



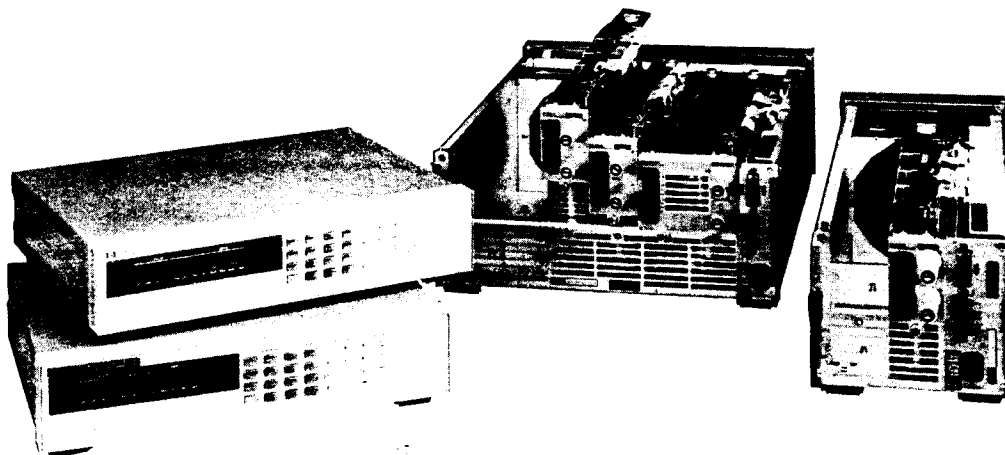
466

DC ELECTRONIC LOADS

Electronic Load Family

HP 6050A - 6063A, 60501A - 60504A

- HP-IB control of current, voltage, and resistance
- HP-IB readback of current, voltage, and power
- Built-in pulse waveform generation with programmable amplitude, frequency, duty cycle and slew rate. Continuous and pulse modes
- Full protection from overpower, overtemperature, overcurrent, overvoltage and reverse polarity
- Software calibration
- Trigger for external synchronization
- Can be controlled by an analog voltage in constant current mode
- Can be paralleled in constant current mode
- Remote voltage sense in constant voltage mode
- High voltage loads now available
- Standard 3-year warranty



HP dc Electronic Loads

Hewlett-Packard dc electronic loads are ideal for the test and evaluation of dc power sources and power components. The HP dc electronic load family offers advantages in performance, quality, and reliability. These loads are well-suited for applications in areas such as R & D, production, and incoming inspection.

The Hewlett-Packard One-Box Solution

HP single-input loads and load mainframes are equipped with standard HP-IB interfaces. The built-in IEEE-488 interface allows complete control of all load functions as well as readback of input voltage, current, power, and detailed operating status. Each HP standalone load or load module also includes programming inputs that allow control of load current via an analog control voltage. Other system features contributing to the one-box solution concept are internal voltage and current monitors and an internal transient generator with programmable amplitudes, frequency, duty cycle and slew rate. The HP one-box solution saves space, cost, and time while making HP dc electronic loads easy to integrate into automated test systems.

Fully Compatible Operation

The features and SCPI (equivalent to TMSL) instruction set of all HP dc electronic loads are fully compatible with one another. For example, test programs developed for an HP 6060A 300-watt single-input electronic load or an HP 60502A 300-watt single-input load module are interchangeable.

The HP dc electronic load family is also fully compatible with the HP 59510A relay accessory (see page 488). HP dc electronic loads typically have a maximum input resistance of 10,000 ohms. The HP 59510A provides physical isolation of the HP dc electronic load from the device under test or any other test instrument by switching power and sense leads. Capable of switching up to 60 amperes and 200 volts dc, the HP 59510A can be controlled by rear panel signals on the HP electronic load.

System or Manual Applications

HP dc electronic loads are equally suitable for manual use on the bench. The front panel LCD meters indicate voltage, current and power readings. The full function front panel keypad allows easy, repeatable, and reliable control of the load when it is used manually. Six volatile user-definable states allow you to easily save settings for later recall. An additional user-definable power-up state allows you to define settings that are remembered when the unit is switched off and then recalled when it is switched on again.

