FLUKE ®

Calibration

5502A

Multi-Product Calibrator

Getting Started

PN 4155209
November 2012

LIMITED WARRANTY AND LIMITATION OF LIABILITY

Each Fluke product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year and begins on the date of shipment. Parts, product repairs, and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a Fluke authorized reseller, and does not apply to fuses, disposable batteries, or to any product which, in Fluke's opinion, has been misused, altered, neglected, contaminated, or damaged by accident or abnormal conditions of operation or handling. Fluke warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Fluke does not warrant that software will be error free or operate without interruption.

Fluke authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Fluke. Warranty support is available only if product is purchased through a Fluke authorized sales outlet or Buyer has paid the applicable international price. Fluke reserves the right to invoice Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

Fluke's warranty obligation is limited, at Fluke's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Fluke authorized service center within the warranty period.

To obtain warranty service, contact your nearest Fluke authorized service center to obtain return authorization information, then send the product to that service center, with a description of the difficulty, postage and insurance prepaid (FOB Destination). Fluke assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Fluke determines that failure was caused by neglect, misuse, contamination, alteration, accident, or abnormal condition of operation or handling, including overvoltage failures caused by use outside the product’s specified rating, or normal wear and tear of mechanical components, Fluke will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

THIS WARRANTY IS BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. FLUKE SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court or other decision-maker of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

Fluke Corporation
P.O. Box 9090
Everett, WA 98206-9090
U.S.A.

Fluke Europe B.V.
P.O. Box 1186
5602 BD Eindhoven
The Netherlands

11/99

OPERATOR SAFETY SUMMARY

WARNING

HIGH VOLTAGE

is used in the operation of this equipment

LETHAL VOLTAGE

may be present on the terminals, observe all safety precautions!

To prevent electrical shock hazard, the operator should not electrically contact the output HI or sense HI terminals or circuits connected to these terminals. During operation, lethal voltages of up to 1020 V ac or dc may be present on these terminals.
When the nature of the operation permits, keep one hand away from equipment to reduce the hazard of current flowing through vital organs of the body.

Table of Contents

List of Tables

List of Figures

Getting Started

Introduction

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury, read all safety Information before you use the Product.

The 5502A Calibrator (“the Product” or “the Calibrator”) in Figure 1 can be configured to source:

- DC voltage from 0 V to ±1020 V.
- AC voltage from 1 mV to 1020 V, with output from 10 Hz to 500 kHz.
- AC current from 29 µA to 20.5 A, with variable frequency limits.
- DC current from 0 to ±20.5 A.
- Resistance values from a short circuit to 1100 MΩ.
- Capacitance values from 220 pF to 110 mF.
- Simulated output for eight types of Resistance Temperature Detectors (RTDs).
- Simulated output for 11 types of thermocouples.

