltage for which the supply was set at the factory. If necessary, the user can convert the instrument from one line voltage option to another by following the instructions in the “Line Voltage Option Conversion” section in this chapter.

Power Connection

Caution: Connection of this supply to an ac power source should only be performed by an electrician or other qualified person. Before connecting the supply to the ac power source, check the label on the rear panel to ensure that the supply is set for the correct ac voltage to be used. If necessary, convert the line voltage to another by following the instructions under “Line Voltage Conversion”.

Agilent Models 6010A, 6011A, 6012B and 6015A.

To connect input power, to the instrument proceed as follows:

a. Remove the AC filter assembly cover by unscrewing the four locating screws.

b. Insert the power cord through the strain relief clamp located on the cover.

c. Connect the wires to the terminal block in accordance with the prevailing color codes.
Green or green/yellow to the terminal labeled " ⏚ "
White or blue wire to the terminal labeled "N" *
Black or brown wire to the terminal labeled "L"
* In a 2-phase system, such as 208 in the USA, the second phase is connected to the "N" terminal.

WARNING: **For proper protection by the instrument circuit breaker, the wire connected to the "L” terminal on the instrument must be connected to the "L” side of the line (hot); the wire connected to the ”N" terminal must be connected to the "N" side of the line (neutral or common).**
To protect operating personnel, the wire connected to the " ⏚ ” terminal must be connected to earth ground. In no event shall this instrument be operated without adequate ground connection.

d. Replace the cover, tighten all four screws and tighten the strain relief clamp. (All four screws must be tightened for unit to meet RFI specifications.)

e. Connect the other end of the power cord to an appropriate power source.

Note: Connections to the ac power line must be made in accordance with applicable electrical codes. The international color code for identifying mains supply conductors is green/yellow, blue, and brown for earth, neutral, and line respectively. Corresponding USA/Canadian codes are green, white, and black.

Caution: Before applying power to the instrument, check to see that the rear-panel circuit breaker CB1 is on. The breaker may trip due to rough handling during transit. If the breaker is found to be tripped at any other time for unknown reasons, refer to the troubleshooting procedures in the Service Manual.

Agilent Models 6023A and 6028A.

The power supply is shipped from the factory with a power-cord plug appropriate for the user’s location. Figure 2-2 illustrates the standard configuration of power-cord plugs used by Agilent Technologies. With each drawing is the Agilent Part Number for a replacement power cord equipped with a plug of that configuration. If a different power cord is required, contact the nearest Agilent Technologies Sales and Service office.

To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This supply is equipped with a three-conductor power cable; the third conductor is the ground conductor. When the cable is plugged into an appropriate receptacle the supply is grounded. In no event shall this supply be operated without an adequate cabinet ground connection.

The offset pin on the standard power cable three-prong connector is the ground connection. If a two-contact receptacle is encountered, it must be replaced with a properly grounded three-contact receptacle in accordance with the National Electrical Code and any local codes and ordinances. The work should be done by a qualified electrician only.

Note: To reduce noise pickup, it is good practice to keep the ac input lines separated from signal lines.

Line Voltage Option Conversion

Caution: Conversion to or from 100 V operation requires replacement of internal components and calibration in addition to the line voltage components, and is to be done only at the factory. Failure to configure and calibrate the power supply properly may result in damage to the unit.

Agilent Models 6010A, 6011A, 6012B and 6015A.

Line voltage conversion is accomplished by adjusting three components: a two-section line select switch, and a line-voltage jumper. To convert the supply from one line voltage option to another, proceed as follows:

WARNING: **Some components and circuits are at ac line voltage even with the LINE switch off. To avoid electric shock hazard, disconnect line cord and load, and wait two minutes before removing covers.**

a. Remove the outside cover by removing the four screws that hold the carrying straps, spread the bottom of the cover slightly and carefully slide the cover to the rear of the supply until it is clear. Next remove the top inside cover by removing the nine screws, four on top, three on right side, and two on left side, which connect the top inside cover to the supply chassis.

b. Remove the FET board to reach the line-voltage jumper (W1) terminals.

c. Use a small-blade screwdriver to set the two switch sections of S2 to match the pattern printed on the main board for the nominal line voltage to be used. For example, to set switches for 120 V operation, move forward switch section so that its white slot is toward front of supply and move rearward switch section so that its white slot is toward rear of the instrument.

d. Set switch S1 to match the rearward section of S2, i.e., toward the rear for 100/120 V operation, toward the front for 220/240 V operation.

e. One end of W1 is soldered to the main board; the other end has a female quick-connect terminal that fits onto one of two terminals soldered to the main board. For 100 V or 120 V operation, W1 must be connected to terminal J9; for 220 V or 240 V operation, W1 must be connected to terminal J10. Be certain that the jumper is firmly mated with the connector on the main board. Do not grip jumper insulation with pliers; either grip the jumper wire by hand or grip the jumper terminal with pliers.

f. Replace FET board, inside top cover and outside top cover. Mark the unit clearly with a tag or label indicating correct line voltage to be used.

g. Change line label.

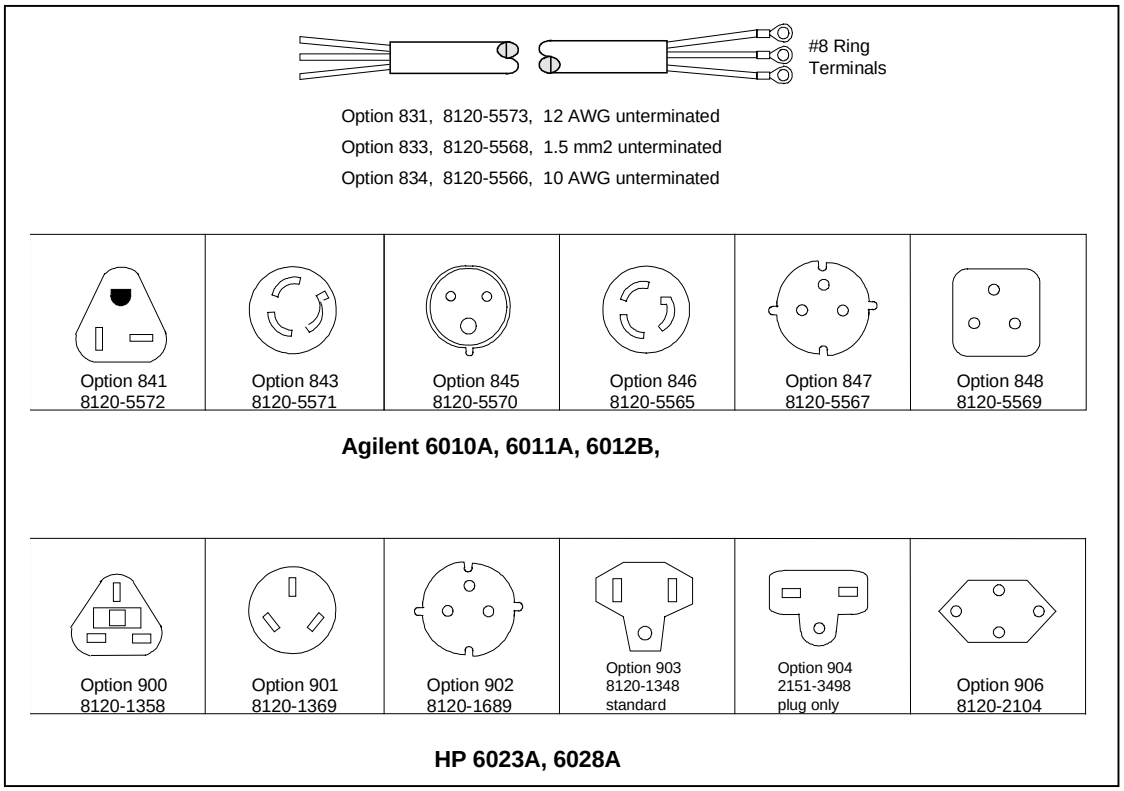


Figure 2-2. Power-Cord Plug Configurations

Agilent Models 6023A and 6028A.

Line voltage conversion is accomplished via three components; a two-section line select switch, line voltage jumper, and a rear panel fuse. To convert the supply from one voltage to another, proceed as follows:

a. Unplug the power supply and wait 2 minutes for internal capacitors to discharge.