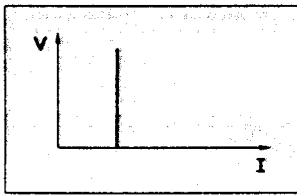
Single-Input Products

The HP 6060A and HP 6063A are single-input loads with standard rear-panel inputs. They are also available with optional front-panel inputs in addition to the rear-panel inputs. Front-panel inputs (option 020) make input connections to the HP electronic load convenient for bench applications. These front-panel terminals are capable of handling the entire current rating of the load and can accept wire gauges up to AWG #4 (22 sq mm). They require no tools to tighten, making the connections quick and easy.

Mainframe Products

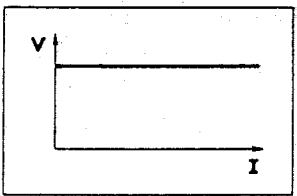
The HP 6050A 1800-watt and HP 6051A 600-watt electronic load mainframes accept the user-installable HP load modules for easy system configuration and future reconfiguration if desired. The HP 6050A holds up to six HP 60501A, 60502A, and 60503A load modules or three HP 60504A load modules, allowing up to 1800 watts total maximum power. The HP 6051A holds up to two HP 60501A, 60502A, 60503A modules or one HP 60504A module allowing up to 600 watts total maximum power. One HP-IB address is all you need for complete control and readback of all load modules within a single mainframe.

Constant Current



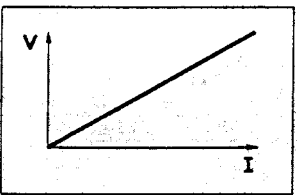
- Power Supply Load Regulation Testing
- Battery Capacity Testing
- Capacitor Discharging

Constant Voltage



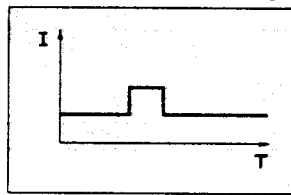
- Current Source Testing
- Current Limit Testing
- Shunt Regulator

Constant Resistance



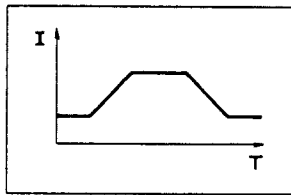
- Characterizing Power Supply Crossover
- Power Supply Start-up Delay
- Power Resistor Emulation

Pulse & Dynamic Loading



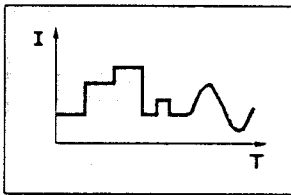
- Power Supply Load Transient Response
- Power Component Testing
- Pulse Electroplating

Programmable Slew Rate



- Power Supply Testing
- Power Component Testing
- Power Supply Load Transient Response

Analog Programming



- Battery Capacity Testing
- "Real-life" Load Simulation

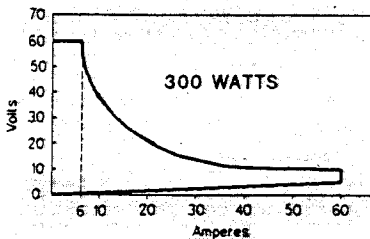
dc Electronic Load Applications

Specifying System Performance

Because Hewlett-Packard electronic loads feature an integrated HP-IB programmer, pulse generator, current shunt, DMM, and cabling, their performance is specified as a system. Our specifications cover all the integrated functions as one unit, which eliminates the need to calculate the actual performance of the automated test system based on each component's specification. The HP one-box solution makes the integration and documentation of your test system fast and easy.

Operating HP Loads Below the Minimum Input Voltage Specification

HP electronic loads meet all specifications when operated above 3.0 volts; however, the dc operating characteristics also extend below this minimum input voltage for static tests. Because of the FET technology used in the power input circuits, HP electronic loads have a low minimum input resistance allowing them to sink high currents even at low voltages.