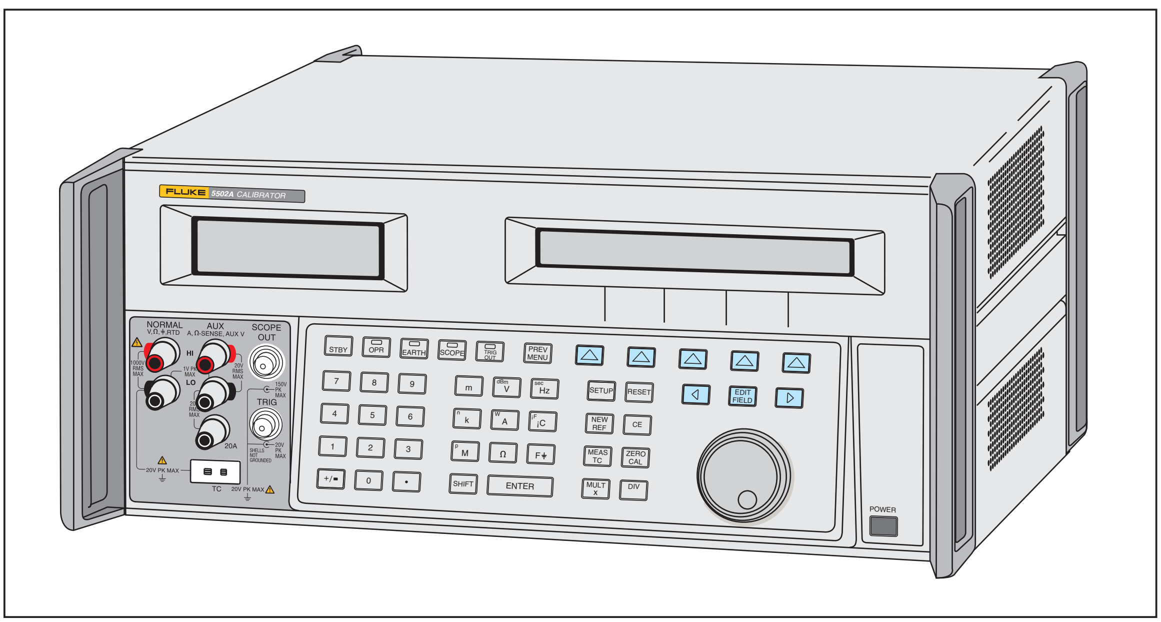


Figure 1. 5502A Multi-Product Calibrator

Calibrator features include:

- Automatic meter error calculation, with reference values that you can select.
- MULT X and DIV ÷ keys that change the output value to predetermined values for various functions.
- Programmable entry limits. These limits do not let you go above preset output limits.
- Voltage and current that can be output at the same time, to an equivalent of 20.9 kW.
- The power to output two voltages at the same time.
- Extended bandwidth mode outputs multiple waveforms down to 0.01 Hz, and sine waves to 2 MHz.
- A Standard IEEE-488 (GPIB) interface that complies with ANSI/IEEE Standards 488.1-1987 and 488.2-1987.
- A EIA Standard RS-232 serial data interface to print, show, or move internally stored calibration constants, and for remote control of the 5502A.
- A pass-through RS-232 serial data interface to send data to the Unit Under Test (UUT).

Safety Information

In this manual, A **Warning** identifies conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury:

- **Use the Product only as specified, or the protection supplied by the Product can be compromised.**
- **Carefully read all instructions.**
- **Do not use the Product around explosive gas, vapor, or in damp or wet environments.**
- **Use this Product indoors only.**
- **Do not touch voltages > 30 V ac rms, 42 V ac peak, or 60 V dc.**
- **Do not use the Product if it operates incorrectly.**
- **Do not use and disable the Product if it is damaged.**
- **Do not use test leads if they are damaged. Examine the test leads for damaged insulation, exposed metal, or if the wear indicator shows. Check test lead continuity.**
- **Use only cables with correct voltage ratings.**
- **Connect the common test lead before the live test lead and remove the live test lead before the common test lead.**
- **Use only the mains power cord and connector approved for the voltage and plug configuration in your country and rated for the Product.**

- **Make sure the ground conductor in the mains power cord is connected to a protective earth ground. Disruption of the protective earth could put voltage on the chassis that could cause death.**
- **Replace the mains power cord if the insulation is damaged or if the insulation shows signs of wear.**
- **Do not connect directly to mains.**
- **Do not use an extension cord or adapter plug.**
- **For safe operation and maintenance of the Product, make sure that the space around the Product meets minimum requirements.**

This Calibrator complies with:

- ANSI/ISA-61010-1 (82.02.01)
- CAN/CSA C22.2 No. 61010-1-04
- ANSI/UL 61010-1:2004
- EN 61010-1:2001
- ANSI/IEEE Standards 488.1-1987 and 488.2-1987.

Symbols used in this manual and on the Product are in Table 1.

Table 1. Symbols

Symbol	Description	Symbol	Description
CAT I	IEC Measurement Category I – CAT I is for measurements not directly connected to mains. Maximum transient Overvoltage is as specified by terminal markings.	C SP US ®	Conforms to relevant North American Safety Standards.
CE	Conforms to European Union directives.		This product complies with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste. Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as category 9 "Monitoring and Control Instrumentation" product. Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.
⚠	Risk of Danger. Important information. See manual.	⚠	Hazardous voltage
⏚	Earth ground	N10140	Conforms to relevant Australian EMC requirements.