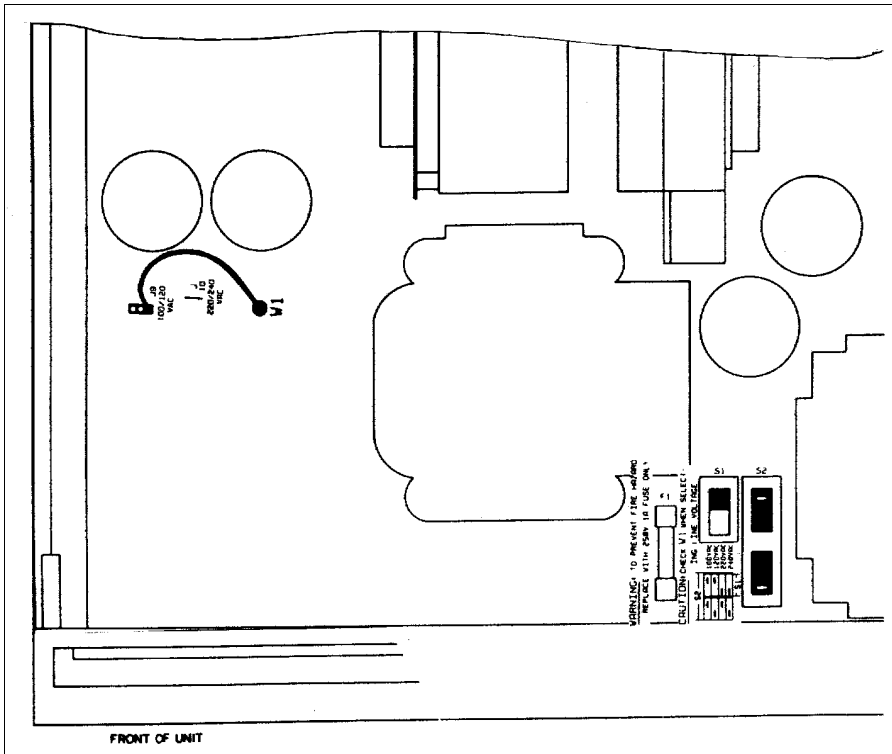
b. Remove the outside cover by removing the rear screw that holds the carrying strap, then carefully slide the cover to the rear of the supply until it is clear. Do not remove the front carrying strap screw.

c. The line voltage select switch (S2) is located in the front left corner of the supply (see Figure 2-3). Use a small-blade screwdriver to set the two switch sections to match the pattern silk-screened on p.c. main board as shown in Figure 2-3. For example, to set switches for 120 V operation (as illustrated), move forward switch section so that its white slot is toward front of supply and move rearward switch section so its white slot is toward rear of supply.

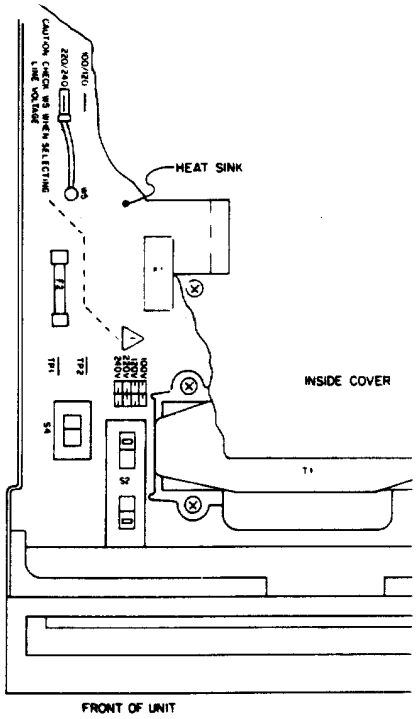
d. One end of W5 is soldered to motherboard; the other end has a female right-angle quick-connect terminal that fits onto one of two terminals soldered to motherboard. For 100 V or 120 V operation, W5 must be connected to terminal closer to center of supply; for 220 V or 240 V operation, W5 must be connected to terminal closer to side of supply. Be certain that jumper is firmly mated with terminal on motherboard. Do not grip jumper insulation with pliers; either grip jumper wire by hand or grip jumper terminal with pliers.

e. Check rating of fuse installed in rear-panel fuseholder. It should be 8 A for 100 or 120 Vac line voltages, or 4 A for 220 or 240 Vac line voltages. If necessary, replace the fuse with one of correct value. Do not use time-delay fuses.
   8 AM, 250 Volt fuse; Agilent part number 2110-0383
   4 AM, 250 Volt fuse; Agilent part number 2110-0055

f. Replace covers and clearly mark the supply with a tag or label indicating the correct line voltage and fuse to be used.



Agilent 6010A, 6011A, 6012B, 6015A



Agilent 6023A, 6028A

Figure 2-3. Line Voltage Conversion Components

AC Line Impedance Check

The power supply is designed for proper operation with line impedances typically found in ac power lines. However, if the supply is connected to an ac power line having a high impedance combined with line voltage near the minimum specified value, (e.g., 104 Vac for nominal 120 Vac), the unit will go out of regulation if it is asked to provide full rated output power. Such a situation might occur if the supply is connected to ac power an extended distance from the main ac distribution terminals and/or if the ac power wires from the main ac distribution terminals are of relatively small gauge.

Measurement of ac line voltage at the supply input terminals typically is not a reliable indication of the actual ac line voltage because of the peak clipping effect of the power supply and the averaging effect of the voltmeter. Symptoms of excessive line impedance may include erratic or no output from the supply and/or inability of the supply to provide full output power. If there is reason to suspect the ac power lines to the supply may have high impedance, perform the following check:

WARNING: **This check should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Turn the power supply off before making or breaking any connections to the power supply. Hazardous voltages are present within the unit even when the power switch is turned off.**

a. Connect a variable load to the supply. Using the OUTPUT ADJUST controls and DISPLAY SETTINGS, set voltage and current (see Section III for detailed description) to maximum rating.

b. Set the load to the maximum rated output current for the power supply (see Appendix A, Figure A-1). The power supply output voltage should be greater than:

Model	Voltage
Agilent 6010A	65V
Agilent 6011A	8V
Agilent 6612B	22V
Agilent 6015A	220V
Agilent 6023A	6V
Agilent 6028A	20V

c. If the supply voltage is less than specified, perform the power limit calibration given in the Service Manual. If the power limit is calibrated correctly, but the unit still does not provide the required output, then the power supply is not receiving adequate ac line input.

Repackaging for Shipment

To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Agilent Technologies Sales and Support office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument specifying the owner, model number, full serial number, and service required or a brief description of the trouble.

Rear Panel Screw Sizes and Part Numbers

Refer to the following list if you need to replace any of the rear panel connection hardware:

Agilent Models 6010A, 6011A, 6012B and 6015A

Item	Description	Agilent Part number
ac input cover		5060-3237
ac input cover screws	M4 X 0.7 X 60 mm (qty 4)	0515-0156
ac input barrier block	3-terminal barrier block	0360-2217
ac input barrier block screws	8-32 X 5/16 (qty 3)	included with ac input barrier block
dc output cover		5040-1626
dc output cover screws	M4 X 0.7 X 10 mm (qty 3)	0515-0414
control signal barrier block	6 - terminal barrier block	0360-2195
sense barrier block	2 - terminal barrier block	0360-2192
barrier block screws	M3.5 X 0.6 X 6 mm (qty 8)	included with dc barrier blocks
output bus bar screws	M5 X 0.8 X 12 mm (qty 4)	0515-0155
output bus bar sense screws	M2 X 0.4 X 8 mm (qty 2)	0515-0212
red/black sense wires	wire kit	5060-2913

Agilent Model 6023A and 6033A

Item	Description	Agilent Part number
barrier block cover		06023-00009
control signal barrier block	6 - terminal barrier block	0360-2195
sense barrier block	2 - terminal barrier block	0360-2192
barrier block screws	M3.5 X 0.6 X 6 mm (qty 8)	included with dc barrier blocks
dc output cover		0360-2191
dc output cover screws	M4 X 0.7 X 8 mm (qty 2)	0515-1085
output buss bar screws (large)	M4 X 0.7 X 8 mm (qty 2)	0515-0885
output buss bar screws (small)	M3 X 0.5 X 6 mm (qty 2)	0515-0886
sense jumpers		0360-2190

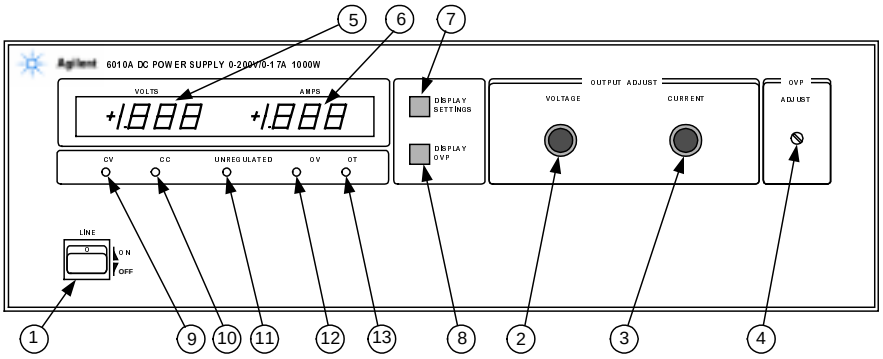
3

Operating Instructions

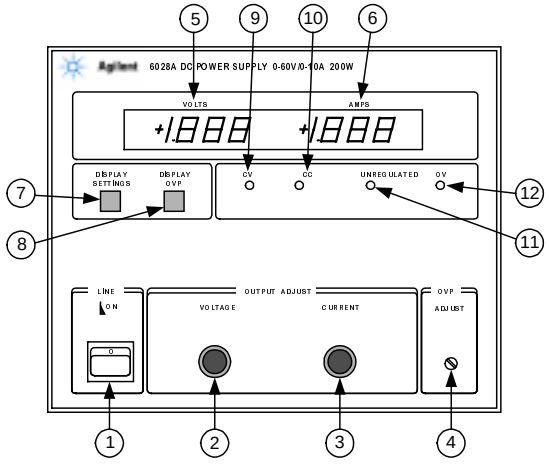
Introduction

This section describes the operating controls and indicators, turn-on checkout procedures, and operating procedures and considerations for the power supply. Front-panel operation and remote resistance/voltage programming is described in this section. The front-panel controls and indicators are shown in Figure 3-1 and described in Table 3-1. Table 3-1 also lists the pages, in which, use of the controls and indicators is described.