HP 60502A INPUT CHARACTERISTICS

The figure above shows the operating range of a typical HP dc electronic load. Notice that low-voltage operation, completely down to 0 volts, is possible at correspondingly reduced current levels depending on the minimum resistance of the load. HP electronic loads, therefore, can be used in many applications that previously required zero volt loads.

Why Not Make Your Own Load?

Many load users have resorted to building their loads in-house when a commercially available electronic load with the right combination of features, power rating, performance, and purchase price could not be found. By making these loads in-house, users incur many hidden costs that can easily be overlooked. There are cost components associated with product development, parts procurement, manufacturing, product documentation, training, and product failure, maintenance or replacement. In addition, the cost components increase as the design complexity changes from simply using resistors to more sophisticated designs addressing application needs for HP-IB programming, readback, and triggering schemes for measurement synchronization.

Equipment buyers with electronic load needs have realized that the purchase price of commercially available electronic loads can be relatively insignificant when compared to the overall cost of designing, manufacturing, and maintaining them in-house.

The HP electronic load family reduces your total cost of ownership by providing superior performance, features, reliability, and complete product documentation at a reasonable purchase price. These loads allow you to use fewer resources for your electronic load test system development, and more resources to remain successful and competitive in your particular industry. The standard 3-year warranty can further reduce your maintenance costs.

The quality, performance, price, and HP support will help you make an intelligent and economical purchase decision.

DC ELECTRONIC LOADS

Specifications and Dimensions

Specifications (Data Subject to Change)

