

# Models 2380-500-30 Programmable DC Electronic Load Instruments

## Performance Verification Manual

2380-500-30-905-01 Rev. A / November 2015



2380-500-30-905-01A

A Greater Measure of Confidence



# **Model 2380-500-30 Programmable DC Electronic Load Instruments Performance Verification Manual**

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Cleveland, Ohio, U.S.A.

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The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

**Responsible body** is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

**Operators** use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

**Maintenance personnel** perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

**Service personnel** are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley Instruments products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety ground) connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a  screw is present, connect it to protective earth (safety ground) using the wire recommended in the user documentation.

The  symbol on an instrument means caution, risk of danger. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means caution, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits — including the power transformer, test leads, and input jacks — must be purchased from Keithley Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of January 2013.

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## Introduction

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## Welcome

Thank you for choosing a Keithley Instruments product. The Model 2380-500-30 / 2380J-500-30 is a programmable high-precision load instrument that supports constant current (CC), constant voltage (CV), constant resistance (CR), constant power (CP), and transient operating modes. Its working power is 750 W. The resolution of its voltage and current are 0.1 mV and 0.01 mA. Its adjustable current rise and fall times range from 0.0001 A/ $\mu$ s to 2.5 A/ $\mu$ s. Its measurement speed of voltage and current reaches up to 50 KHz. The load can be controlled externally from 0 through 10 V using analog interfaces. It is equipped with built-in ports: RS232, USB, and GPIB. The load also provides a special LED mode to conduct LED electronic load tests by simulating an LED current load.

## Extended warranty

Additional years of warranty coverage are available on many products. These valuable contracts protect you from unbudgeted service expenses and provide additional years of protection at a fraction of the price of a repair. Extended warranties are available on new and existing products. Contact your local Keithley Instruments office, sales partner, or distributor for details.

## Contact information

If you have any questions after you review the information in this documentation, please contact your local Keithley Instruments office, sales partner, or distributor, or call Keithley Instruments corporate headquarters (toll-free inside the U.S. and Canada only) at 1-888-KEITHLEY (1-888-534-8453), or from outside the U.S. at +1-440-248-0400. For worldwide contact numbers, visit the [Keithley Instruments website](http://www.keithley.com) (<http://www.keithley.com>).

## Specifications

This section contains specifications for the Series 2380 and Series 2380J Programmable DC electronic load. All specifications are guaranteed unless noted as "typical." Typical specifications are provided for your convenience but are not guaranteed. Specifications that are marked with the symbol  $\checkmark$  are checked in performance verification.

### Model 2380-500-30 / 2380J-500-30 specifications

Parameter	Description
Constant Voltage Operation, nominal	This value can be set as a constant voltage
Voltage Range	Low range: 0~50 V, High range: 0~500 V
Voltage Resolution, nominal	1~10 mV.
$\checkmark$ Voltage Setting Accuracy	0.05% FS $\pm$ 0.025% at 25 °C $\pm$ 5 °C
Constant Current Operation, nominal	This value can be set as a constant current
Current Range	Low range: 0~3 A, High range: 0~30 A
Current Resolution, nominal	0.1~1 mA
$\checkmark$ Current Setting Accuracy	+0.05% FS $\pm$ 0.05% at 25 °C $\pm$ 5 °C
T1&T2	20 $\mu$ S~3600 S /Res:1 $\mu$ S
Accuracy of transient mode	5 $\mu$ S $\pm$ 100 ppm
rise/fall slope	Low range: 0.0001~0.1 A/ $\mu$ S, High range: 0.001~1 A/ $\mu$ S
Minimum rising time	$\approx$ 10 $\mu$ S
Constant Resistance Operation, nominal	This value can be set as a constant resistance
Resistance Range	Low range :0.15~10 $\Omega$ , High range: 10 $\Omega$ ~7.5 K $\Omega$
Resistance Resolution, nominal	16 bit.
Resistance Setting Accuracy	Under the temperature of 25 °C $\pm$ 5 °C, the accuracy for low range is 0.01% + 0.08 S, the accuracy for high range is 0.01% + 0.0008 S
Constant Power Operation, nominal	This value can be set as a constant power
Power Range	750 W
Power Resolution, nominal	10 mW
Power Setting Accuracy	0.2% FS $\pm$ 0.2% at 25 °C $\pm$ 5 °C
Meter, nominal	Internal readback capability: voltage, current and power are measured internally
Voltage Readback Range	Low range: 0~50 V, High range: 0~500 V
Voltage Readback Resolution, nominal	1~10 mV
$\checkmark$ Voltage Readback Accuracy	0.025% FS $\pm$ 0.025% at 25 °C $\pm$ 5 °C
Current Readback Range	Low range: 0~3 A, High range: 0~30 A
Current Readback Resolution, nominal	0.1~1 mA
$\checkmark$ Current Readback Accuracy	0.05% FS $\pm$ 0.05% at 25 °C $\pm$ 5 °C
Power Readback Range	750 W
Power Readback Resolution, nominal	10 mW
Power Readback Accuracy	0.2% FS $\pm$ 0.2% at 25 °C $\pm$ 5 °C