More theoretical descriptions regarding the operational features of power supplies in general are given in the Operating and Service manual for your specific model and in the DC Power Supply Handbook, Application Note 90B (Agilent part number 5952-4020).



6010A, 6011A, 6012B, 6015A



6023A, 6028A

Figure 3-1. Front-Panel Controls and Indicators

Table 3-1. Controls and Indicators

Number	Controls/Indicators	Description	Page
1	LINE Switch	Pressing at the top of the switch applies ac mains voltage to the units bias and power circuits. Unit is operational approximately 3 seconds after power on.	27
2	VOLTAGE CONTROL	Clockwise rotation increases the output voltage, 0 to full scale Vdc.	27
3	CURRENT CONTROL	Clockwise rotation increases the output current, 0 to full scale Adc.	27
4	OVP ADJUST	The recessed, single-turn screwdriver control sets the overvoltage protection trip voltage	30
5	Voltage Display	A 3-1/2-digit display with automatically positioned decimal point that can indicate output voltage, output voltage setting or overvoltage shutdown setting. During an error condition, the output may exceed the display range and the display will indicate + OL.	27
6	Current Display	A 3-1/2 digit display with automatically positioned decimal point that can indicate output current or output current setting. During an error condition, the output may exceed the display range, and the display will indicate + OL.	27
7	DISPLAYS SETTINGS Pushbutton Switch	Causes numeric displays to indicate programmed voltage and current values, rather than actual output values; allows both settings to be made without the necessity of opening or shorting load.	33, 34
8	DISPLAY OVP Pushbutton Switch	Causes VOLTS display to indicate OVP trip voltage, AMPS display is blanked; allows setting to be made without changing output settings or load connections	33, 34
9	CV Status Indicator	CV (Constant Voltage) indicates that the power supply is regulating its output at a constant voltage.	33
10	CC Status Indicator	CC (Constant Current) indicates that the power supply is regulating its output at a constant current.	34
11	UNREGULATED Status Indicator	UNR (Unregulated) indicates that the power supply is operating beyond its maximum output power specification and that the output is not regulated or has been shutdown by a protective circuit.	31, 32
12	OVERVOLTAGE Status Indicator	OV (Overvoltage) indicates that the power supply output has been shut down and latched by the occurrence of an overvoltage condition. Removing the cause of the overvoltage and turning the supply off and back on will reset the unit.	31
13	OVERTEMPERATURE Status Indicator	OT (Over temperature) indicates an overheating condition on either the diode or FET boards. OT automatically resets when the temperature drops to a safe operating level.	31

Turn-On Checkout Procedure

WARNING: **Before the instrument is turned on, all protective earth terminals, extension cords, and devices connected to the power supply should be connected to a protective earth ground. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.**

Caution: This instrument can be damaged by electrostatic discharge into the control connectors, or the switches on the rear panel even *while the unit is turned on*. Do not cause an electrostatic discharge into these connectors and switches (which may occur when they are touched). Also, consistent with good engineering practice, leads attached to customer accessible signal/monitoring ports should be twisted and shielded to maintain the instruments specified performance.

The following procedure ensures that the supply is operational, and may be used as an incoming inspection check.

a. Check that the rear-panel mode switches are set as shown in Figure 3-3.

b. Check that + lead is connected to +S and the – lead is connected to –S and tightened securely. The + Sense lead is connected to + Output and the – sense lead is connected to – Output lead at the factory.

c. Check that the rear panel label indicates that the unit is set for the mains input voltage to be used. If not, refer to “Line Voltage Conversion” in chapter 2.

d. Plug the unit into the appropriate ac power outlet.

e. Turn the Voltage control all the way down (fully counter clockwise) and the Current control up slightly clockwise to ensure CV operation.

f. Check that the recessed OVP ADJUST control on the front panel is fully clockwise.

g. Press the top of the LINE rocker switch in to turn the power supply on. You should hear the fan. Check that the CV indicator remains on.

h. The VOLTS and AMPS displays should indicate approximately 0.00.

i. Press the momentary-contact DISPLAY OVP pushbutton switch and check that VOLTS display indicates maximum OVP for the power supply.

j. Press the DISPLAY SETTINGS switch, Turn the CURRENT knob clockwise, and check that the AMP setting increases. The CV indicator should be on and the CC indicator should be off.

k. Turn the VOLTAGE control clockwise and check that the output voltage increases from zero to full output voltage as indicated on VOLTS display. Continued clockwise rotation may cause VOLTS display to indicate + OL.

l. Check the overvoltage protection circuit by turning OVP ADJUST control counterclockwise until OVP circuit trips. Output should drop to 0 V, CV indicator turns off and OV indicator turn on .

m. Reset the OVP circuits by turning OVP ADJUST control fully clockwise and turning unit off and back on.

n. To check the constant current circuit, turn the power supply off and short rear panel + and - output terminals with a wire of sufficient gauge to carry the supply's maximum current output (see Table 3-3).

o. Turn the power supply on and adjust the CURRENT control clockwise. Check that the output current increases from zero to full output current as indicated on AMPS display. Continued clockwise rotation may cause AMPS display to indicate + OL. The CC indicator should be on and CV indicator should be off.

p. Turn off the power supply, remove the short from the output, and read following instructions before connecting load to supply.

Initial Setup and Interconnections

WARNING: **Turn off input ac power before changing any rear-panel connection and make certain all wires and straps are properly connected and terminal block screws are securely tightened before reapplying power. Be certain to replace both terminal block covers before reapplying power to avoid exposing the operator to hazardous voltages.**

Connecting the Load

Load connections to the power supply are made at the + and – output terminals on the rear panel. Higher power units have output bus bars. The bus bars are covered by an impact-resistant plastic cover, which is secured to the unit with four M4 x 8 screws. Be certain to replace the cover after making connections. Two factors must be considered when selecting wire size for load connections, conductor temperature and voltage drop.

To satisfy safety requirements, the wires to the load should be at least heavy enough not to overheat while carrying the maximum power supply output current that would flow if the load were shorted. Use Tables 3-2 and 3-3 to determine the proper wire gauge for load connections to the power supply. When 2 or more wires are bundled together, the current carrying capacity of each wire is reduced (see Table 3-3, Note 3). All wires must be properly terminated with connectors securely attached. Do not connect unterminated wires to the power supply. Wire sizes of AWG #14 (2,5mm^2) or smaller are normally used only for sense leads.

The minimum wire size required to prevent overheating will not usually be large enough to provide good voltage regulation at the load. For proper regulation the load wires should be large enough to limit the voltage drop to no more than 0.5 volts per lead. Table 3-2 lists resistivity for various wire sizes and the maximum lengths that may be used to limit voltage drop to 0.5 volts for various currents. Lengths listed are the sum of the lengths of the (+) and (-) load wires. Lengths are given in meters and (feet).

To determine maximum lengths (in meters or feet) for currents not listed, use the formula:

$$\text{maximum length} = \frac{0.5 \text{ x } 1000}{\text{current x resistance}}$$

where current is expressed in amps and resistance is expressed in ohms/km or ohms/1000 feet. If load regulation is critical, use remote voltage sensing .

WARNING: **While calculating load wire size, remember that the wire must be large enough not to overheat while carrying the current that would flow if the load were shorted.**

Table 3-3 lists the maximum current-carrying capacity (ampacity) for various sizes of stranded copper wire.

If multiple loads are connected to one supply, each load should be connected to the supply's output terminals using separate pairs of connecting wires. This minimizes mutual coupling effects and takes full advantage of the supply's low output impedance. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup and radiation.

