

# ***OPERATING MANUAL***

## **600 WATT ELECTRONIC LOAD MODULE Agilent Model 60504B**



**FOR MODULES WITH SERIAL NUMBERS:  
3121A-00101 AND ABOVE**



**Agilent Technologies**

**Agilent Part No. 60504-90009  
Microfiche No. 60504-90010**

**Printed in U.S.A.  
June, 1991**

## DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

**Manufacturer's Name:** Agilent Technologies

**Manufacturer's Address:** New Jersey Division  
140 Green Pond Road  
Rockaway, NJ 07866 U.S.A.

declares that the product

**Product Name:** Load mainframe and modules

**Model Number(s):** Agilent 6050A, 6051A mainframes with modules  
Agilent 60501A/B, 60502A/B, 60503A/B, 60504A/B, 60507A/B

conform(s) to the following Product Specifications:

**Safety:** IEC 348:1978 / HD401 S1:1981<sup>1</sup>

**EMC:** CISPR 11:1990 / EN 55011:1991 - Group 1, Class B  
IEC 801-2:1991 / EN 50082-1:1992 - 4kV CD, 8 kV AD  
IEC 801-3:1984 / EN 50082-1:1992 - 3 V/m  
IEC 801-4:1988 / EN 50082-1:1992 - 0.5 kV Sig. Lines, 1 kV  
Power Lines

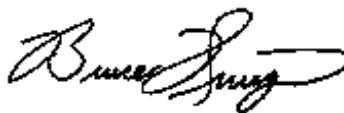
### Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Note 1: The product family was introduced prior to 12/93

New Jersey  
Location

January 1997  
Date



Bruce Krueger / Quality Manager

European Contact: Your local Agilent Technologies Sales and Service Office or Agilent Technologies GmbH,  
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# 600-Watt Module

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## About This Manual

This manual provides information for the Agilent 60504B 600-Watt Electronic Load Module. It is designed as a supplement to the Agilent 6050A/6051A Multiple Input Mainframe Electronic Load Operating Manual (part number 06050-90001). Four tables provide the following module-specific information:

Table 60504-1 lists both the specifications and supplemental characteristics of the module. Specifications indicate warranted performance in the  $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  region of the total temperature range (0 to  $55\text{ }^{\circ}\text{C}$ ). Supplemental characteristics indicate non-warranted, typical performance and are intended to provide additional information by describing performance that has been determined by design or type testing.

Table 60504-2 lists the ranges that can be programmed in constant current, constant resistance, and constant voltage modes. It shows the maximum and minimum programming values for each range. Refer to this table when programming the module locally as described in Chapter 4, or remotely as described in Chapter 5 of the operating manual.

Table 60504-3 gives the factory default values of the module. Unless you have saved your own wake-up settings, the module will be set to the factory default values whenever power is applied. See Chapter 4 in the operating manual.

Table 60504-4 provides calibration information for the module. This information is needed to perform the annual calibration procedure described in Chapter 6 of the operating manual.

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## Module Installation and Operation

Except for the module-specific information in this manual, all installation, operation, and calibration instructions are given in the Mainframe Operating Manual. The Agilent Electronic Load Family Programming Reference Manual (part number 06060-90005) contains complete programming details that apply to all Electronic Load models.

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**Note:** The following information in Chapter 2 of the Mainframe Operating Manual does not apply to electronic load modules with the serial numbers listed on the title page of this manual: The section titled "Extended Power Operation", and the section titled "Extended Power Limit". Also for these modules, change the 3-second delay referred to under "Nominal Power Limit" to 50 milliseconds.

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## Items Supplied

In addition to this manual, a 10-pin connector plug is also shipped with your Electronic Load module. Refer to Chapter 3 in the operating manual for more information.