**Model 2380-500-30 / 2380J-500-30 characteristics**

Characteristic	Description			
Instrument Characteristics, nominal	Characteristics and specifications of features unique to this product			
Instrument-Specific Mains Requirements	<b>2380-500-30</b>			
	Line Selection (Switch)	Voltage	Frequency	Fuse Rating
	115 V	115 V $\pm$ 10%	50/60 Hz	1.25 AT
	230 V	230 V $\pm$ 10%	50/60 Hz	0.5 AT
Instrument-Specific Mains Requirements	<b>2380J-500-30</b>			
	Line Selection (Switch)	Voltage	Frequency	Fuse Rating
	100 V	100 V $\pm$ 10%	50/60 Hz	1.25 AT
	220 V	220 V $\pm$ 10%	50/60 Hz	0.5 AT

**Common characteristics**

Item	Description
Setup Memory, nominal	100 points
Input Timer, nominal	You can set a timer to disable the input after a certain period of time
Timer Set Time, nominal	The timer may be set to any value between 1 and 999,999 seconds
Timer Accuracy	$\pm$ 100 ppm
Cleaning Requirements, nominal	To clean the exterior surface, perform the following steps: 1. Remove loose dust on the outside of the electronic load with a lint-free cloth, and avoid scratching the display 2. Use a soft cloth dampened with water to clean the electronic load, it is recommended to use a solution of 75% isopropyl alcohol for more efficient cleaning Caution: To avoid damage to the surface of the electronic load, do not use any abrasive chemical cleaning agents. Caution: Avoid dampening the inside of the instrument with just enough cleaning solution to moisturize the cloth or swab.

**Common characteristics**

Item	Description
Isolation Voltage, Output to Chassis	Any output can be isolated up to 240 V (DC + peak AC with AC at maximum of 3 V pk-pk and a maximum of 60 Hz) relative to the earth ground terminal.

**Environment performance**

Parameter	2380J-500-30 / 2380-500-30
Temperature	Operating: 0 °C to 40 °C Non-operating: -20 °C to 70 °C
Humidity	Operating: 5% to 95% relative humidity at up to 40 °C, noncondensing Non-operating: 5% to 95% relative humidity at up to 40 °C, 5% to 60% relative humidity above 40 °C up to 70 °C, noncondensing
Altitude	Operating: 100% capability up to 2,000 meters above sea level Nonoperating: Up to 4,000 meters

**Safety characteristics**

<b>Item</b>	<b>2380-500-30 / 2380J-500-30</b>
Safety Certifications	U.S. Nationally Recognized Testing Laboratory (NRTL) Listing UL61010-1-2004 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
	Canadian Certification CAN/CSA C22.2 No. 61010-1-2004 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
	European Union Compliance Low voltage Directive 2006/95/EC EN61010-1 2001 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
	Additional Compliance EC61010-1 2001 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.

**Electromagnetic Compatibility (EMC) — measurement, laboratory, and control product family**

<b>Item</b>	<b>2380-500-30 / 2380J-500-30</b>
Regional Certifications, Classifications, and Standards List	
European Union	EC Council EMC Directive 2004/108/EC Demonstrated using: EN 61326-1:2006 Electrical Equipment for Measurement, Control, and Laboratory 1, 2 Emissions CISPR 11, Class A Immunity IEC 61000-4-2 IEC 61000-4-3 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6 IEC 61000-4-8 IEC 61000-4-11 EN 61000-3-2 EN 61000-3-3 1 1. Emissions that exceed the levels defined by this standard may occur when this equipment is connected to a test object. 2. Use high-quality shielded cables to maintain compliance
Australia	EMC Framework, demonstrated per Emission Standard CISPR11 in accordance with EN61326-1
Immunity	
Immunity, Electrostatic Discharge (ESD), Enclosure Port	IEC 61000-4-2 EN 61326-1, Performance Criterion "B"
Immunity, Conducted Radio Frequency	IEC 61000-4-6 EN 61326-1, Performance Criterion "A"

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## Performance Verification

### In this section:

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## Introduction

This section contains performance verification procedures for the specifications. Additional test equipment is required to complete the verification procedures.

You can print out the [Test record](#) and use it to record the performance test results for your instrument.

### NOTE

Completion of the performance verification procedure does not affect the stored time and date of the latest successful adjustment. The date and time are updated only when the factory adjustment procedures are successfully completed.

The performance verification procedures verify the performance of your instrument. They do not adjust your instrument. If your instrument fails any of the performance verification tests, you should contact your local Keithley service agency.