If load considerations require the use of output distribution terminals that are located remotely from the supply, then the power supply output terminals should be connected to the remote distribution terminals by a pair of twisted or shielded wires. Each load should be separately connected to the remote distribution terminals. Remote voltage sensing is suggested under these circumstances. Sense either at the remote distribution terminals, or (if one load is more sensitive than the others) directly at the most critical load.

Table 3-2. Maximum Wire Lengths To Limit Voltage Drops

Wire Size		Resistivity		Maximum Length In Meters (Feet)To Limit Voltage Drop To 0.5V Or Less					
AWG	Cross-section (mm^2)	Ω/kft	Ω/km	5 A	10A	17 A	30A	50A	120A
22		16.15		(6.19)	*	*	*	*	*
	0,5		40.1	2.5	*	*	*	*	*
20		10.16		(9.8)	*	*	*	*	*
	0,75		26.7	3.7	1.8	*	*	*	*
18		6.388		(15.6)	(7.8)	*	*	*	*
	1		20,0	5.0	2.5	*	*	*	*
16		4.018		(24.8)	(12.4)	(7.3)	*	*	*
	1,5		13.7	7.3	3.64	*	*	*	*
14		2.526		(40)	(19.7)	(11.6)	(6.6)	*	*
	2,5		8.21	12.2	6.1	3.5	*	*	*
12		1.589		(62.9)	13.46)	(18.5)	(10.49)	*	*
	4		5.09	19.6	9.8	5.7	3.27	*	*
10		.9994		(100)	(50)	(29.4)	(16.68)	(10.01)	*
	6		3.39	29.5	14,7	8.6	5.9	*	*
8		0.6285		(160)	(79.5)	(46.7)	(26.52)	(15.91)	*
	10		1.95	51,2	25,6	15	8.55	5.13	*
6		0.3953		(252)	(126.5)	(74.4)	(42.16)	(25.3)	*
	16		1.24	80.6	40,3	23.7	13.44	8.06	*
4		0.2486		(402)	(201)	(118)	(67.04)	(40.23)	(16.76)
	25		0.795	125.7	62.8	37	20.96	12.58	5.24
2		0.1564		(639)	(319)	(188)	(106.5)	(63.94)	(26.64)
	35		0.565	176.9	88.5	52	29.5	17.7	7.37
	50		0.393	254.4	127	74.8	42.4	25.45	10.6
0		0.09832		(1017)	(508)	(299)	(169.5)	(101.7)	(42.38)

* Wire not rated for power supply maximum current rating.

Table 3-3. Stranded Copper Wire Ampacity

Wire Size		Ampacity
AWG	Cross Section (mm^2)	
22		5.0
20		8.33
	0.75	10
	1	13.5
18		15.4
	1.5	16
16		19.4
	2.5	25
14		31.2
	4	32
12		40
	6	40
10		55
	10	63
8		75
6		100
4		135
2		180
0		245

NOTES:

1. Ratings for AWG-sized wires are derived from MIL-W-5088B. Ratings for metric-sized wires are derived from IEC Publication 335-1.
2. Ampacity of aluminum wire is approximately 84% of that listed for copper wire.
3. When two or more wires are bundled together, ampacity for each wire must be reduced to the following percentages:
   - 2 conductors 94%
   - 3 conductors 89%
   - 4 conductors 83%
   - 5 conductors 76%
4. Maximum temperatures: Ambient, 50°C; conductor, 105°C

Either positive or negative voltages can be obtained from the supply by grounding one of the output terminals. It is best to avoid grounding the output at any point other than the power supply output terminals to avoid noise problems caused by common-mode current flowing through the load leads to ground. Always use two wires to connect the load to the supply regardless of where or how the system is grounded. Never ground the system at more than one point. The maximum potential (including output voltage) that either output terminal is from ground must not exceed that specified on the output label on the rear chassis.

The PARD specifications in Table 1-1 apply at the power supply output terminals. However, noise spikes induced in the load leads at or near the load may affect the load although the spikes are inductively isolated from the power supply. To minimize voltage spikes at the load, connect a bypass capacitor as shown in Figure 3-2. With this setup, peak-to-peak noise at the load can actually be reduced to a level below the value specified at the power supply output terminals.

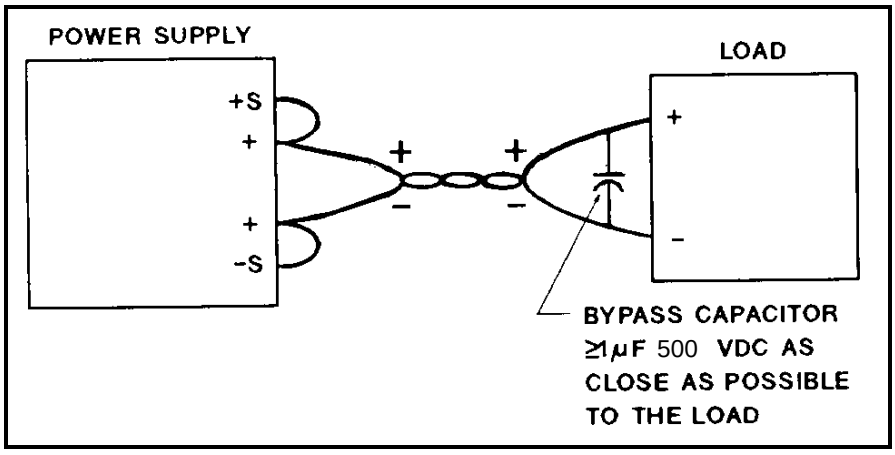


Figure 3-2. Connecting a Bypass Capacitor

Overvoltage Protection (OVP)

The overvoltage trip point is adjusted at the front panel. The approximate trip voltage range is from zero volts to approximately 107% of maximum rated voltage of the power supply. When the OVP circuit trips, the power supply output is disabled and delivers no output power, and the OVP and UNREGULATED indicators turn on.

Adjustment. OVP is set by the recessed single-turn OVP ADJUST potentiometer on the front panel. Rotating the control clockwise sets the trip voltage higher. (It is set to maximum at the factory.) When adjusting the OVP trip point, the possibility of false tripping must be considered. If the trip voltage is set too close to the supply's operating voltage, a transient in the output would falsely trip the OVP. For this reason it is recommended that the OVP trip voltage be set higher than the output voltage by at least 1 volt. To adjust the OVP trip voltage, proceed as follows:

a. Turn on supply and hold DISPLAY OVP pushbutton in.
b. Insert a small-blade screwdriver through hole in front panel and adjust OVP trip voltage to desired level.

OVP Reset. To reset OVP, turn the LINE switch off and then back on. The cause of the overvoltage must be removed before the OVP circuit is reset or the circuit will trip again immediately. If the OVP circuit trips continuously check the load and the trip voltage.

Protective Shutdown

Protective circuits within the power supply may limit or turn off the output in case of abnormal conditions. The cause of the protective action can be determined by observing the front panel indicators (lights and meters).

Unregulated. If an overrange condition exists (load tries to draw more power than the supply can deliver), the UNREGULATED indicator turns on and both the CV and CC indicators are off. The product of the VOLTS and AMPS displays will exceed the maximum output power of the supply. Also, if the power supply output is disabled by protective

circuits within the supply the power supply output drops to zero and the UNREGULATED indicator turns on. The power supply can be disabled by overvoltage, overtemperature, or by low or high ac line (mains) voltage.

Overvoltage. If the voltage across the power supply output terminals rises above a preset level, possibly because of a hardware malfunction, the overvoltage protection (OVP) circuit will trip. If this occurs, the power supply will be disabled and the OV indicator turned on. To reset the OVP circuit, first ensure that the condition that caused the overvoltage is corrected, then turn the power supply off and back on.

Overtemperature. If the overtemperature protection circuit trips, the power supply will be disabled and the OT indicator turned on. The overtemperature circuit will reset automatically and the power supply output will be restored when the temperature drops sufficiently for safe operation.

AC Line Over/Under Voltage. If the ac line (mains) input voltage increases or decreases beyond the range for safe operation the power supply output may be disabled. The power supply output will be restored when the input voltage returns within range.

Operating Modes

Settings or the rear panel Mode switch determines the operating mode of the unit. In Normal operating mode the unit is set for local sensing, (where the output voltage is sensed directly at the output terminals) and front panel voltage and current programming. Other operating modes covered in this chapter include remote voltage sensing, remote programming of voltage and current using either external resistors or voltage sources, and multiple supply operation such as auto parallel and auto series.