Amperes	0-60 A	0-10 A	0-30 A	0-120 A
Volts	3-60 V	3-240 V	3-60 V	3-60 V
Maximum Power (at 40°C)	300 W	250 W	150 W	600 W
Hewlett-Packard Model	HP 6060A, 60502A	HP 6063A, 60503A	HP 60501A	HP 60504A
Constant current mode Ranges	0-6 A, 0-60 A	0-1 A, 0-10 A	0-3 A, 0-30 A	0-12 A, 0-120 A
Accuracy	0.1% ±75 mA	±0.15 ±10 mA	0.1% ±40 mA	0.12% ±130 mA
Resolution	60 A range: 16 mA 6 A range: 1.6 mA	10 A range: 2.6 mA 1 A range: 0.26 mA	30 A range: 8 mA 3 A range: 0.8 mA	120 A range: 32 mA 12 A range: 3.2 mA
Temperature coefficient	100 ppm/°C ±5 mA/°C	150 ppm/°C ±1 mA/°C	100 ppm/°C ±3 mA/°C	120 ppm/°C ±8 mA/°C
Regulation	±10 mA	±8 mA	±10 mA	±10 mA
Constant voltage mode Accuracy	0.1% ±50 mV	±0.12% ±120 mV	0.1% ±50 mV	0.1% ±50 mV
Resolution	16 mV	64 mV	16 mV	16 mV
Regulation	±10 mV	±10 mV	±5 mV	±20 mV
Temperature coefficient	100 ppm/°C ±5 mV/°C	120 ppm/°C ±10 mV/°C	100 ppm/°C ±5 mV/°C	100 ppm ±5 mV/°C
Constant resistance mode Ranges	0.033 - 1.0 Ω 1 Ω - 1 KΩ 10 Ω - 10 KΩ	0.20 - 24.0 ohm 24 - 1000Ω 240 - 5000Ω	0.067 - 2 Ω 2 Ω - 2 K Ω 20 Ω - 10 KΩ	0.017 - 0.5 Ω 0.5 Ω - 500 Ω 5 Ω - 5 KΩ
Accuracy	1 Ω: 0.8% ±8 mΩ (with ≥6A at input) 1 K Ω: 0.3% ±8 mS (with ≥6V at input) 10 K Ω: 0.3% ±8 mS (with ≥6V at input)	24Ω: 0.8% ±200 mΩ (with ≥1A at input) 10 KΩ: 0.3% ±0.3 mS (with ≥24V at input) 50 KΩ: 0.3% ±0.3 mS (with ≥24V at input)	2 Ω: 0.8%, ± 16 mΩ (with ≥3A at input) 2 KΩ: 0.3% ±5 mS (with ≥6V at input) 10 KΩ: 0.3% ±5 mS (with ≥6V at input)	0.5 Ω: 0.8% ±5 mΩ (with ≥12A at input) 500 Ω: 0.3% ± 16 mS (with ≥6V at input) 5 KΩ: 0.3% ± 16 mS (with ≥6V at input)
Resolution	1 Ω: 0.27 mΩ 1 KΩ: 0.27 mS 10 KΩ: 0.027 mS	24Ω: 6 mΩ 10 KΩ: 0.011 mS 50 KΩ: 0.001 mS	2 Ω: 0.54 mΩ 2 KΩ: 0.14 mS 10 KΩ: 0.014 mS	5 Ω: 0.14 mΩ 500 Ω: 0.54 mS 5 KΩ: 0.054 mS
Regulation	1 Ω: 10 mV 1 KΩ: 10 mA 10 KΩ: 10 mA	24Ω: 10 mV 10 KΩ: 8 mA 50 KΩ: 8 mA	2 Ω: 10 mV 2 KΩ: 10 mA 10 KΩ: 10 mA	5 Ω: 20 mV 500 Ω: 10 mA 5 KΩ: 10 mA