### WARNING

*Observe all safety precautions listed in this manual before using this product and any associated instrumentation. Although some instruments and accessories are used with nonhazardous voltages, there are situations where hazardous conditions may occur. This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Before using the product, carefully read and follow all installation, operation, and maintenance information. Refer to this manual for complete product specifications. Before performing any maintenance, disconnect the line cord and all test cables. Operators of this instrument must be protected from electric shock at all times. The responsible personnel must make sure that operators are prevented access to and/or insulated from every connection point. In some cases of connections must be exposed to potential human contact, operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit operates at or above 1000 volts, no conductive part of the circuit may be exposed.*

**⚠ CAUTION**

Use properly rated load wires. All load wires must be heavy enough not to overheat when carrying the maximum short-circuit output current of the electronic load. If there is more than one load, then any pair of load wires must be capable of safely carrying the full-rated short-circuit output current of the electronic load.

**⚠ WARNING**

*Do not loosen any screw on this product. There are no user serviceable components inside.*

## Test record

Model	Serial number	Procedure performed by	Date
<hr/>			
<b>Test</b>		<b>Passed</b>	<b>Failed</b>
<hr/>			
Self-test			
<hr/>			
DC voltage accuracy			
<hr/>			
DC voltage readback accuracy			
<hr/>			
DC current accuracy			
<hr/>			
DC current readback accuracy			
<hr/>			
Voltage noise at 7 MHz			
<hr/>			
<b>Test</b>		<b>Passed</b>	<b>Failed</b>
<hr/>			
Voltage noise at 20 MHz			
<hr/>			
Current noise at 20 MHz			
<hr/>			

Test description	Expected value	Measured value	Low limit	High limit	Unit	Test result
<b><u>Set accuracy current (3 A range)</u></b>						
Low current (0 A)	0.0000	0.0000	-0.0015	0.0015	A	Pass
Low current (0.75 A)	0.7500	0.7499	0.7481	0.7519	A	Pass
Low current (1.5 A)	1.5000	1.4999	1.4978	1.5023	A	Pass
Low current (2.25 A)	2.2500	2.2499	2.2474	2.2526	A	Pass
Low current (3 A)	3.0000	2.9999	2.9970	3.0030	A	Pass
<b><u>Readback accuracy current (3 A range)</u></b>						
Low current (0 A)	0.00000	0.00000	-0.00149	0.00151	A	Pass
Low current (0.75 A)	0.75000	0.74992	0.74804	0.75179	A	Pass
Low current (1.5 A)	1.50000	1.49994	1.49766	1.50216	A	Pass
Low current (2.25 A)	2.25000	2.24988	2.24723	2.25248	A	Pass
Low current (3 A)	3.00000	2.99994	2.99693	3.00293	A	Pass
<b><u>Set accuracy current (30 A range)</u></b>						
High current (0 A)	0.000	0.0000	-0.0150	0.0150	A	Pass
High current (7.5 A)	7.500	7.4996	7.4813	7.5188	A	Pass
High current (15 A)	15.000	14.9989	14.9775	15.0225	A	Pass
High current (22.5 A)	22.500	22.4986	22.4738	22.5263	A	Pass
High current (30 A)	30.000	29.9983	29.9700	30.0300	A	Pass
<b><u>Readback accuracy current (30 A range)</u></b>						
High current (0 A)	0.000	0.0000	-0.0150	0.0150	A	Pass
High current (7.5 A)	7.500	7.4997	7.4808	7.5183	A	Pass
High current (15 A)	15.000	14.9991	14.9764	15.0214	A	Pass

<b>Test description</b>	<b>Expected value</b>	<b>Measured value</b>	<b>Low limit</b>	<b>High limit</b>	<b>Unit</b>	<b>Test result</b>
High current (22.5 A)	22.500	22.4995	22.4724	22.5249	A	Pass
High current (30 A)	30.000	29.9999	29.9683	30.0283	A	Pass
<b><u>Set sense accuracy voltage (50 V range)</u></b>						
Low voltage (0.1 V)	0.100	0.099	0.075	0.125	V	Pass
Low voltage (12.5 V)	12.500	12.499	12.472	12.528	V	Pass
Low voltage (25 V)	25.000	24.999	24.969	25.031	V	Pass
Low voltage (37.5 V)	37.500	37.498	37.466	37.534	V	Pass
Low voltage (50 V)	50.000	49.999	49.963	50.038	V	Pass
<b><u>Readback sense accuracy voltage (50 V range)</u></b>						
Low voltage (0.1 V)	0.100	0.099	0.087	0.112	V	Pass
Low voltage (12.5 V)	12.500	12.499	12.484	12.515	V	Pass
Low voltage (25 V)	25.000	24.998	24.980	25.017	V	Pass
Low voltage (37.5 V)	37.500	37.498	37.476	37.520	V	Pass
Low voltage (50 V)	50.000	49.999	49.974	50.024	V	Pass
<b><u>Set sense accuracy voltage (500 V range)</u></b>						
High voltage (0.1 V)	0.10	0.09	-0.15	0.35	V	Pass
High voltage (125 V)	125.00	125.00	124.72	125.28	V	Pass
High voltage (250 V)	250.00	249.99	249.69	250.31	V	Pass
High voltage (375 V)	375.00	374.99	374.66	375.34	V	Pass
High voltage (500V)	500.00	500.01	499.63	500.38	V	Pass