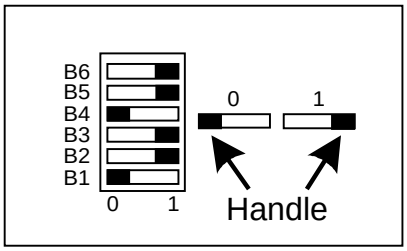
Figure 3-3 shows six switches on the rear panel that configure the power supply programming (either front-panel controls) or remote analog programming (resistance or voltage). When shipped from the factory the switches are set for front-panel programming, which is the normal operating mode for this power supply. The two analog programming modes are available for use in special circumstances.

Typically, only one programming mode is used for both output parameters (voltage and current). However, the mode switches allow voltage and current to be programmed independently. For example, voltage could be programmed from the front panel, while current is resistance programmed. Note that only one programming mode can be used for each parameter at one time.

Normal Mode

The unit is shipped from the factory configured in the normal operating mode – with the + and – outputs jumpered to the + and sense connectors. The mode switch is set as shown in the following figure.

Figure 3-3. Factory Settings, Mode Switch



The power supply can operate as a constant voltage (CV) or constant current (CC) source over a wide range of output voltage and current combinations. The specifications table contains a graph showing the overall output range of the power supply. Figure 3-4 shows a rectangular operating locus that is defined by voltage and current settings of the power supply. The load resistance determines the point on that locus at which the power supply actually operates. Three load-resistance lines are shown on Figure 3-4. The line representing load resistance A, the highest load resistance shown on the graph,

crosses the operating locus at point 1. Point 1 is on the part of the operating locus defined by the voltage setting, so the power supply operates in CV mode.

Similarly, the line representing load resistance C, the lowest load resistance shown on the graph, crosses the operating locus at point 3. Point 3 is on the part of the operating locus defined by the current setting, so the power supply operates in CC mode.

Load Resistance B equals the crossover resistance for the particular combination of voltage and current settings shown on the graph. Either the CV or CC LED will light. If the load resistance increases, the voltage setting decreases, or the current setting increases, the power supply will operate in CV mode. Conversely, if the load resistance decreases, voltage setting increases, or current setting decreases, the power supply will operate in CC mode.

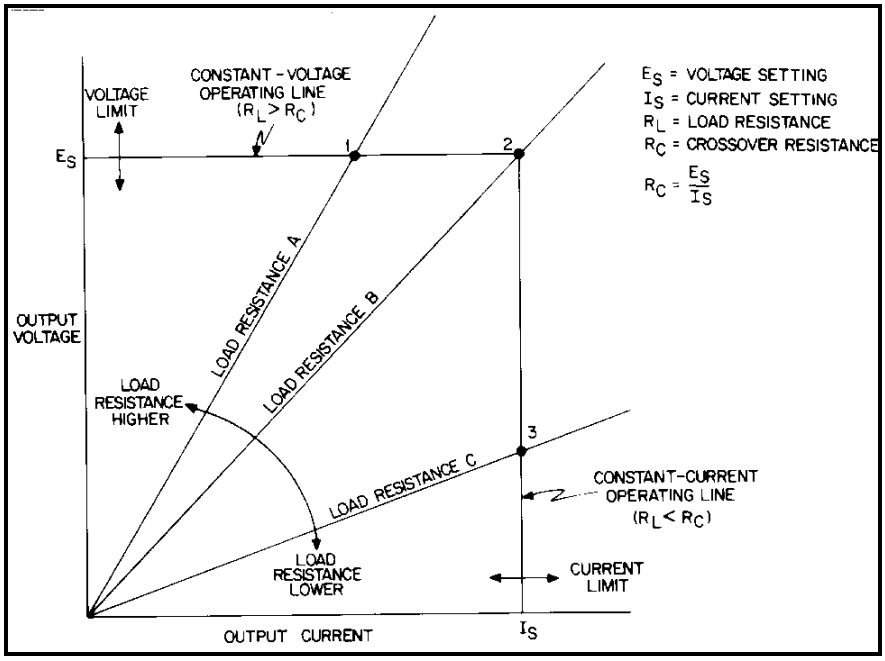


Figure 3-4. Determining Operating Point

In Figure 3-5, the voltage and current settings are high enough that the rectangular operating locus is cut off by the maximum output power boundary of the power supply. For the load resistance A, the power supply operates in CV mode at the voltage and current values for point 1. Similarly, for load resistance D the power supply operates in CC mode at point 4.

For load resistance between B and C, the operating point will be on the maximum output-power boundary between points 2 and 3, and the UNREGULATED indicator will be on. The VOLTS and AMPS displays will indicate the voltage and current being supplied to the output. (The product of the two readings will exceed rated output power of the supply.) Note that the actual boundary is beyond the specified minimum boundary. The UNREGULATED indicator will light only if the actual boundary is exceeded.

The supply can operate in the overrange region for sustained periods without being damaged. However, the supply is not guaranteed to meet specifications in overrange. Output ripple increases substantially and regulation is seriously degraded.

Note: Under certain conditions of line and load, it is possible for the supply to provide more than rated output power and still maintain regulation. If this occurs, the unit will operate normally and the OVERRANGE indicator will be off. However, the slightest change in either line or load may cause the unit to go out of regulation. Operation of the unit beyond the rated-output-power boundary is not recommended.

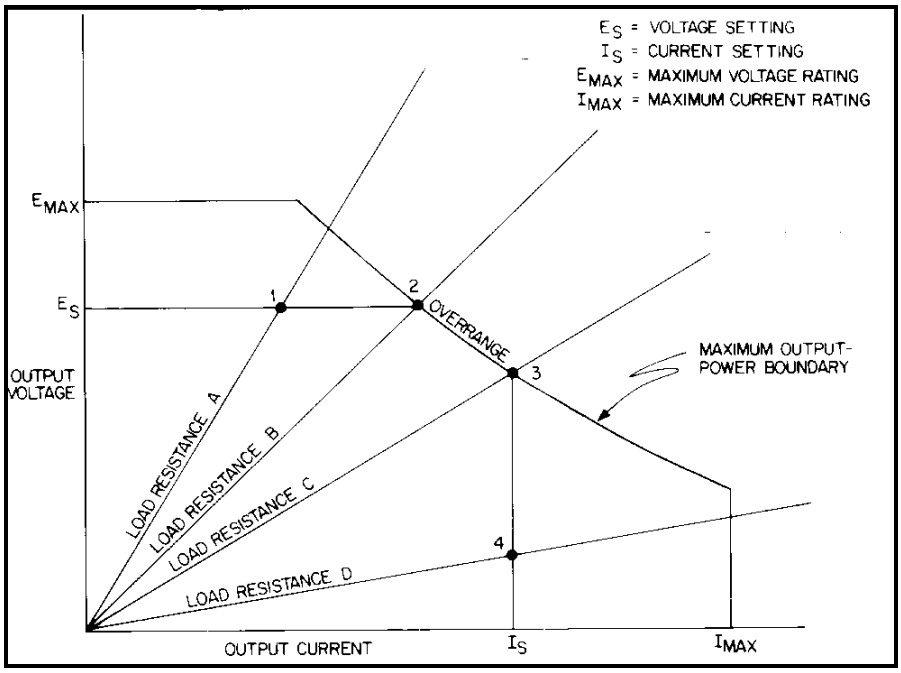


Figure 3-5. Overrange Operation

Constant Voltage Operation

By pressing the DISPLAY SETTINGS pushbutton switch you can observe the setting (limits) of both the output voltage and the output current, rather than the actual output values. This you set the current limit when the power supply is operating in CV mode, or set the voltage limit while in CC mode, without having to disconnect or adjust the load.

To set up the power supply for constant voltage operation:

a. With power supply turned off, connect the load to the output terminals.

b. Turn on power supply. Hold in DISPLAY OVP pushbutton switch and set OVP ADJUST potentiometer for the desired OVP trip voltage.

c. Hold DISPLAY SETTINGS pushbutton switch in and rotate CURRENT control to set desired current limit.

d. Adjust output voltage to desired level. The CV indicator should be on.

e. If a load change causes the current limit to be exceeded, the power supply automatically crosses over to constant current operation (CC indicator will come on) and the output voltage drops proportionately. In setting the current limit, make adequate allowance for high current peaks that could cause unwanted mode crossover.

Constant Current Operation

To set up the power supply for constant current operation:

a. With power supply turned off, connect the load to the output terminals.

b. Turn on the power supply. Hold in DISPLAY OVP pushbutton switch and set OVP ADJUST potentiometer for the desired OVP trip voltage. In CC mode the voltage setting will limit output voltage under quiescent conditions, and the OVP circuit provides added protection against hardware faults.

c. Hold the DISPLAY SETTINGS pushbutton switch in, and rotate the VOLTAGE control to set desired voltage limit.

d. Adjust the output current to the desired level. The CC indicator should be on.

e. If a load change causes the voltage limit to be exceeded, the power supply automatically crosses over to constant voltage operation and the output current drops proportionately. In setting the voltage limit, make adequate allowance for voltage peaks that could cause unwanted mode crossover.