**Table 60504-1. Specification and Supplemental Characteristics**

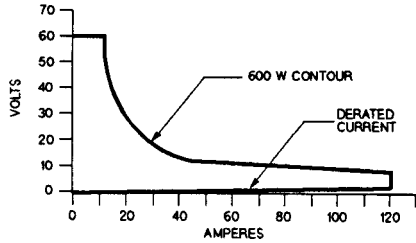
**SPECIFICATIONS**

**DC Input Rating:**

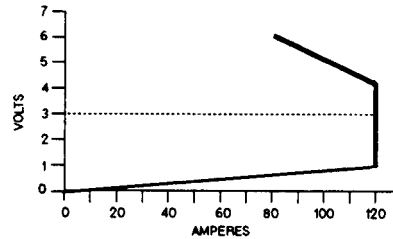
**Current:** 0 to 120 A

**Voltage:** 3 V to 60 V (minimum dc operation from 0 to 2 V for 0 to 10 A)

**Power:** 600 W at 40 °C (derated to 450 W at 55 °C)



**A. OPERATING CHARACTERISTICS**



**B. DERATED CURRENT DETAIL**

**Constant Current Mode:**

**Ranges:** 0 to 12 A; and 0 to 120 A  
**Accuracy:** (after 30 second wait):  $\pm 0.12\% \pm 130$  mA (both ranges)  
**Resolution:** 3.2 mA (12 A range); 32 mA (120 A range)  
**Regulation:** 10 mA (both ranges)  
**Temperature Coefficient:** 120 ppm/°C  $\pm$  8 mA/°C (both ranges)

**Constant Resistance Mode:**

**Ranges:** 0.017 to 0.5  $\Omega$ ; 0.5  $\Omega$  to 500  $\Omega$ ; and 5  $\Omega$  to 5 k $\Omega$   
**Accuracy:**  $\pm 0.8\% \pm 5$  m $\Omega$  with  $\geq 12$  A at input (0.5  $\Omega$  range);  
 $\pm 0.3\% \pm 18$  mS with  $\geq 6$  V at input (500  $\Omega$  and 5 k $\Omega$  ranges)  
**Resolution:** 0.14 m $\Omega$  (0.5  $\Omega$  range); 0.54 mS (500  $\Omega$  range); 0.054 mS (5 k $\Omega$  range)  
**Regulation:** 20 mV with remote sensing (0.5  $\Omega$  range); 10 mA (500  $\Omega$  and 5 k $\Omega$  ranges)  
**Temperature Coefficient:** 800 ppm/°C  $\pm$  0.2 m $\Omega$ /°C (0.5  $\Omega$  range);  
 300ppm/°C  $\pm$  1.2 mS/°C (500  $\Omega$  and 5 k $\Omega$  ranges)

**Constant Voltage Mode:**

**Range:** 0 to 60 V  
**Accuracy:**  $\pm 0.1\% \pm 50$  mV  
**Resolution:** 16 mV  
**Regulation:** 20 mV (remote sense); 100 mV (local sense)  
**Temperature Coefficient:** 100 ppm/°C  $\pm$  5 mV/°C

**Table 60504-1 Specifications and Supplemental Characteristics (continued)**

**Transient Operation:**

**Continuous Mode**

<b>Frequency Range:</b>	0.25 Hz to 10 kHz
<b>Frequency Resolution:</b>	4%
<b>Frequency Accuracy:</b>	3%
<b>Duty Cycle Range:</b>	3% to 97% (0.25 Hz to 1 kHz); 6% to 94% (1 kHz to 10 kHz)
<b>Duty Cycle Resolution:</b>	4%
<b>Duty Cycle Accuracy:</b>	6% of setting $\pm$ 2%

**Pulsed Mode**

<b>Pulse Width:</b>	50 $\mu$ s $\pm$ 3% minimum; 4 s $\pm$ 3% maximum
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**Transient Current Level (0 to 12 A and 0 to 120 A ranges):**

<b>Resolution:</b>	52 mA (12 A range); 520 mA (120 A range)
<b>Accuracy:</b>	$\pm$ 0.15% $\pm$ 160 mA (12 A range); $\pm$ 0.15% $\pm$ 700 mA (120 A range)
<b>Temperature Coefficient:</b>	150 ppm/ $^{\circ}$ C $\pm$ 10 mA/ $^{\circ}$ C

**Transient Resistance Level (0.017 to 0.5  $\Omega$ , 0.5  $\Omega$  to 500  $\Omega$ , and 5  $\Omega$  to 5 k $\Omega$  ranges):**

<b>Resolution:</b>	2.2 m $\Omega$ (0.5 $\Omega$ range); 8.7 mS (500 $\Omega$ range); 0.87 mS (5 k $\Omega$ range)
<b>Accuracy:</b>	$\pm$ 0.8% + 7 m $\Omega$ with $\geq$ 12 A at input (0.5 $\Omega$ range) $\pm$ 0.3% + 26 mS with $\geq$ 6 V at input (500 $\Omega$ range) $\pm$ 0.3% + 18 mS with $\geq$ 6 V at input (5 k $\Omega$ range)

