



HEWLETT
PACKARD

OPERATING MANUAL
240 VOLT ELECTRONIC LOAD MODULE
HP MODEL 60503B

HP Part No. 60503-90007

FOR MODULES WITH SERIAL NUMBERS:
3119A-00101 AND ABOVE

JAN

240-Volt Module

About This Manual

This manual provides information for the HP 60503B 250-Watt Electronic Load Module. It is designed as a supplement to the the HP 6050A/6051A Multiple Input Mainframe Electronic Load Operating Manual (part number 06050-90001). Four tables provide the following module-specific information:

Table 60503-1 lists both the specifications and supplemental characteristics of the module. Specifications indicate warranted performance in the $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ region of the total temperature range (0 to 55°C). Supplemental characteristics indicate nonwarranted, typical performance and are intended to provide additional information by describing performance that has been determined by design or type testing.

Table 60503-2 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 60503-3 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 60503-4 provides calibration information for the module. This information is needed to perform the annual calibration procedure described in chapter 6 of the operating manual.

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 HP Electronic Load Family Programming Reference Manual (part number 06060-90005) contains complete programming details that apply to all Electronic Load models.

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.

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 60503-1. Specification and Supplemental Characteristics

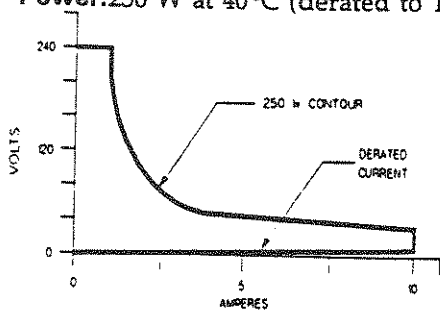
SPECIFICATIONS

DC Input Rating:

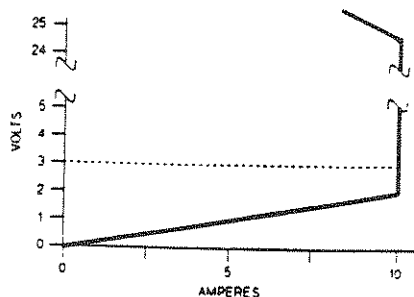
Current: 0 to 10 A

Voltage: 3 V to 240 V (minimum dc operation from 0 to 2 V for 0 to 10 A)

Power: 250 W at 40°C (derated to 187 W at 55°C)



A. OPERATING CHARACTERISTICS



B. DERATED CURRENT DETAIL

Constant Current Mode:

Ranges: 0 to 1 A; and 0 to 10 A

Accuracy: (after 30 second wait): $\pm 0.15\% \pm 10$ mA (both ranges)

Resolution: 0.26 mA (1 A range); 2.6 mA (10 A range)

Regulation: 8 mA (both ranges)

Temperature Coefficient: 150 ppm/°C ± 1 mA/°C (both ranges)

Constant Resistance Mode:

Ranges: 0.20 to 24 Ω ; 24 Ω to 10 k Ω ; and 240 Ω to 50 k Ω

Accuracy: $\pm 0.8\% \pm 200$ m Ω with ≥ 1 A at input (24 Ω range);

$\pm 0.3\% \pm 0.3$ mS with ≥ 24 V at input (10 k and 50 k Ω ranges)

Resolution: 6 m Ω (24 Ω range); 0.011 mS (10 k Ω range); 0.001 mS (50 k Ω range)

Regulation: 10 mV with remote sensing (24 Ω range); 8 mA (10 k and 50 k Ω ranges)

Temperature Coefficient: 800 ppm/°C ± 10 m Ω /°C (24 Ω range);

300ppm/°C ± 0.03 mS/°C (10 k and 50 k Ω ranges)

Constant Voltage Mode:

Range: 0 to 240 V

Accuracy: $\pm 0.12\% \pm 120$ mV

Resolution: 64 mV

Regulation: 10 mV (remote sense); 40 mV (local sense)