Test description	Expected value	Measured value	Low limit	High limit	Unit	Test result
<b><u>Readback sense accuracy voltage (500 V range)</u></b>						
High voltage (0.1 V)	0.10	0.09	-0.03	0.22	V	Pass
High voltage (125 V)	125.00	124.99	124.84	125.15	V	Pass
High voltage (250 V)	250.00	249.98	249.80	250.18	V	Pass
High voltage (375 V)	375.00	374.99	374.77	375.20	V	Pass
High voltage (500V)	500.00	500.01	499.76	500.26	V	Pass
High voltage (500 V)	500.00	500.01	499.76	500.26	V	Pass
<b><u>Set local accuracy voltage (50 V range)</u></b>						
Low voltage (0.1 V)	0.100	0.100	0.075	0.125	V	Pass
Low voltage (12.5 V)	12.500	12.500	12.472	12.528	V	Pass
Low voltage (25 V)	25.000	24.999	24.969	25.031	V	Pass
Low voltage (37.5 V)	37.500	37.499	37.466	37.534	V	Pass
Low voltage (50 V)	50.000	50.000	49.963	50.038	V	Pass
<b><u>Readback local accuracy voltage (50 V range)</u></b>						
Low voltage (0.1 V)	0.100	0.099	0.087	0.112	V	Pass
Low voltage (12.5 V)	12.500	12.499	12.484	12.515	V	Pass
Low voltage (25 V)	25.000	24.999	24.980	25.018	V	Pass
Low voltage (37.5 V)	37.500	37.498	37.477	37.521	V	Pass
Low voltage (50 V)	50.000	49.999	49.975	50.025	V	Pass

Test description	Expected value	Measured value	Low limit	High limit	Unit	Test result
<b><u>Set local accuracy voltage (500 V range)</u></b>						
High voltage (0.1 V)	0.10	0.09	-0.15	0.35	V	Pass
High voltage (125 V)	125.00	125.00	124.72	125.28	V	Pass
High voltage (250 V)	250.00	249.99	249.69	250.31	V	Pass
High voltage (375 V)	375.00	374.99	374.66	375.34	V	Pass
High voltage (500 V)	500.00	500.01	499.63	500.38	V	Pass
<b><u>Readback local accuracy voltage (500 V range)</u></b>						
High voltage (0.1 V)	0.10	0.09	-0.03	0.22	V	Pass
High voltage (125 V)	125.00	124.99	124.84	125.15	V	Pass
High voltage (250 V)	250.00	249.99	249.80	250.18	V	Pass
High voltage (375 V)	375.00	374.99	374.77	375.21	V	Pass
High voltage (500 V)	500.00	500.01	499.76	500.26	V	Pass
High voltage (500 V)	500.00	500.01	499.76	500.26	V	Pass
<b><u>Set accuracy power (750 W range)</u></b>						
Power (0 W)	0.00	0.00	-1.50	1.50	W	Pass
Power (187.5 W)	187.50	187.42	185.63	189.38	W	Pass
Power (375 W)	375.00	374.77	372.75	377.25	W	Pass
Power (562.5 W)	562.50	562.34	559.88	565.13	W	Pass
Power (750 W)	750.00	749.55	747.00	753.00	W	Pass

Test description	Expected value	Measured value	Low limit	High limit	Unit	Test result
<b><u>Readback accuracy power (750 W range)</u></b>						
Power (0 W)	0.00	0.00	-1.50	1.50	W	Pass
Power (187.5 W)	187.50	187.44	185.55	189.30	W	Pass
Power (375 W)	375.00	374.79	372.52	377.02	W	Pass
Power (562.5 W)	562.50	562.36	559.71	564.96	W	Pass
Power (750 W)	750.00	749.57	746.55	752.54	W	Pass
<b><u>Set accuracy resistance (10 <math>\Omega</math> range)</u></b>						
Low resistance (0.15 $\Omega$ )	0.150	0.150	0.148	0.152	$\Omega$	Pass
Low resistance (2.5 $\Omega$ )	2.500	2.500	2.083	3.125	$\Omega$	Pass
Low resistance (5 $\Omega$ )	5.000	5.001	3.571	8.335	$\Omega$	Pass
Low resistance (7.5 $\Omega$ )	7.500	7.501	4.687	18.755	$\Omega$	Pass
Low resistance (10 $\Omega$ )	10.000	10.003	5.555	50.025	$\Omega$	Pass
<b><u>Set accuracy resistance (7500 <math>\Omega</math> range)</u></b>						
High resistance (10 $\Omega$ )	10.000	10.003	9.920	10.082	$\Omega$	Pass
High resistance (100 $\Omega$ )	100.00	100.10	92.58	108.71	$\Omega$	Pass
High resistance (1000 $\Omega$ )	1000.0	1008.0	555.5	5002.5	$\Omega$	Pass
High resistance (3000 $\Omega$ )	3000.0	3120.4	882.3	-----	$\Omega$	Pass
High resistance (7500 $\Omega$ )	7500.0	8146.8	1071.4	-----	$\Omega$	Pass