Contact Fluke Calibration

To contact Fluke Calibration, call one of the following telephone numbers:

- Technical Support USA: 1-877-355-3225
- Calibration/Repair USA: 1-877-355-3225
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31-40-2675-200
- Japan: +81-3-6714-3114
- Singapore: +65-6799-5566
- China: +86-400-810-3435
- Brazil: +55-11-3759-7600
- Anywhere in the world: +1-425-446-6110

To see product information and download the latest manual supplements, visit Fluke Calibration's website at www.flukecal.com.

To register your product, visit http://flukecal.com/register-product.

Overload Protection

The Calibrator supplies reverse-power protection, fast output disconnection, and/or fuse protection on the output terminals for all functions.

Reverse-power protection prevents damage to the calibrator from occasional, accidental, normal-mode, and common-mode overloads to a maximum of ±300 V peak. It is not intended as protection against frequent (systematic and repeated) abuse. Such abuse will cause the Calibrator to fail.

For volts, ohms, capacitance, and thermocouple functions, there is fast output disconnection protection. This protection senses applied voltages higher than 20 volts on the output terminals. It quickly disconnects the internal circuits from the output terminals and resets the calibrator when such overloads occur.

For current and aux voltage functions, user replaceable fuses supply protection from overloads applied to the Current/Aux Voltage output terminals. The fuses are accessed by an access door on the bottom of the calibrator. You must use replacement fuses of the same rating and type specified in this manual, or the protection supplied by the Calibrator will be compromised.

Operation Overview

The Calibrator can be operated at the front panel or remotely with the RS-232 or IEEE-488 ports. For remote operations, software is available to integrate 5502A operation into a wide variety of calibration requirements.

Local Operation

Typical local operations include front-panel connections to the UUT, and then manual keystroke entries at the front panel to put the Calibrator in the necessary output mode. [MULT X] and [DIV ÷] make it easy to step up or down at the push of a key. You can also examine Calibrator specifications at the push of two buttons. The backlit LCD is easy to read from many different angles and can be read in dim or bright light. The large, easy-to-read keys are color-coded and give tactile feedback.

Remote Operation (RS-232)

There are two rear-panel serial data RS-232 ports: SERIAL 1 FROM HOST, and SERIAL 2 TO UUT (see Figure 2). Each port is dedicated to serial-data communications to operate and control the Product during calibration procedures. For complete information on remote operation, see Chapter 5 of the Operators Manual.

The SERIAL 1 FROM HOST serial data port connects a host terminal or personal computer (PC) to the Calibrator. To send commands to the Calibrator: enter commands from a terminal (or a PC running a terminal program), write your own procedures with BASIC, or use optional Windows-based software such as MET/CAL Plus.

The SERIAL 2 TO UUT serial data port connects a UUT to a PC or terminal with the 5502A (see Figure 2). This "pass-through" configuration removes the requirement for two COM ports at the PC or terminal. A set of four commands control the operation of the SERIAL 2 TO UUT serial port. See Chapter 6 for a discussion of the UUT_ commands.