Temperature Coefficient: 120 ppm/°C ± 10 mV/°C

Transient Operation:

Continuous Mode

Frequency Range: 0.25 Hz to 10 kHz

Frequency Resolution: 4%

Frequency Accuracy: 3%

Duty Cycle Range: 3% to 97% (0.25 Hz to 1 kHz); 6% to 94% (1 kHz to 10 kHz)

Duty Cycle Resolution: 4%

Duty Cycle Accuracy: 6% of setting $\pm 2\%$

Pulsed Mode

Pulse Width: 50 μ s $\pm 3\%$ minimum; 4 s $\pm 3\%$ maximum

Table 60503-1 Specifications and Supplemental Characteristics (continued)

Transient Current Level (0 to 1 A and 0 to 10 A ranges):

Resolution: 4 mA (1 A range); 43 mA (10 A range)
Accuracy: $\pm 0.18\%$ ± 13 mA (1 A range); $\pm 0.18\%$ ± 50 mA (10 A range)
Temperature Coefficient: 180 ppm/ $^{\circ}$ C ± 1.2 mA/ $^{\circ}$ C

Transient Resistance Level (0.20 to 24 Ω , 24 Ω to 10 k Ω , and 240 Ω to 50 k Ω ranges):

Resolution: 100 m Ω (24 Ω range); 0.18 mS (10 k Ω range); 0.018 mS (50 k Ω range)
Accuracy: $\pm 0.8\%$ $+200$ m Ω with ≥ 1 A at input (24 Ω range)
 $\pm 0.3\%$ $+0.5$ mS with ≥ 24 V at input (10 k Ω range)
 $\pm 0.3\%$ $+0.4$ mS with ≥ 24 V at input (50 k Ω range)

Transient Voltage Level (0 to 240 V):

Resolution: 1.0 V
Accuracy: $\pm 0.15\%$ ± 1.1 V
Temperature Coefficient: 120 ppm/ $^{\circ}$ C ± 10 mV/ $^{\circ}$ C

Current Readback:

Resolution: 2.7 mA (via HP-IB); 10 mA (front panel)
Accuracy (after 30 minute wait): $\pm 0.12\%$ ± 10 mA
Temperature Coefficient: 100 ppm/ $^{\circ}$ C ± 1 mA/ $^{\circ}$ C

Voltage Readback:

Resolution: 67 mV (via HP-IB); 100 mV (front panel)
Accuracy: $\pm 0.1\%$ ± 150 mV
Temperature Coefficient: 100 ppm/ $^{\circ}$ C ± 8 mV/ $^{\circ}$ C
Maximum Readback Capability: 260 V (typical)

Power Readback:

Accuracy: $\pm 0.2\%$ ± 3 W

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

Bandwidth: 10 kHz (3 db frequency)
Accuracy: $\pm 3\%$ ± 10 mA (0 to 1 A range)
 $\pm 3\%$ ± 20 mA (0 to 10 A range)
 $\pm 0.5\%$ ± 150 mV (0 to 240 V range)
Temperature Coefficient: 150 ppm/ $^{\circ}$ C ± 1 mA/ $^{\circ}$ C (current ranges)
120 ppm/ $^{\circ}$ C ± 10 mV/ $^{\circ}$ C (voltage range)

External Current Monitor (0 to 10 V):

Accuracy: $\pm 3\%$ ± 10 mA (referenced to analog common)
Temperature Coefficient: 100 ppm/ $^{\circ}$ C ± 1 mA/ $^{\circ}$ C

External Voltage Monitor (0 to 10 V):

Accuracy: $\pm 0.4\%$ ± 240 mV (referenced to analog common)
Temperature Coefficient: 70 ppm/ $^{\circ}$ C ± 1.2 mV/ $^{\circ}$ C

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

Table 60503-1 Specifications and Supplemental Characteristics (continued)

Maximum Input Levels:

Current: 10.2 A (programmable to lower limits)
Voltage: 250 V

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

PARD (20 Hz to 10 MHz noise):

Current: 1 mA rms/10 mA p-p
Voltage: 6 mV rms

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

Digital Inputs:

Vlo: 0.9 V maximum at Ilo = -1 mA
Vhi: 3.15 V minimum (pull-up resistor on input)

Digital Outputs:

Vlo: 0.72 V maximum at Ilo = 1 mA
Vhi: 4.4 V minimum at Ilo = -20 μ A

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 0.2 A and decreases with input currents over 2 A. The following are typical values; $\pm 25\%$ tolerance):

Current Slew Rate:*

Rate #	10 A Range Step	1 A Range Step	Transition Time
1	0.17 A/ms	17 A/s	8.0 ms
2	0.42 A/ms	42 A/s	3.2 ms
3	0.83 A/ms	83 A/s	1.6 ms
4	1.7 A/ms	0.17 A/ms	800 μ s
5	4.2 A/ms	0.42 A/ms	320 μ s
6	8.3 A/ms	0.83 A/ms	160 μ s
7	17 A/ms	1.7 A/ms	80 μ s
8	42 A/ms	4.2 A/ms	32 μ s
9	83 A/ms	8.3 A/ms	20 μ s
10	0.17 A/ μ s	17 A/ms	20 μ s
11	0.42 A/ μ s	42 A/ms	16 μ s
12	0.83 A/ μ s	83 A/ms	16 μ s

*AC performance specified from 3 to 240 V.

Voltage Slew Rate:

Rate #	Voltage Range Step	Transition Time*
1	4 V/ms	8.0 ms
2	10 V/ms	3.2 ms
3	20 V/ms	1.6 ms
4	40 V/ms	800 μ s
5	100 V/ms	320 μ s
6	200 V/ms	160 μ s
7	0.4 V/ μ s	100 μ s
8	1 V/ μ s	100 μ s
9	2 V/ μ s	100 μ s

*Transition time based on low capacitance current source.

Resistance Slew Rate (24 Ω range): Uses the value programmed for voltage slew rate.

Resistance Slew Rate (10 k and 50 k Ω ranges): Uses the value programmed for current slew rate.

Table 60503-1. Specifications and Supplemental Characteristics (continued)

Transient Current Overshoot (When programmed from 0A):

Range	Transient Current Level	Current Slew Rate	Overshoot*
10 A	2-10 A	All slew rates	0
	0.5 A	0.17 A/ μ s to 0.83 A/ μ s	5%
	0.5 A	0.17 A/ms to 42 A/ms	0
	1 A	0.83 A/ μ s	1%
	1 A	0.17 A/ms to 0.17 A/ μ s	0
1 A	0.5 A	8.3 A/ms	4%
	0.5 A	0.17 A/s and 0.17 A/ms	0
	1 A	All slew rates	0

* All overshoot values assume a total inductance of 1 μ H, or less, in the load leads connected to the D.U.T.

Source Turn-On Current Overshoot: Less than 5% of final value (in CC and CR modes when connected to power supplies with voltage rise times of greater than 500 μ s).

Programmable Short Circuit: 0.20 Ω (0.10 Ω typical)

Programmable Open Circuit: 80 k Ω (typical)

Drift Stability (over an 8 hour interval):

Current: $\pm 0.03\%$ ± 1.5 mA

Voltage: $\pm 0.01\%$ ± 20 mV

Reverse Current Capacity: 20 A when unit is on; 10 A when unit is off

Weight: 3.2 kg (7 lbs.)