## Performance verification procedures

The following conditions must be met before performing the procedures:

1. The device under test (DUT) and all test equipment must have been operating continuously for 20 minutes in an environment that meets the operating range specifications for temperature and humidity. Test setup changes affecting the remote sense require an additional 20-minute warm-up period.
2. The procedures are intended to be applied in sequence. If it is necessary to partially test the DUT applying an individual test, a 20-minute warm-up period is required for the individual test.
3. You must connect the DUT and the test equipment to the same AC power circuit. Connect the DUT and test instruments into a common power strip if you are unsure of the AC power circuit distribution. Connecting the DUT and test instruments into separate AC power circuits can result in offset voltages between the equipment, which can invalidate this performance verification procedure.

The AC power source for the DUT must match the voltage selector switch setting located on the bottom of the DUT, as shown in the following the table:

<b>AC source voltage</b>	115 V	230 V
<b>DUT voltage selector</b>	110/115	220/230

## Equipment required

These procedures use external equipment to directly check warranted characteristics. The following table lists the required equipment.

**Table 1: Test equipment**

Number	Item	Minimum requirements	Example
1	Connectors	Connectors for connecting wire assemblies and test resistors, item numbers 5, 6, 9, 10, and 11. <ul style="list-style-type: none"> <li>#10 fork lugs similar to Tyco part number 52951 (Qty. 6)</li> <li>Stackable, gold-plated banana plugs/jacks similar to Pomona model 4897-0, which are used for lower current connections, connections to the load resistors (items 10 and 11), and used for noise testing (Qty.14)</li> <li>Sheathed banana jacks similar to Pomona model 4834 to mount connectors on the resistors (Qty. 4)</li> </ul>	
2	DC power source	The DC source output voltage must be greater than electronic load's rated voltage.	Keithley 2260B-80-40
3	Digital Multimeter	With voltage measuring range from 100 nV to 1 KV and DC resistance measuring range from 100 $\mu\Omega$ to 100 M $\Omega$ . For multi-points measurement application, user can measure input signals up to 20 channels sequentially with the help of an optional switching board	Keithley Model 2000 DMM
4	High-current hookup wire (high-current connections are indicated with bold lines in the setup illustrations)	18 AWG (minimum) hookup wire assemblies To perform all tests, the following wire assemblies are required to be installed: <ul style="list-style-type: none"> <li>#10 fork lug to #10 fork lug (Qty. 2)</li> <li>Stackable banana to #10 fork lug (Qty. 2)</li> <li>Stackable banana to bare wire (Qty. 2)</li> </ul> Wire lengths are optional.	
5	Low-current hookup wire (low-current connections are indicated with light lines in the setup illustrations)	22 AWG (minimum) hookup wires. To perform all tests, the following wire assemblies are required to be installed: <ul style="list-style-type: none"> <li>Banana plug to Banana plug (Qty. 2)</li> <li>Bare Wire to stackable Banana (Qty. 2)</li> <li>Bare Wire to Banana (Qty. 2)</li> </ul> Wire lengths are optional.	

6	DC Current precision shunt resistor	The selected shunt must be able to withstand the maximum current of electronic load.	RUG-Z-R001-0.1-TK1, UNR4-3425 OR1BTCRT
7	Current sense resistor cabling	Kelvin 4 terminal measuring cables for shunt resistor to voltmeter.	Guildline 92301 cable set
8	Oscilloscope	20 MHz bandwidth-limited oscilloscope at 1 mV/division	Tektronix MDO3014
9	Oscilloscope probe	Low capacitance 1 M $\Omega$ /10 M $\Omega$ 1X/10X 6 MHz/200 MHz probe	Tektronix P2220, 1X probe
10	Oscilloscope probe	Low capacitance 10 M $\Omega$ 500 MHz probe	Tektronix P6139A, 10X

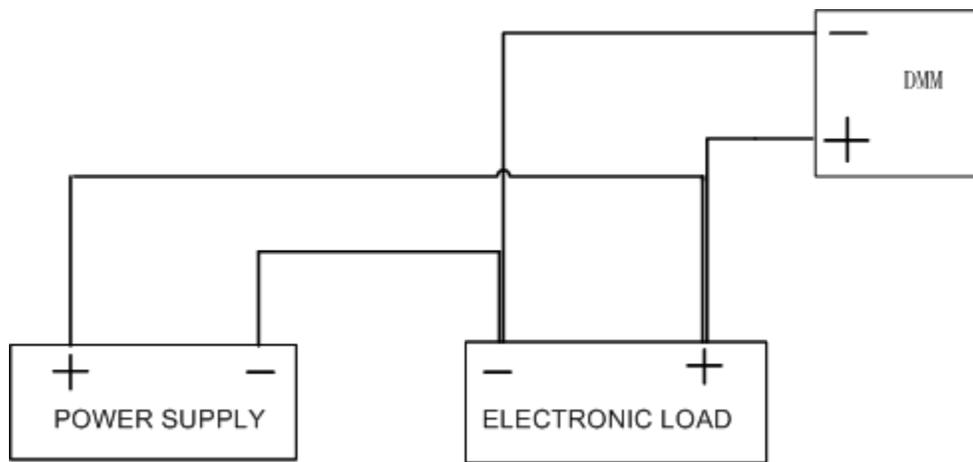
## Check DC voltage setting accuracy and voltage readback accuracy