Remote Voltage Sensing

The remote sensing connections shown in Figure 3-6 improve the voltage regulation at the load by monitoring the voltage there instead of at the supply's output terminals. Remote sensing allows the power supply to automatically increase the output voltage and compensate for the voltage drops in the load leads. This improves the voltage regulation at the load, and is especially useful for CV operation with loads that vary and have significant load-lead resistance. Note that with remote sensing, the internal voltmeter is connected at the load. Remote sensing has no effect during CC operation. When using remote sensing, turn off the power supply before changing the rear-panel straps, sense leads, or load leads. Connect the unit for remote voltage sensing by connecting load leads from + OUT and - OUT terminals to the load, disconnecting straps between + Out and + S and between - Out and - S, and connecting sense leads from the + S and - S terminals to the load as shown in Figure 3-6.

Note: Sensing is independent of other power supply functions; either local or remote sensing can be used regardless of how the power supply is programmed.

The load leads should be of the heaviest practical wire gauge, at least heavy enough to limit the voltage drop in each load lead to 0.5 volts. The power supply has been designed to minimize the effects of long load-lead inductance, but best results will be obtained by using the shortest load leads practical.

Note: The OV circuit senses the voltage at + Out and at the output side of the internal current sampling resistor in the – output lead. Remote voltage sensing compensates for a voltage drop of up to 0.5 V in each load lead, and there may be up to 0.12 V drop between the – output and the internal sensing resistor at the point the OVP circuit is connected. Therefore, the voltage sensed by the OVP circuit could be as much as 1.12 V more than the voltage being regulated at the load. It may be necessary to readjust the OVP trip voltage to compensate for these drops when remote sensing.

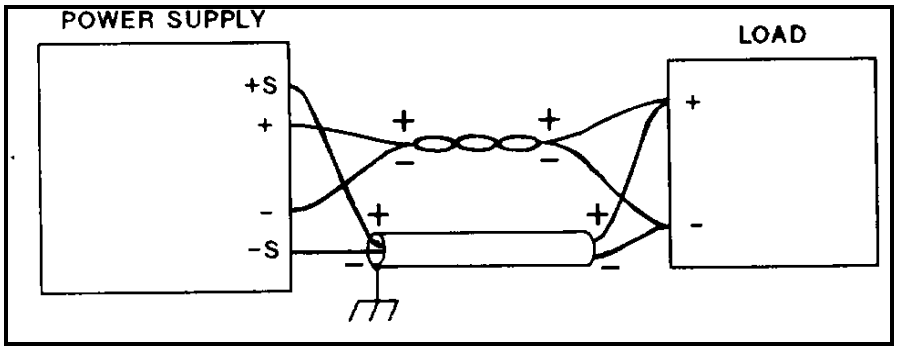


Figure 3-6. Remote Voltage Sensing

Because the sensing leads carry only a few milliamperes, the wires used for sensing can be much lighter than the load leads. Each sense lead should have no more than 0.2 ohms resistance. Use the resistivity columns in Table 3-2 to determine the minimum wire size for the length of sense leads being used. The sense leads should be a shielded, twisted pair to minimize the pickup of external noise. Any noise picked up on the sensing leads will appear at the supply's output, and CV load regulation may be adversely affected. The shield should be grounded at the power supply end only, and should not be used as one of the sensing conductors. The sensing leads should be connected as close to the load as possible.

If slightly degraded CV load regulation can be tolerated, the power supply will provide remote voltage sensing with up to 2 Vdc drop in each load lead and with more than 0.2 ohms resistance in each sense lead. As the voltage drop in the load leads increases, the load voltage error due to sense-lead resistance increases according to the formula:

$$\frac{(2Rs + 0.5)V1}{1000}$$

where Rs is the resistance in ohms of each sense lead and Vl is the voltage drop in each load lead. For example, if the resistance in each sense lead is 1 ohm and the voltage drop in each load lead is 2 Vdc, the load voltage might differ by [2(1) + 0.5] 2/1000 = 5 mVdc from that with no sense-lead.

The sensing leads are part of the supply's programming circuits, so they should be connected in such a way as to make it unlikely that they might inadvertently become open circuited. If the sense leads open during operation, the voltage at the load will rise slightly above its' programmed value.

Note: The power supply includes protection resistors that reduce the effect of open sense leads during remote-sensing operation. If a sense lead opens there will be a change in the output voltage. See Table 3-4 for the approximate voltage change.

Table 3-4. Voltage change due to open sense lead

Model	+S	-S	Both
6010A	1.6%	-0.1%	1.5%
6011A	4%	1%	4.8%
6012B	1.6%	-0.1%	1.5%
6015A	1.6%	-0.1%	1.5%
6023A	4%	1%	4.8%
6028A	4%	1%	4.8%

Analog Programming

These instruments can obtain their output voltage and current programming information from three distinct sources: 1) locally from the front panel, 2) remotely from an external isolated, voltage source or, 3) remotely from an external isolated, resistance. Mode switches B1, B2, .through B6, located on the rear of these products, enable the user to make these selections. The remote analog programming signals are connected to rear-panel screw-on terminals.

When the power supply is configured for remote voltage or resistance programming, the front panel VOLTAGE or CURRENT controls of the parameter being controlled are disconnected and have no effect on the output.

Note: Switches B1, B2 and B3 are for selecting the programming source for the output current. Switches B4, B5 and B6 select the programming source for the output voltage. The source of the Constant Current programming information is selected *independently* from the source of the Constant Voltage programming information. Both can be done at the same time.

Caution: The common terminal (P) is internally connected to the minus (-) output terminal. **If either output is grounded, the external programmer MUST be floating. Failure to float the programmer may result in significant damage to the power supply.**

For resistance programming, internal CV and CC current sources supply 1.25 mA currents through the programming resistors to create programming voltages for the power supply. A resistance of 0 to 4 K ohms will program the output voltage or current from 0 to full scale. A variable resistor can control the output over its entire range. Or, a variable resistor connected in series and/or parallel with a fixed resistor can have its control restricted to a limited portion of the output range. Alternatively, a switch can be used to select fixed values of programming resistance to obtain a set of discrete voltages or currents.

Note: The switching configuration used may require make before-break contacts to avoid producing the output voltage transients caused by momentarily opening the programming terminals.

To maintain the temperature and stability specifications of the power supply, any resistors used for programming must be stable, low-noise resistors with a temperature coefficient of less than 25ppm per °C and a power rating of at least 1/2 watt.

Both voltage and current outputs can also be controlled by a voltage source. A voltage of 0 to 5 volts programs the output voltage or current from zero to full scale. Voltage sources of more than 5 volts can be scaled down to the proper range.

The following paragraphs discuss in greater detail the methods of remotely programming the output voltage or current using either a resistance or voltage input. Whichever method is used, the wires connecting the programming device must be shielded to reduce noise pickup. The outer shield of the cable should not be used as a conductor, and should be connected to ground at one end only.

Although the following setup drawings (Figure 3-7 through 3-11) show the supply strapped for local sensing, analog programming and remote voltage sensing do not interact and may be used simultaneously.

Constant Voltage Output, Resistance Control.

The setup shown in Figure 3-7 allows the output voltage to be varied by using an external resistor to program the power supply. A programming resistor variable from 0 to 4000 ohms produces a proportional output voltage from zero to full scale. Note that fixed resistors may be connected in series and/or parallel with the variable programming resistor to set lower and/or upper output voltage limits. The resultant programming resistance is the sum of the series/parallel resistor combination, and must be between 0 and 4000 ohms. For example, a 2000 ohm resistor connected in series with the variable programming resistor will set the lower limit for output voltage at one-half full scale.

Note: If the programming terminals (VP to ⏚P) become open circuited during resistance programming, the output voltage will rise above the power supply rating. The supply will not be damaged if this occurs, but the overvoltage trip point should be properly adjusted to protect the user's load.

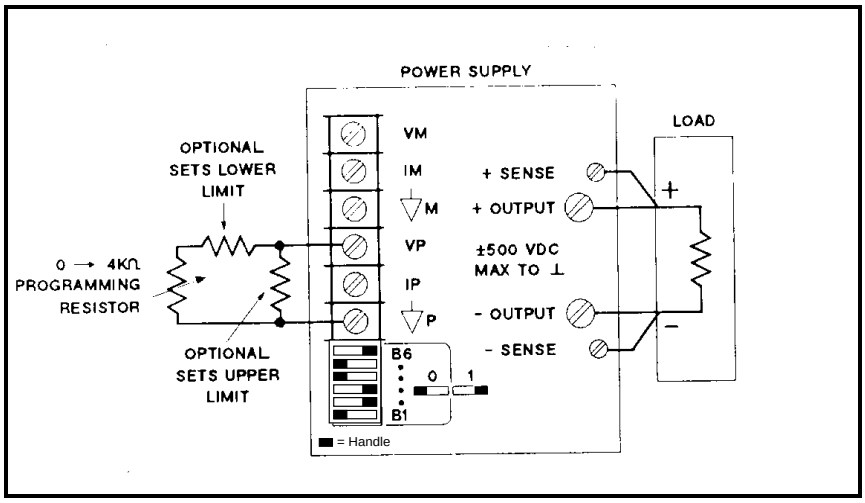


Figure 3-7. Resistance Programming of Output Voltage

Constant Voltage Output, Voltage Control.