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Table 60503-2. Programming Ranges

Function	Front Panel Key	Front Panel Display	HP-SL Command (Short Form)	Range of Values
Constant Current Set Range Low Range High Range Set Main Level Low Range High Range Set Slew Rate Low Range High Range Set Transient Level *Set Triggered Level	Range CURR (shift) Slew Tran Level	C:RNG value CURR value C:SLW value C:TLV value	"CURR:RANG value" "CURR value" "CURR:SLEW value" "CURR:TLEV value" "CURR:TRIG value"	≥ 0 and ≤ 1 A > 1 A and ≤ 10 A 0 to 1 A 0 to 10 A 0.000007 to .083 (A/ μ s) 0.00017 to 0.83 (A/ μ s) same as main level same as main level
Constant Resistance Set Range Low Range Middle Range High Range Set Main Level Low Range Middle Range High Range Set Slew Rate Low Range Middle/High Range Set Transient Level *Set Triggered Level	Range RES (shift) Slew Tran Level	R:RNG value RES value V:SLW value C:SLW value R:TLV value	"RES:RANG value" "RES value" "VOLT:SLEW value" "CURR:SLEW value" "RES:TLEV value" "RES:TRIG value"	≥ 0 and ≤ 24 Ω > 24 Ω and ≤ 24 k Ω > 24 k Ω and ≤ 24 k Ω 0 to 24 Ω 24 Ω to 24 k Ω 240 Ω to 240 k Ω same as voltage slew same as current slew same as main level same as main level
Constant Voltage Set Main Level Set Slew Rate Set Transient Level *Set Triggered Level	VOLT (shift) Slew Tran Level	VOLT value V:SLW value V:TLV value	"VOLT value" "VOLT:SLEW value" "VOLT:TLEV value" "VOLT:TRIG value"	0 to 240 V 0.004 to 2 (V/ μ s) same as main level same as main level
Transient Operation Set Frequency Set Duty Cycle *Set Pulse Width	Freq (shift) Dcycle	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
Trigger Operation *Set Trigger Period			"TRIG:TIM value"	0.000008 to 4 s
Current Protection *Set Current Level *Set Delay Time			"CURR:PROT value" "CURR:PROT:DEL value"	0 to 10.2 A 0 to 60 s

*Can only be programmed remotely via the HP-IB.

Table 60503-3. 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	0.17 A/ μ s	Short (on/off)	off
CURR range	10 A	Transient operation (on/off)	off
*CURR protection (on/off)	off	***TRAN mode	continuous
**CURR protection level	10.2 A	(continuous, pulse, toggle)	
**CURR protection delay	15 s	TRAN frequency	1 kHz
RES level	50 k Ω	TRAN duty cycle	50%
RES transient level	50 k Ω	**TRAN pulse width	0.5 ms
RES range	50 k Ω	**TRIG source	hold
VOLT level	240 V	(bus, external, hold, timer, line)	
VOLT transient level	240 V	**TRIG period	0.001 s
VOLT slew rate	2 V/ μ s	**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 s, not to the factory default.

** Can only be programmed remotely via the HP-IB.

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

Table 60503-4. Calibration Information

Ranges and Calibration Points	Variables	Variables Values	Power Supply Settings	Current Shunt
High Current Range	Hi_curr_rng	10	25 V/10.5 A	15 A
High Current Offset	Hi_curr_offset	0.0048		
Low Current Range	Lo_curr_rng	1	25 V/2 A	15 A
Low Current Offset	Lo_curr_offset	0.0032		
Voltage Range	N/A	N/A	246 V/0.6 A	N/A
Voltage Hi point	Volt_hipt	240		
Voltage Lo point	Volt_lopt	2		
Low Resistance Range	Lo_res_rng	24	60 V/1.82 A	15 A
Low Resistance Hi point	Lo_res_hipt	23.9		
Low Resistance Lo point	Lo_res_lopt	0.88		
Middle Resistance Range	Mid_res_rng	240	43.6 V/4 A	15 A
Middle Resistance Hi point	Mid_res_hipt	500		
Middle Resistance Lo point	Mid_res_lopt	24		
High Resistance Range	Hi_res_rng	24020	240 V/2 A	15 A
High Resistance Hi point	Hi_res_hipt	2000		
High Resistance Lo point	Hi_res_lopt	240		

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