Temperature coefficient	1 Ω: 800 ppm/°C ±0.4 mΩ/°C 1 KΩ: 300 ppm/°C ±0.6 mS/°C 10 KΩ: 300 ppm/°C ±0.6 mS/°C	24 Ω: 800 ppm/°C 800 ppm/°C ± 10 mΩ/°C 10 KΩ: 300 ppm/°C 300 ppm/°C ±0.03 mS/°C 50 KΩ: 300 ppm/°C 300 ppm/°C/-0.03 mS/°C	2 Ω: 800 ppm/°C ±0.8 mΩ/°C 2 KΩ: 300 ppm/°C ±0.5 mS/°C 10 KΩ: 300 ppm/°C ±0.5 mS/°C	0.5 Ω: 800 ppm/°C ±0.2 mΩ/°C 500 Ω: 300 ppm/°C ±1.2 mS/°C 5 KΩ: 300 ppm/°C ±1.2 mS/°C
Transient generator Frequency range	0.25 Hz - 10 kHz	0.25 Hz - 10 kHz	0.25 Hz - 10 kHz	0.25 Hz - 10 kHz
Resolution	4% or less	4% or less	4% or less	4% or less
Accuracy	3%	3%	3%	3%
Duty cycle range	3 - 97% (0.25 Hz - 1 kHz) 6 - 94% (1 kHz - 10 kHz)	3%-97% (0.25 Hz - 1 kHz) 6-94% (1 kHz - 10 kHz)	3 - 97% (0.25 Hz - 1 kHz) 6 - 94% (1 kHz - 10 kHz)	3 - 97% (0.25 Hz - 1 kHz) 6-94% (1 kHz - 10 kHz)
Resolution	4%	4%	4%	4%
Accuracy	6% of setting ±2%	6% of setting ±2%	6% of setting ±2%	6% of setting ±2%
Current level high range Resolution	60 A range: 260 mA	10 A range: 43 mA	30 A range: 130 mA	120 A range: 520 mA
Accuracy	0.1% ±350 mA	0.18% ±50 mA	0.1%, ±200 mA	0.15% ±700 mA
Current level low range Resolution	6 A range: 26 mA	1 A range: 4 mA	3 A range: 13 mA	12 A range: 52 mA
Accuracy	0.1% ±80 mA	0.18% ±13 mA	0.1% ±40 mA	0.15% ±160 mA
Current temperature coefficient	100 ppm/°C ±7 mA/°C	180 ppm/°C ±1.2 mA/°C	100 ppm ±5 mA/°C	150 ppm/°C ±10 mA/°C
Voltage level	3 to 60 V	3 - 240 V	3 to 60 V	3 to 60 V
Voltage level resolution	260 mV	1 V	260 mV	260 mV
Voltage level accuracy	0.1% ±300 mV	0.15% ±1.1 V	0.1% ±300 mV	0.15% ±300 mV
Net weight (approx.)	6060A: 6.4 kg (14 lb) 60502A: 3.2 kg (7 lb)	6063A: 6.4 kg (14 lb) 60503A: 3.2 kg (7 lb)	3.2 kg (7 lb)	5.9 kg (13 lb)
Shipping weight	6060A: 7.5 kg (17 lb) 60502A: 4.5 kg (10 lb)	6063A: 7.5 kg (17 lb) 60503A: 4.5 kg (10 lb)	4.5 kg (10 lb)	7.3 kg (16 lb)