The setup shown in Figure 3-8 allows the output voltage to be varied by using an external voltage source to program the supply. A voltage source variable from 0 to + 5 volts produces a proportional output voltage from zero to full scale. The static load on the programming voltage source is less than 5µA. A source resistance of less than 10k is necessary to avoid degradation of offset and drift specifications.

Note: If external resistors are used to limit the remote-programming voltage to 5Vdc, the resulting high programming-source resistance can degrade the power supply's programming speed, offset and drift performance. Limit the equivalent source resistance to 10k ohm maximum. Figure 3-9 shows a convenient way to calculate suitable voltage-divider resistance values for a 5k ohm source resistance.

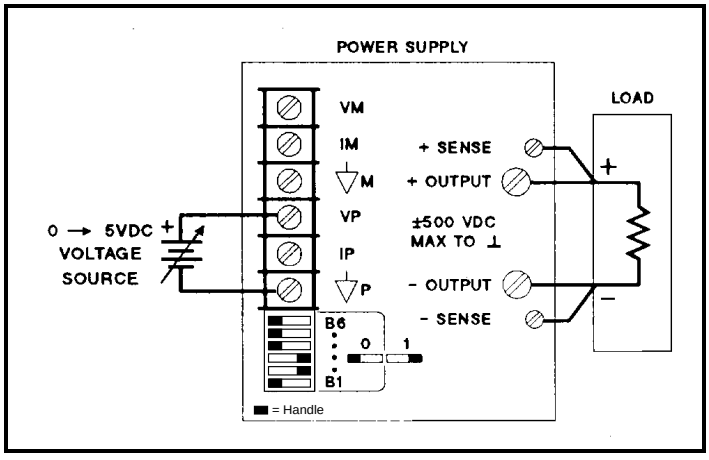


Figure 3-8. Voltage Programming of Output Voltage

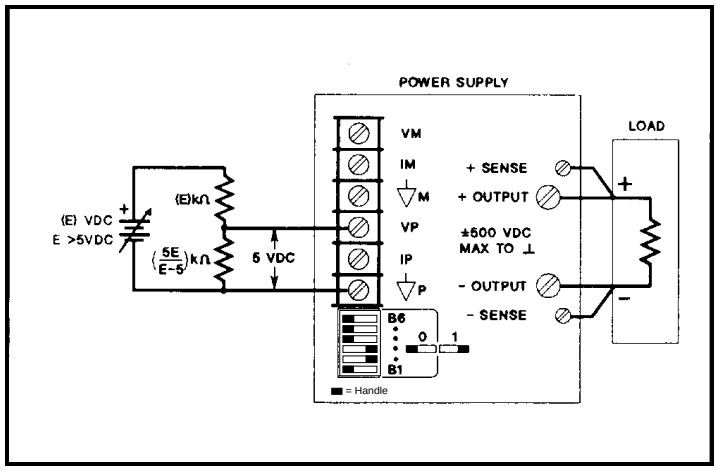


Figure 3-9. Optional Voltage Divider for Program Source

Constant Current Output, Resistance Control.

The setup shown in Figure 3-10 allows the output current to be varied by using an external resistor to program the supply. A programming resistor variable from 0 to 4000 ohms produces a proportional output current from zero to full scale. Note that fixed resistors may be connected in series and/or parallel with the variable programming resistor to set lower and/or upper output current limits. The resultant programming resistance is the sum of the series/parallel resistor combination, and must be between 0 and 4000 ohms. For example, a 2000 ohm resistor connected in series with the variable programming resistor will set the lower limit for output current at one-half full scale.

Caution: If the programming terminals (IP to ⏚ P) become open circuited during resistance programming the output current will tend to rise above rating. The power supply will not be damaged if this occurs, but the user's load may be damaged. If there is a possibility that the programming leads may be opened, it is suggested that the optional resistor be connected directly across terminals IP and ⏚ P, as shown in Figure 3-10. The value of this resistor should be selected to limit the output current to the maximum that the load can handle without damage. For example, if the load can handle half the current rating of the power supply, a 2000 ohm resistor should be connected from IP to ⏚ P. If this resistor is used, the actual resistance value programming the supply is the parallel combination of the two resistors.

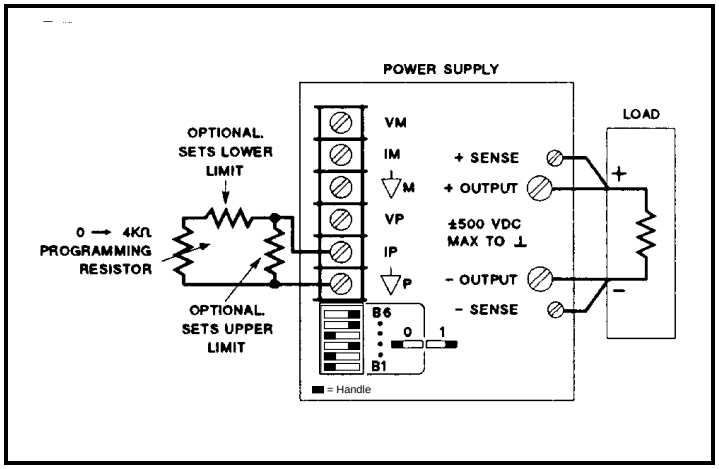


Figure 3-10. Resistance Programming of Output Current

Constant Current Output, Voltage Control.

The setup shown in Figure 3-11 allows the output current to be varied by using an external voltage to program the supply. A voltage source variable from 0 to + 5 volts produces a proportional output current from zero to full scale. The static load on the programming voltage source is less than 5μA. A source resistance of less than 10k is necessary to avoid degradation of offset and drift specifications.

Note: If external resistors are used to limit the remote-programming voltage to 5Vdc, the resulting high programming-source resistance can degrade the power supply's programming speed, offset and drift performance. Limit the equivalent source resistance to 10k ohm maximum. Figure 3-9 shows a convenient way to calculate suitable voltage-divider resistance values for a 5k ohm source resistance.

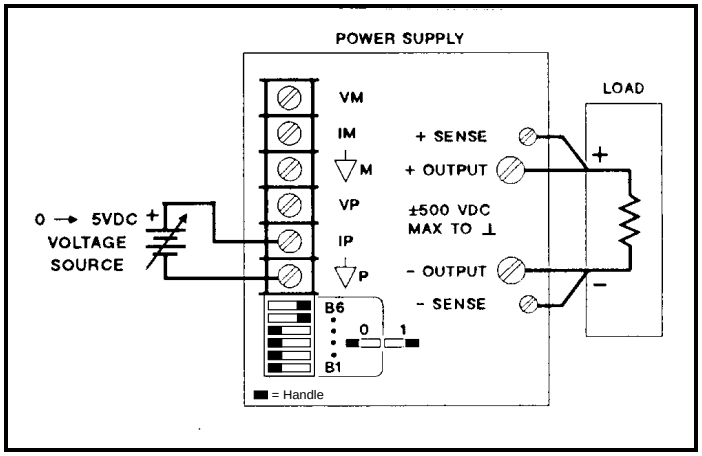


Figure 3-11. Voltage Programming of Output Current

Multiple-Supply Operation

The power supply can be operated in combination with other power supplies to provide increased output capability. Auto-parallel operation of two power supplies can provide up to twice the output current. Other configurations are possible. Contact Agilent Technologies, Power Products Division for specific application assistance.

Auto-Parallel Operation

Two units can be connected in an auto-parallel combination to provide twice the output current capability. One of the power supplies, the master, is programmed normally. The other power supply, the slave, is analog programmed by the master. The mode switches of the slave must be set so that the slave is analog programmed by the master. Figure 3-12 shows the rear-panel mode switch settings and terminal connections for auto-parallel operation.