You can use the text below to verify whether the electronic load’s setting accuracy and readback accuracy in CV mode are within the specification.

Equipment required	
DC source	The DC source output voltage must be greater than electronic load’s rated voltage
Digital voltage meter	Keithley Model 2000
High-current cable (thick cable)	22 AWG hookup wires
Low-current cable (thin cable)	18 AWG hookup wires

1. Set up the equipment, as shown in the following figure.

**Figure 1: Voltage accuracy test setup**



**NOTE**

Ensure the warm-up requirement has been met, as described in the [Performance Verification Procedures](#).

To ensure accurate measurements, the voltmeter must be connected to the DUT, as close as possible to the DUT. It is recommended to use fork lugs between the electronic load and the DUT and banana plugs between the DUT and voltmeter.

Another solution is to use fork lugs for both connections with the DUT.

1. Set the DVM to DC voltage measuring mode and auto range mode.
2. Set the electronic load as follows:
  - Mode: CV
  - Range: CVL for low range, CVH for high range
  - Voltage: 0.1 V for low range, 1 V for high range
3. Set the DC source as follows:

- Current: 1 A
  - Voltage: greater than electronic load’s voltage
4. Vary the voltage of the electronic load from the minimum to maximum of its range. Turn on the output for DC source first and then turn on the input of the electronic load.
  5. Record the reading values when the DVM measurement data is stable.
    - Record the electronic load’s measured voltage value on VFD (display value).
    - Record the DVM reading value.
    - Record the electronic load’s setting voltage.
  6. Vary the voltage of the electronic load by sampling the low, median, and high points of its range, then repeat step 6.
  7. Turn off the DC source and the electronic load. Then switch the electronic load to high voltage range (CVH).
  8. Set the DC source and electronic load according to steps 3 and 4, then repeat steps from 5 through 8.
  9. Power off all the equipment after the test.
  10. Calculate the deviation and determine whether it is within the specification.
    - Voltage setting accuracy: the measured value by DVM versus voltage setting value.
    - Voltage read-back accuracy: the measured value by DVM versus the displayed value on VFD.

### Check DC current and DC current readback accuracy

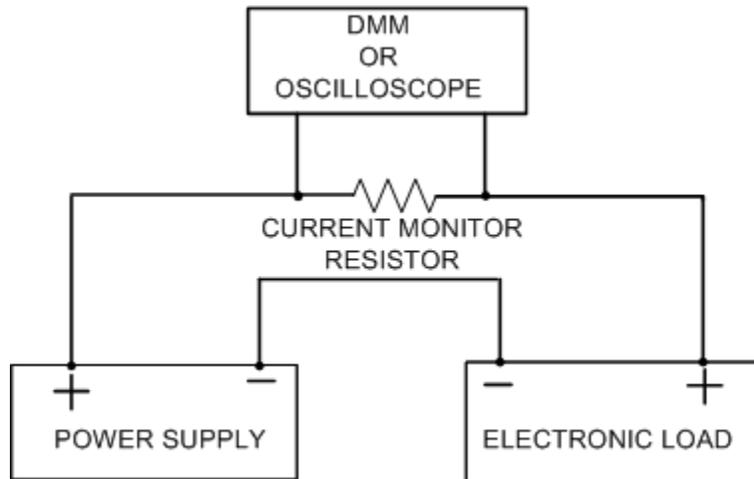
You can use the text below to verify whether the electronic load’s setting accuracy and readback accuracy in CC mode are within the specification.

Equipment required	
DC source	The DC source output current must be greater than electronic load’s rated current.
Digital voltage meter	Keithley Model 2000
High precision shunt	The selected shunt must be able to withstand the maximum current of electronic load.
Cable for high current (thick-cable)	22 AWG hookup wires
Cable for low current (thin-cable)	18 AWG hookup wires

1. Set up the equipment, as shown in the following figure.

## NOTE

Ensure the warm-up requirement has been met, as described in the [Performance Verification Procedures](#).