HP 6050A, 6051A weight

Net Weight: 6050A: 9.5 kg (21 lb)

6051A: 5.5 kg (12 lb)

Shipping Weight: 6050A: 13.6 kg (30 lb)

6051A: 7.5 kg (17 lb)

Safety agency compliance

Hewlett-Packard Electronic Loads are designed to comply with the following regulatory standards: IEC 348, VDE 0411, UL 1244, and CSA Electrical Bulletin 556B

HP-IB interface capabilities

The following HP-IB functions are implemented: SH1, AH1, L4, SR1, DC1, DT1, and RL1

60502A
↓

Specifications - continued

Hewlett-Packard Model	HP 6060A, 60502A	HP 6063A, 60503A	HP 60501A	HP 60504A
Transient generator (continued)				
Voltage temperature coefficient	150 ppm/°C ± 5 mV/°C	120 ppm/°C ± 10 mV/°C	150 ppm/°C ± 5 mV/°C	150 ppm/°C ± 5 mV/°C
Programmable slew rate	60 A range: 1 A/ms - 5 A/μs 6 A range: 0.1 A/ms - 0.5 A/μs	10 A Range: 0.17 A/ms - 0.83 A/μs 1 A range: 17 A/s - 83 A/ms	30 A range: 0.5 A/ms - 2.5 A/μs 3 A range: 0.05 A/ms - 0.25 A/μs	120 A range: 2 A/ms - 10A/μs 12 A range: 200 A/s - 1 A/μs
Rise/fall time	12 μs to 8 ms	16 μs to 8 ms	12 μs - 8 ms	12 μs - 8 ms
Analog programming bandwidth	10 kHz (-3 db freq.)	10 kHz (-3 db freq.)	10 kHz (-3 db freq.)	10 kHz (-3 db freq.)
Analog programming accuracy				
Current (low range)	4.5% ± 75 mA	3% ± 8 mA	4.5% ± 40 mA	4% ± 200 mA
Current (high range)	4.5% ± 250 mA	3% ± 12 mA	4.5% ± 130 mA	4% ± 400 mA
Temperature coefficient	100 ppm/°C ± 6 mA/°C	150 ppm/°C ± 1 mA/°C	100 ppm/°C ± 3 mA/°C	100 ppm/°C ± 12 mA/°C
Voltage	0.8% ± 200 mV	0.5% ± 150 mV	0.8% ± 200 mV	0.8% ± 200 mV
Temperature coefficient	100 ppm/°C ± 1 mV/°C	120 ppm/°C ± 10 mV/°C	100 ppm/°C ± 1 mV/°C	100 ppm/°C ± 1 mV/°C
Analog programming voltage	0-10 V	0-10 V	0-10 V	0-10 V
Readback specifications				
current readback resolution	17 mA (via HP-IB) 20 mA (front panel)	2.7 mA (via HP-IB) 10 mA (front panel)	9 mA (via HP-IB) 10 mA (front panel)	32 mA (via HP-IB) 100 mA (front panel)
Current readback accuracy	0.05% ± 65 mA	0.12% ± 10 mA	0.06% ± 40 mA	0.1% ± 110 mA
Temperature coefficient	50 ppm/°C ± 5 mA/°C	100 ppm/°C ± 1 mA/°C	65 ppm/°C ± 3 mA/°C	100 ppm/°C ± 8 mA/°C
Voltage readback resolution	17 mV (via HP-IB) 20 mV (front panel)	67 mV (via HP-IB) 100 mV (front panel)	17 mV (via HP-IB) 20 mV (front panel)	16 mV (via HP-IB) 20 mV (front panel)
Voltage readback accuracy	0.05% ± 45 mV	0.1% ± 150 mV	0.05% ± 45 mV	0.1% ± 45 mV
Temperature coefficient	50 ppm/°C ± 1.2 mV/°C	100 ppm/°C ± 8 mV/°C	50 ppm/°C ± 1.2 mV/°C	100 ppm/°C ± 2 mV/°C
Power readback accuracy	0.2% ± 4 W	0.2% ± 3 mV	0.2% ± 2 W	0.2% ± 8 W
Analog monitor accuracy				
Current monitor (0 to 10 V out)	4% ± 85 mA	3% ± 10 mA	4% ± 40 mA	4% ± 170 mA
Temperature coefficient	50 ppm/°C ± 6 mA/°C	100 ppm/°C ± 1 mA/°C	60 ppm/°C ± 3 mA/°C	100 ppm/°C ± 10 mA/°C
Voltage monitor (0 to 10 V out)	0.25% ± 40 mV	0.4% ± 240 mV	0.25% ± 40 mV	0.4% ± 60 mV
Temperature coefficient	50 ppm/°C ± 0.2 mV/°C	70 ppm/°C ± 1.2 mV/°C	50 ppm/°C ± 0.2 mV/°C	100 ppm/°C ± 2 mV/°C
Remote sensing	5 Vdc maximum between sense and load input			
Minimum operating voltage	2 volts (typical 1.2 V)	2 volts (typical 1.2 V)	2 volts (typical 1.2 V)	2 volts (typical 1.4 V)
Programmable short	0.033 Ω (0.020 typical)	0.20 Ω (0.10 typical)	0.066 Ω (0.040 typical)	0.017 Ω (0.012 typical)
Programmable open (typical)	20 KΩ (typical)	80 KΩ (typical)	20 KΩ (typical)	20 KΩ (typical)
Drift (over 8 hour interval)				
Current	0.03% ± 10 mA	0.03% ± 15 mA	0.03% ± 5 mA	0.03% ± 20 mA
Voltage	0.01% ± 10 mV	0.01% ± 20 mV	0.01% ± 10 mV	0.01% ± 10 mV
PAR (20 Hz to 10 MHz noise)				
Current	4 mA rms 40 mA peak-peak	1 mA rms 10 mA peak-peak	2 mA rms 20 mA peak-peak	6 mA rms 60 mA peak-peak
Voltage	6 mV rms	6 mV rms	5 mV rms	8 mV rms
dc solution voltage	±240 Vdc, between any input and chassis ground			
Digital inputs	V _{IL} = 0.9 V max at I _{IL} = -1 mA V _{IH} = 3.15 V min (pull-up resistor on input)			
Digital outputs	V _{OL} = 0.72 V max at I _{OL} = 1 mA V _{OH} = 4.4 V min at I _{OH} = -20 μA			

Notes:

1. Operating temperature range is 0 to 55°C. All specifications apply for 25°C ± 5°C, except as noted.
2. Maximum continuous power available is derated linearly from 40°C to 75% of maximum at 55°C.
3. dc current accuracy specifications apply 30 seconds after input is applied.