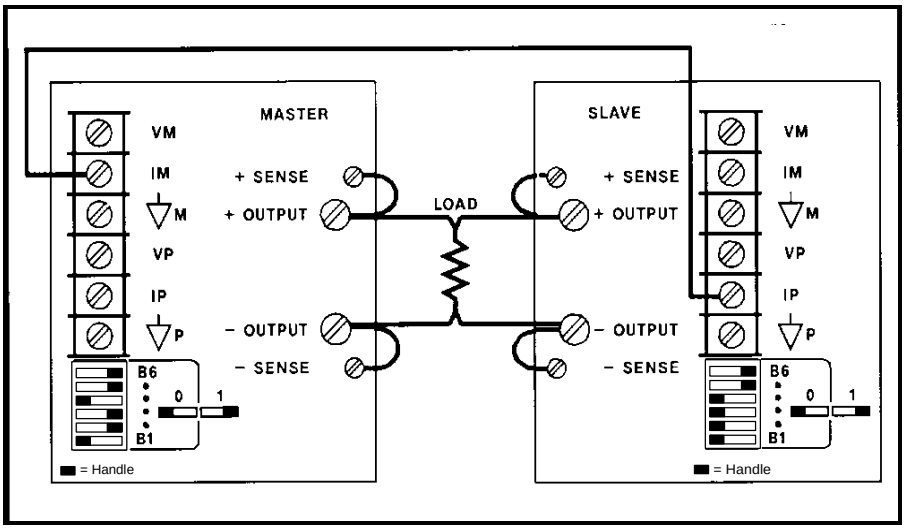


Figure 3-12. Auto-Parallel Operation

Setting Voltage and Current. Program the slave unit's output voltage above the master's to avoid interference with master-unit CV control. The slave unit's mode switches disable the slave unit's digital current setting from having any effect in auto-parallel operation. Program the master unit to the desired output voltage and 50% of total current. Verify that the slave is in CC operation.

When in CV operation, the master unit's voltage setting is the output voltage of the auto-parallel combination. The output current is the total current from all units. The fraction of total current that each unit provides is the same as the ratio of that unit's output current capability to the total output current capability of the auto-parallel combination.

In CC operation, the user must add up the current outputs from each unit and adjust the master until the total equals the desired load current.

Overvoltage Protection. Adjust the desired OVP shutdown limit using the master unit's OVP ADJUST control. Set the slave unit's OVP limit above the master's. When the master unit shuts down, the master programs the slave unit to zero voltage output. If a slave unit shuts down (because its OVP shutdown limit is set lower than the master's), it shuts down only itself, and the other unit supplies all the load current. The shut down slave unit will draw some current through its down programming circuit. The extra current required from the master may cause the master to switch from CV to CC mode.

Remote Sensing. To remote sense with auto-parallel operation, connect remote-sense leads only to the master unit according to the instructions under “Remote Sensing”.

Note: Down-programming speed is slower with auto-parallel operation because only the master unit's down programmer operates.

Series Operation

Up to two supplies can have their outputs connected in series to provide increased output voltage. Multiple loads may be connected in series, and the combination may be grounded at any one point to provide both positive and negative outputs. Regardless of whether or where the load is grounded, no point may be at a greater potential (+ or -) from ground than that specified on the output label on the rear chassis.

Caution: It is not recommended that Agilent 6015A supplies be connected in series. If you do so, the common connection between the two supplies must be connected to earth ground (see Figure 3-13).

Add the voltage settings of each power supply together to determine the total output voltage. Set the current limits for each power supply to the maximum that the load can handle without damage.

Caution: When two supplies are operated in series, they should be programmed to the same voltage to prevent possible damage to the lower voltage supply during short circuit conditions. Contact the factory if this is not possible.

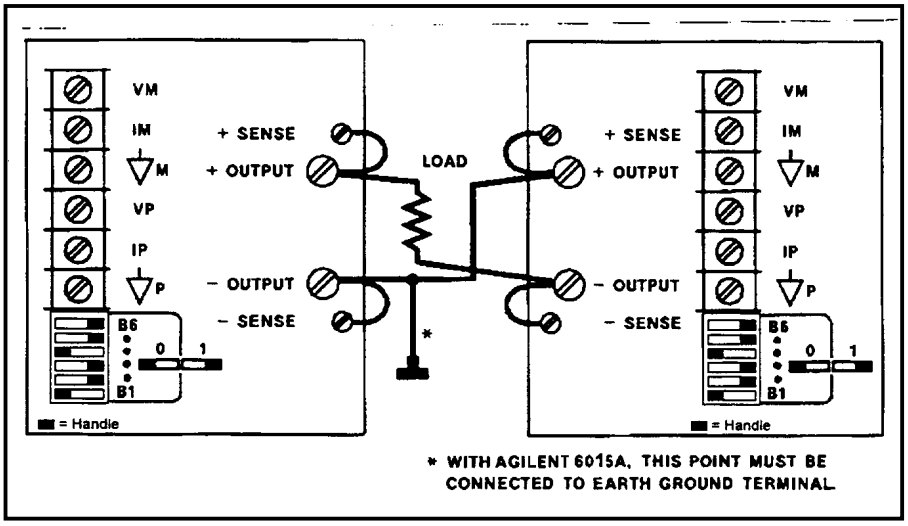


Figure 3-13. Series Operation

Monitor Signals

Amplified and buffered voltage and current monitor output signals are available at the rear-panel terminal strip. These signals can be connected to remote meters to indicate output voltage and current. The signals vary from 0 to 5 volts to indicate a zero to full-scale output. Both monitor-output terminals are referenced to the monitor-common terminal. Output impedance of the monitor terminals is 10.2k ±5%; a load of 1 megohm will maintain 1% reading accuracy.

Caution: The common terminal (⏚ M) is internally connected to the **minus** (-) output terminal. If either power supply output terminal is grounded the remote monitor terminals must not be grounded. Failure to float the remote terminals may damage the power supply.

A

100 VAC Input Power Option 100

General Information

Description

Option 100 is a modification of the power supply that involves changing the values of resistors located in the Overvoltage Protection and Power Limit Circuits. It also entails recalibrating the unit and changing the Front Panel. These changes allow the unit to operate at a lower line voltage of 90-105 Vac, while operating on the same line frequency of 48-63 Hz. The reduced input voltage limits the output power, while retaining the standard unit's output current rating. Other parameters that change due to Option 100 include the Overvoltage Trip Range and the Remote Analog Programming Specification.

Scope of Appendix A

This appendix contains all the information necessary to support the power supply when it is equipped with Option 100. The appendix describes only the changes pertaining to Option 100 and how they affect the other portions of this manual. Unless otherwise specified in Appendix A, all other portions of the manual apply to both the standard supply and Option 100 supply.

Using Appendix A

The Option 100 changes are listed sequentially, starting with Section 1 in the main body of the manual and working back through Section 3. It is recommended that the user mark all the necessary changes directly into the manual using Appendix A as a guide. This will update the manual for Option 100 and eliminate the need for constant referrals back to Appendix A.

Section 1 Manual Changes

In Section 1 change the following values in Figure 1-1.

Figure 1-1. Output Characteristic Curve

Agilent Model	6010A	6011A	6012B	6015A	6023A	6028A
VP_1	170	20	50	425	17	50
IP_1	4.7	35	16	1.38	10	3.7
VP_2	90	12	35	225	11.1	35
IP_2	10.8	73	26	3.20	18	5.7
VP_3	42	5.2	13.5	150	5	15
IP_3	17	120	50	5.0	30	10

Section 2 Manual Changes

For Agilent Models 6010A, 6011A, 6012B and 6015A: On page 23 under "AC line Impedance Check", where the maximum output voltages are tabulated, change the voltages as shown below:

6010A change 65 V to 50 V
6011A change 8 V to 6 V
6012B change 22 V to 13.5 V
6015A change 220 V to 150 V

Section 3 Manual Changes

On page 30 under “Overvoltage Protection”, change 107% to 90%.

On page 36 under “Analog Programming”, in the 3rd paragraph, change the second sentence to read: “A resistance of 0 to 3.33 K ohms programs the output voltage from 0 to full scale and a resistance of 0 to 4 K ohms programs the output current from 0 to full scale.”.

On page 36 under “Analog Programming” in the 5th paragraph, change the second sentence to read, “A voltage of 0 to 4.25 V programs the output voltage from 0 to full scale and a voltage of 0 to 5 volts programs the output current from 0 to full scale.”.

On page 36 under “Constant Voltage Output, Resistance Control”, in the second sentence, change 4000 ohms to 3.33k ohms.

On page 37 under “Constant Voltage Output, Voltage Control”, change “0 to + 5 volts” to “0 to 4.25 volts”.

In Figures 3-8 and 3-9, where 5 Vdc, 5 E or 5 appear, change them to read +4.25 Vdc, 4.25E, or 4.25 respectfully.

On page 41 under “Monitor Signals”, change “0-5 Volts” to “ 0-4.5 Volts for Voltage monitor and 0-5 Volts for current” .

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Manual Updates

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

2/01/00

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

9/20/04

The Declaration of Conformity has been updated.