**Figure 2: DC current accuracy test setup**

2. Set the DVM to DC voltage measuring mode and auto range mode.
3. Set the electronic load as follows:
  - Mode: CC
  - Range: CCL for low range, CCH for high range
  - Current: 0.1 A for low range, 1 A for high range
4. Set the DC source as follows:
  - Current: greater than electronic load's rated current value
  - Voltage: less than 10% of electronic load's rated voltage
5. Vary the current of the electronic load from the minimum to maximum of its range. Turn on the output for DC source first and then turn on the input of the electronic load.
6. Record the reading values when the DVM measurement data is stable.
  - Record the electronic load's measured current value on VFD (displayed value).
  - Record the DVM reading value, for example the shunt voltage.
  - Record the electronic load's current setting.
7. Vary the current of the electronic load by sampling the low, median, and high points of its range, then repeat step 6.
8. Turn off the DC source and electronic load, then switch the electronic load to high current range (CCH).
9. Set the DC source and electronic load according to steps 3 and 4, then repeat steps from 5 through 8.
10. Power off all the equipment after the test.
11. Calculate the deviation and determine whether it is within the specification.
  - The measured actual current:  $\text{DVM reading voltage} / \text{shunt resistance}$
  - Current setting accuracy: the measured actual current versus current setting value
  - Current read-back accuracy: The measured actual current versus the display current value on VFD

## Check DC power and DC power readback accuracy

You can use the text below to verify whether the electronic load’s setting accuracy and readback accuracy in CW mode are within the specification.

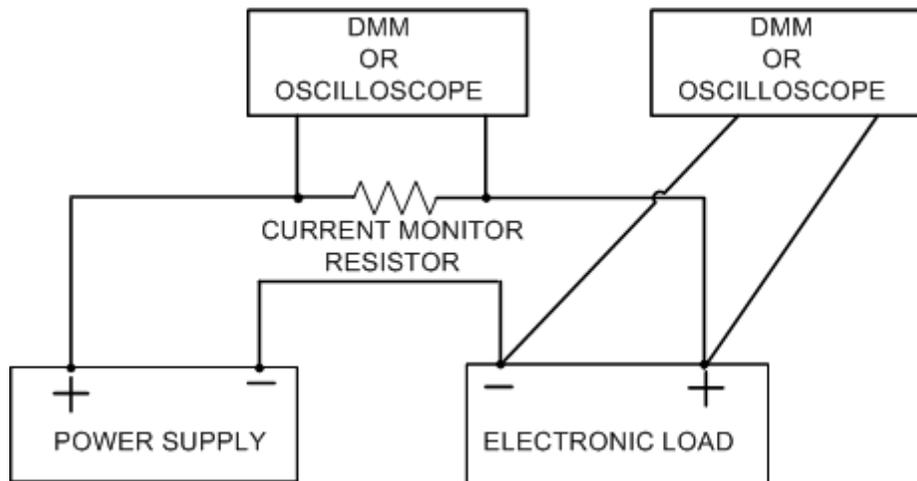
Equipment required	
DC source	The DC source output current must be greater than the electronic load’s rating current.
Digital voltage meter	Keithley Model 2000
High precision shunt	The selected shunt must be able to withstand the maximum current of electronic load.
Cable for high current (thick-cable)	22 AWG hookup wires
Cable for low current (thin-cable)	18 AWG hookup wires

1. Set up the equipment, as shown in the following figure.

**NOTE**

Ensure the warm-up requirement has been met, as described in the beginning of [Performance Verification Procedures](#).

**Figure 3: DC power accuracy test setup**



2. Set the DVM to DC voltage measuring mode and auto range mode.
3. Set the electronic load as follows:
  - Mode: CW
  - Range: refer to actual model’s datasheet
  - Power: 10 W (refer to actual model’s datasheet)
4. Set the DC source as follows:

- Current setup: 1 A greater than electronic load's rated current value
  - Voltage setup: the electronic load's rated power / the electronic load's rated current
5. Vary the power of the electronic load from the minimum to maximum of its range. Turn on the output for DC source first and then turn on the input of the electronic load.
  6. Record the reading values when the DVM measurement data is stable.
    - Record the electronic load's measured power value on VFD (displayed value).
    - Record the reading value of DVM (#1), for example the shunt voltage.
    - Record the reading value of DVM (#2), for example the measured actual voltage of the electronic load.
    - Record the electronic load's power setting.
  7. Vary the electronic load's power by increasing 5% of the rated power, then repeat step 6.
  8. Power off all the equipment after the test.
  9. Calculate the deviation and determine whether it is within the specification.
    - The measured actual current: reading voltage /shunt resistance
    - The measured actual power: reading voltage the measured actual current value
    - Power setting accuracy: the measured actual power versus power setting value
    - Power read-back accuracy: the measured actual power versus the displayed power value on VFD