**Transient Voltage Level (0 to 60 V):**

<b>Resolution:</b>	260 V
<b>Accuracy:</b>	$\pm$ 0.15% $\pm$ 300 V
<b>Temperature Coefficient:</b>	150 ppm/ $^{\circ}$ C $\pm$ 5 mV/ $^{\circ}$ C

**Current Readback:**

<b>Resolution:</b>	34 mA (via GPIB); 100 mA (front panel)
<b>Accuracy:</b>	(after 30 minute wait): $\pm$ 0.1% $\pm$ 110 mA
<b>Temperature Coefficient:</b>	100 ppm/ $^{\circ}$ C $\pm$ 1 mA/ $^{\circ}$ C

**Voltage Readback:**

<b>Resolution:</b>	17 mV (via GPIB); 20 mV (front panel)
<b>Accuracy:</b>	$\pm$ 0.1% $\pm$ 45 mV
<b>Temperature Coefficient:</b>	100 ppm/ $^{\circ}$ C $\pm$ 2 mV/ $^{\circ}$ C
<b>Maximum Readback Capability:</b>	65 to 70 V (typical)

**Power Readback:**

<b>Accuracy:</b>	$\pm$ 0.2% $\pm$ 8 W
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**Table 60504-1 Specifications and Supplemental Characteristics (continued)**

**External Analog Programming 0 to 10 V (dc or ac):**

<b>Bandwidth:</b>	10 kHz (3 db frequency)
<b>Accuracy:</b>	± 4% ± 200 mA (0 to 12 A range) ± 4% ± 400 mA (0 to 120 A range) ± 0.8% ± 200 mV (0 to 60 V range)
<b>Temperature Coefficient:</b>	100 ppm/°C ± 12 mA/°C (current ranges) 100 ppm/°C ± 1 mV/°C (voltage range)

**External Current Monitor (0 to 10 V):**

<b>Accuracy:</b>	± 0.4% ± 170 mA (referenced to analog common)
<b>Temperature Coefficient:</b>	100 ppm/°C ± 10 mA/°C

**External Voltage Monitor (0 to 10 V):**

<b>Accuracy:</b>	± 0.4% ± 60 mV (referenced to analog common)
<b>Temperature Coefficient:</b>	100 ppm/ °C ± 2 mV/ °C

**Remote Sensing:** 5 Vdc maximum between sense and input binding posts

**Maximum Input Levels:**

<b>Current:</b>	122.4 A (programmable to lower limits)
<b>Voltage:</b>	75 V

**Minimum Operating Voltage:** 2 V (derated to 0 V at 0 A)

**PARD (20 Hz to 10 MHz noise):**

<b>Current:</b>	6 mA rms/60 mA p-p
<b>Voltage:</b>	8 mV rms

**DC Isolation Voltage:** ± 240 Vdc between + or - input binding post and chassis ground

**Digital Inputs:**

<b>V<sub>lo</sub>:</b>	0.9 V maximum at I <sub>lo</sub> = -1 mA
<b>V<sub>hi</sub>:</b>	3.15 V minimum (pull-up resistor on input)

**Digital Outputs:**

<b>V<sub>lo</sub>:</b>	0.72 V maximum at I <sub>lo</sub> = 1 mA
<b>V<sub>hi</sub>:</b>	4.4 V minimum at I <sub>lo</sub> = 20 μA

**SUPPLEMENTAL CHARACTERISTICS**

**Programmable Slew Rate** (For any given input transition, the time required will be either the total slew time or a minimum transition time, whichever is longer. The minimum transition time increases when operating with input currents under 2 A. The following are typical values; ± 25% tolerance):

**Table 60504-1 Specifications and Supplemental Characteristics (continued)**

**Current Slew Rate:\***

Rate #	120 A Range Step	12 A Range Step	Transition Time
1	2 A/ms	0.2 A/s	8.0 ms
2	5 A/ms	0.5 A/s	3.2 ms
3	10 A/ms	1 A/ms	1.6 ms
4	20 A/ms	2 A/ms	800 $\mu$ s
5	50 A/ms	5 A/ms	320 $\mu$ s
6	100 A/ms	10 A/ms	160 $\mu$ s
7	0.2 A/ $\mu$ s	20 A/ms	80 $\mu$ s
8	0.5 A/ $\mu$ s	50 A/ms	32 $\mu$ s
9	1 A/ $\mu$ s	100 A/ms	16 $\mu$ s
10	2 A/ $\mu$ s	0.2 A/ $\mu$ s	12 $\mu$ s
11	5 A/ $\mu$ s	0.5 A/ $\mu$ s	12 $\mu$ s
12	10 A/ $\mu$ s	1 A/ $\mu$ s	12 $\mu$ s

\*AC performance specified from 3 to 60 V.