Ordering Information

Model	Price	Options							
		Front Panel Inputs	ac Input			Rackmount Kit			Extra Manuals
			100 VAC Japan Only	220 VAC	240 VAC	800	908	909	
HP 6050A	\$1,920	-	\$0*	\$0*	\$0*	-	+\$37†	+\$98†	+\$52*
HP 6051A	\$1,700	-	\$0*	\$0*	\$0*	+\$67†	+\$67†	-	+\$50*
HP 6060A	\$2,100	+\$82*	\$0*	\$0*	\$0*	-	+\$32*	+\$75*	+\$35*
HP 6063A	\$2,500	+\$82*	\$0*	\$0*	\$0*	-	+\$32*	+\$75*	+\$35*
HP 60501A	\$1,315	-	-	-	-	-	-	-	+\$32*
HP 60502A	\$1,620	-	-	-	-	-	-	-	+\$32*
HP 60503A	\$1,950	-	-	-	-	-	-	-	+\$32*
HP 60504A	\$2,275	-	-	-	-	-	-	-	+\$32*

† Option 908 and 909 for the HP 6050A, and Option 800 and 908 for the HP 6051A, require either the slide kit (P/N 1494-0059) or slide rails to support the weight of the load mainframe. Slide kits can be purchased using the above part number.

* This feature is available as an option.

- This feature is not available.

Option Descriptions

Opt 020 Front panel inputs.

Opt 100 87-106 Vac, 47-66 Hz (for Japan only).

Opt 220 191-233 Vac, 47-66 Hz.

Opt 240 209-250 Vac, 47-66 Hz.

Opt 800 Rackmounting kit for two units mounted side-by-side. (HP part numbers 5062-3994 and 5062-3978).

Opt 908 Rackmounting kit includes (HP P/N 5062-3978 with an HP 6050A, HP P/N 5062-3960 with HP 6051A, and HP P/N 5062-3974 with an HP 6060A).

Opt 909 Rackmounting kit with handles (HP P/N 5062-3984 when mounting an HP 6050A and HP P/N 5062-3975 when mounting an HP 6060A).

Opt 910 Extra manual set, including one each of the Operating Manual, Programming Reference Manual, and Service Manual. The Programming Manual is available with the Mainframe, and therefore not individual modules. (Operating Manuals and Programming Manuals only are shipped with standard units).

Specifications -

Hewlett-Packard Model	HP 6060A, 60502A
Transient generator (continued)	
Voltage temperature coefficient	150 ppm/°C ± 5 mV/°C
Programmable slew rate	60 A range: 1 A/ms - 5 A/μs 6 A range: 0.1 A/ms - 0.5 A/μs
Rise/fall time	12 μs to 8 ms
Analog programming bandwidth	10 kHz (-3 db freq.)
Analog programming accuracy	
Current (low range)	4.5% ± 75 mA
Current (high range)	4.5% ± 250 mA
Temperature coefficient	100 ppm/°C ± 6 mA/°C
Voltage	0.8% ± 200 mV
Temperature coefficient	100 ppm/°C ± 1 mV/°C
Analog programming voltage	0-10 V
Readback specifications	
current readback resolution	17 mA (via HP-IB) 20 mA (front panel)
Current readback accuracy	0.05% ± 65 mA
Temperature coefficient	50 ppm/°C ± 5 mA/°C
Voltage readback resolution	17 mV (via HP-IB) 20 mV (front panel)
Voltage readback accuracy	0.05% ± 45 mV
Temperature coefficient	50 ppm/°C ± 1.2 mV/°C
Power readback accuracy	0.2% ± 4 W
Analog monitor accuracy	
Current monitor (0 to 10 V out)	4% ± 85 mA
Temperature coefficient	50 ppm/°C ± 6 mA/°C
Voltage monitor (0 to 10 V out)	0.25% ± 40 mV
Temperature coefficient	50 ppm/°C ± 0.2 mV/°C
Remote sensing	
Minimum operating voltage	2 volts (typical 1.2 V)
Programmable short	0.033 Ω (0.020 typical)
Programmable open (typical)	20 KΩ (typical)
Drift (over 8 hour interval)	
Current	0.03% ± 10 mA
Voltage	0.01% ± 10 mV
PARD (20 Hz to 10 MHz noise)	
Current	4 mA rms 40 mA peak-peak
Voltage	6 mV rms
dc solution voltage	
Digital inputs	
Digital outputs	