## Check resistance accuracy

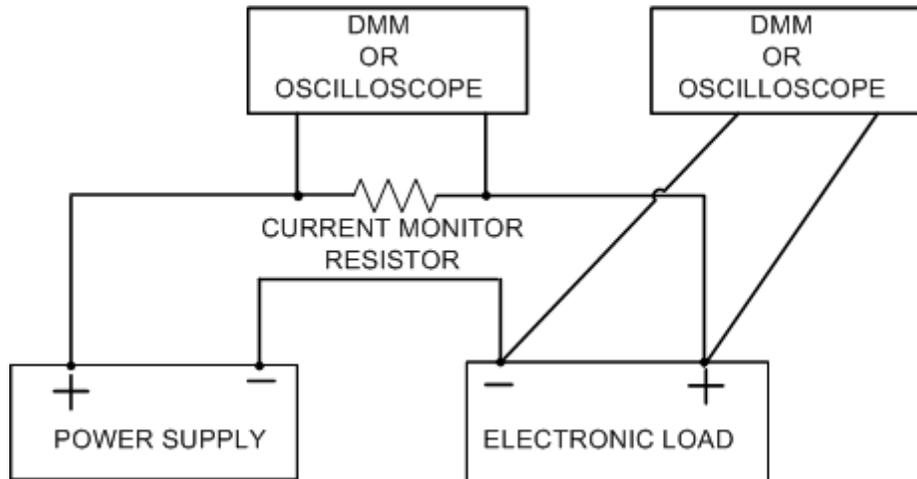
You can use the text below to verify whether the electronic load's setting accuracy and readback accuracy in CR mode are within the specification.

Equipment required	
DC source	The DC source output current must be greater than the electronic load's rating current.
Digital voltage meter	Keithley Model 2000
High precision shunt	The selected shunt must be able to withstand the maximum current of electronic load.
Cable for high current (thick-cable)	22 AWG hookup wires
Cable for low current (thin-cable)	18 AWG hookup wires

1. Set up the equipment, as shown in the following figure.

### NOTE

Ensure the warm-up requirement has been met, as described in the [Performance Verification Procedures](#).

**Figure 4: Resistance accuracy test setup**

2. Set the DVM to DC voltage measuring mode and auto range mode.
3. Set the electronic load as follows:
  - Mode: CR
  - Range: CRL for low range, CRH for high range (refer to an actual model's datasheet)
  - Resistance: 0.1 for low range, 1 for high range (refer to actual model's datasheet)
4. Set the DC source as follows:
  - Current setup: 10% greater than the electronic load's working current range
  - Voltage setup: 10% greater than the electronic load's working voltage range
5. Vary the resistance of the electronic load from the minimum to maximum of its range. Turn on the output for DC source firstly and then turn on the input of electronic load.
6. Record the reading values when the DVM measurement data is stable.
  - Record the electronic load's measured voltage and current value on VFD (displayed value).
  - Record the reading value of DVM (#1), for example the shunt voltage.
  - Record the reading value of DVM (#2), for example the measured actual voltage of the electronic load.
  - Record the electronic load's resistance setting.
7. Increase the resistance by 5% in the low range, by 10% in the high range, then repeat step 6.
8. Power off all the equipment after the test.
9. Calculate the deviation and determine whether it is within the specification.
  - The measured actual current: reading voltage / shunt resistance
  - The measured actual resistance: reading voltage / the measured actual current
  - Resistance setting accuracy: the measured actual resistance versus resistance setting value

## Remote sensing

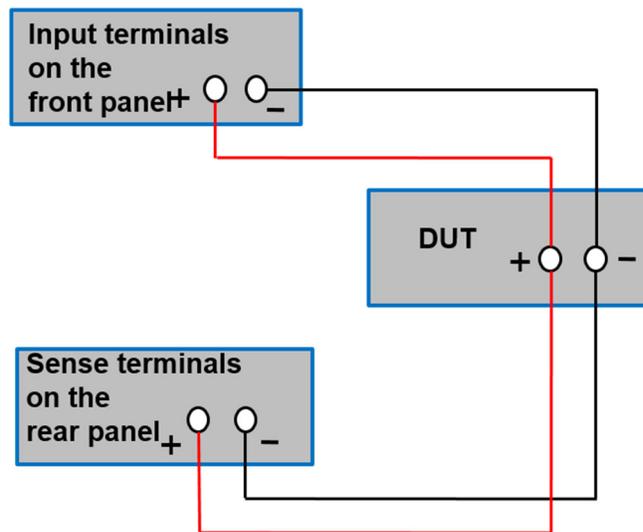
Remote sensing is used to counteract the effect of wire resistance. For example, if you connect an electronic load to the DC source, the voltage at the electronic load's terminals will not be the same as the voltage at the DC source's terminals because of the wire resistance. Using remote sensing, you can sense the voltage at the electronic load's terminals, effectively cancelling the voltage drop caused by the wire resistance. When the remote sensing is applied, the power received by the instrument includes the compensated power for the power dissipated by wire resistance and instrument resistance.

To set the remote sense:

1. Press **Shift** + **9**.
2. Press **Left** / **Right** direction keys to select **Remote Sense**.
3. Press **Enter**.
4. Select **ON** to enable the remote sensing function.

The remote sensing connection diagram is shown below:

**Figure 5: Wiring diagram for remote sense**



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