**Voltage Slew Rate:**

Rate #	Voltage Range Step	Transition Time*
1	1 V/ms	8.0 ms
2	2.5 V/ms	3.2 ms
3	5 V/ms	1.6 ms
4	10 V/ms	800 $\mu$ s
5	25 V/ms	320 $\mu$ s
6	50 V/ms	160 $\mu$ s
7	0.1 V/ $\mu$ s	85 $\mu$ s
8	0.25 V/ $\mu$ s	85 $\mu$ s
9	0.5 V/ $\mu$ s	85 $\mu$ s

\*Transition time based on low capacitance current source.

**Resistance Slew Rate (0.5  $\Omega$  range):** Uses the value programmed for voltage slew rate.

**Resistance Slew Rate (500  $\Omega$  and 5 k $\Omega$  ranges):** Uses the value programmed for current slew rate.

**Transient Current Overshoot (When programmed from 0A):**

Range	Transient Current Level	Current Slew Rate	Overshoot*
120 A	24-120 A	All slew rates	0
	6 A	0.5 A/ $\mu$ s and 10 A/ $\mu$ s	6%
	6 A	2 A/ $\mu$ s	3%
	6 A	1 A/ $\mu$ s	1%
	6 A	0.2 A/ms to 0.5 A/ $\mu$ s	0
	12 A	2 A/ms to 2 A/ $\mu$ s	0
	12 A	5 A/ms and 10 A/ $\mu$ s	2%

Range	Transient Current Level	Current Slew Rate	Overshoot*
12 A	6 A	0.5 A/μs, 1 A/μs	5%
	6 A	0.2 A/μs to 0.2 A/μs	0
	12 A	1 A/μs	2%
	12 A	0.2 A/ms to 0.5 A/μs	0

\*Overshoot may be higher during the first five seconds of programming if unit has been operating at full current. Overshoot values assume a total inductance of 1μH, or less, in the load leads connected to the D.U.T.

**Source Turn-On Current Overshoot:** Less than 10% of final value (in CC and CR modes when connected to power supplies with voltage rise times of greater than 500μs).

**Programmable Short Circuit:** 0.17 Ω (0.012 Ω typical)

**Programmable Open Circuit:** 20 kΩ (typical)

**Drift Stability** (over an 8 hour interval):

**Current:** ±0.03% ± 20 mA  
**Voltage:** ±0.01% ± 10 mV

**Reverse Current Capacity:** 120 A when unit is on; 60 A when unit is off

**Weight:** 5.4 kg (12 lbs.)

**Table 60504-2. Programming Ranges**

Function	Front Panel Key	Front Panel Display	HPSL Command (Short Form)	Range of Values
<b>Constant Current</b>				
Set Range	<b>Range</b>	C:RNG value	"CURR:RANG value"	
Low Range				≥ 0 and ≤ 12 A
High Range				> 12 A and ≤ 120 A
Set Main Level	<b>CURR</b>	CURR value	"CURR value"	
Low Range				0 to 12 A
High Range				0 to 120 A
Set Slew Rate	(shift) <b>Slew</b>	C:SLW value	"CURR:SLEW value"	
Low Range				0.0002 to 1 (A/μs)
High Range				0.002 to 10 (A/μs)
Set Transient Level	<b>Tran Level</b>	C:TLV value	"CURR:TLEV value"	same as main level
*Set Triggered Level			"CURR:TRIG value"	same as main level
<b>Constant Resistance</b>				
Set Range	<b>Range</b>	R:RNG value	"RES:RANG value"	
Low Range				≥ 0 and ≤ 0.5 Ω
Middle Range				> 0.5 Ω and ≤ 500 kΩ
High Range				>500 Ω and ≤ 5 kΩ
Set Main Level	<b>RES</b>	RES value	"RES value"	
Low Range				0 to 0.5 Ω
Middle Range				0.5 Ω to 500 Ω
High Range				5 Ω to 5 kΩ



**Table 60504-2. Programming Ranges (continued)**

Function	Front Panel Key	Front Panel Display	HPSL Command (Short Form)	Range of Values
<b>Constant Resistance</b> Set Slew Rate Low Range Middle/High Range Set Transient Level *Set Triggered Level	(shift) <b>Slew</b>  <b>Tran Level</b>	V:SLW value C:SLW value R:TLV value	"VOLT:SLEW value" "CURR:SLEW value" "RES:TLEV value" "RES:TRIG value"	same as voltage slew same as current slew same as main level same as main level
<b>Constant Voltage</b> Set Main Level Set Slew Rate Set Transient Level *Set Triggered Level	<b>VOLT</b> (shift) <b>Slew</b> <b>Tran Level</b>	VOLT value V:SLW value V:TLV value	"VOLT value" "VOLT:SLEW value" "VOLT:TLEV value" "VOLT:TRIG value"	0 to 60 V 0.001 to 0.5 (V/μs) same as main level same as main level
<b>Transient Operation</b> Set Frequency Set Duty Cycle  *Set Pulse Width	<b>FREQ</b> (shift) <b>Dcycle</b>	FREQ value DCYCLE value	"TRAN:FREQ value" "TRAN:DCYC value"  "TRAN:TWID value"	0.25 Hz to 10 kHz 3-97% (0.25 Hz-1 kHz) 6-94% (1 kHz-10 kHz) 0.00005 to 4 s
<b>Trigger Operation</b> *Set Trigger Period			"TRIG:TIM value"	0.000008 to 4 s
<b>Current Protection</b> *Set Current Level *Set Delay Time			"CURR:PROT value" "CURR:PROT:DEL value"	0 to 122.4 A 0 to 60 s

\*Can only be programmed remotely via the GPIB.

**Table 60504-3. Factory Default Settings**

Function	Settings	Function	Setting
CURR level	0 A	Mode (CC, CR, CV)	CC
CURR transient level	0 A	Input (on/off)	on
*CURR slew rate	2 A/μs	Short (on/off)	off
CURR range	120 A	Transient operation (on/off)	off
*CURR protection (on/off)	off	***TRAN mode	continuous
**CURR protection level	122.4 A	(continuous, pulse, toggle)	
**CURR protection delay	15 s	TRAN frequency	1 kHz
RES level	500 Ω	TRAN duty cycle	50%
RES transient level	500 Ω	**TRAN pulse width	0.5 ms
RES range	500 Ω	**TRIG source	hold
VOLT level	60 V	(bus, external, hold, timer, line)	
VOLT transient level	60 V	**TRIG period	0.001 s
VOLT slew rate	5 V/μs	**PORT0 output (on/off)	off (logic 0)
		**CAL mode (on/off)	off

The \*RST command resets the CURR slew rate to 0.83 A/μ, not to the factory default.

\*\*Can only be programmed remotely via the GPIB.  
\*\*\*Continuous transient mode is the only mode available at the front panel. Pulsed, toggled, and continuous modes can all be programmed remotely via the GPIB.

**Table 60504-4. Calibration Information**

<b>Ranges and Calibration Points</b>	<b>Variables</b>	<b>Variables Value</b>	<b>Power Supply Settings</b>	<b>Current Shunt</b>
High Current Range High Current Offset	Hi_curr_rng Hi_curr_offset	120 0.0594	5 V/121 A	300 A
Low Current Range Low Current Offset	Lo_curr_rng Lo_curr_offset	12 0.0497	5 V/15 A	300 A
Voltage Range Voltage Hi point Voltage Lo point	N/A Volt_hipt Volt_lopt	N/A 60 2.7	61 V/10 A	N/A
Low Resistance Range Low Resistance Hi point Low Resistance Lo point	Lo_res_rng Lo_res_hipt Lo_res_lopt	0.5 0.499 0.02	15 V/21.8 A	100 A
Middle Resistance Range Middle Resistance Hi point Middle Resistance Lo point	Mid_res_rng Mid_res_hipt Mid_res_lopt	5 15 0.5	10.9 V/30 A	100 A
High Resistance Range High Resistance Hi point High Resistance Lo point	Hi_res_rng Hi_res_hipt Hi_res_lopt	501 50 6	60 V/12 A	100 A

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