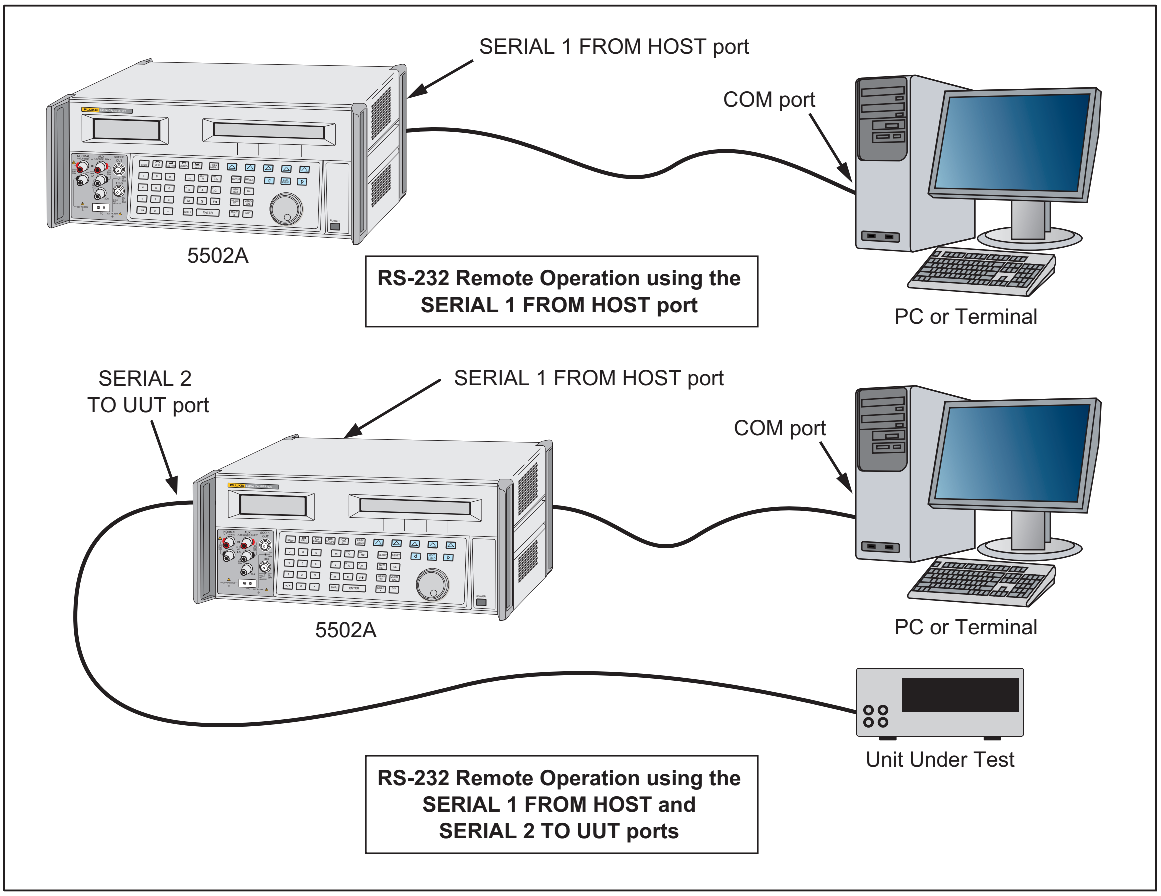


Figure 2. RS-232 Remote Connection

Remote Operation (IEEE-488)

The rear-panel IEEE-488 port is a fully programmable parallel interface bus that complies with standard IEEE-488.1 and supplemental standard IEEE-488.2. When the Calibrator is used by remote control of an instrument controller, the Calibrator operates exclusively as a "talker/listener." You can write your own programs with the IEEE-488 command set or run the optional Windows-based MET/CAL Plus software. See Chapter 6 of the Operators Manual for a discussion of the commands available for IEEE-488 operation.

Unpack and Inspection

The calibrator is shipped in a container to prevent damage. Examine the calibrator carefully for damage and immediately report damage to the shipper. Instructions for inspection and claims are included in the shipping container.

When you unpack the calibrator, make sure that you have all the standard equipment in Table 2. Examine the shipping list to make sure other items that you purchased are included. Refer to the “Accessories” section in Chapter 8 of the Operators Manual for more information. Report missing items to the point of purchase or to the nearest Fluke Calibration Service Center (see “Contact Fluke Calibration”). A performance test is in the “Maintenance” section of Chapter 7 in the Operators Manual.

If you ship the calibrator to Fluke Calibration, use the initial container. If it is not available, you can get a new container from Fluke Calibration with the Calibrator model and serial number.

Table 2. Standard Equipment

Item	Model or Part Number
Calibrator	5502A
Mains Power Cord	See Table 3 and Figure 4
5502A Getting Started Manual	4155209
5502A Operators Manual on CD-ROM	4155227

Select Line Voltage

The Calibrator comes from the factory configured for the line voltage typically applicable for the country of purchase, or as specified at the time of your purchase order. You can operate the Calibrator from one of four line-voltage settings: 100 V, 120 V, 200 V, and 240 V (47 Hz to 63 Hz). To verify the line-voltage setting, note the voltage setting that you can see through the window in the power-line fuse compartment cover (Figure 3). The permitted line-voltage variation is 10 % above or below the line-voltage setting.

To change the line-voltage setting, complete the following procedure:

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury, disconnect line power.

1. To open the fuse compartment, put a screwdriver blade in the tab on the left side of the compartment and pry until it can be removed.
2. To remove the line-voltage selector assembly, hold the line-voltage indicator tab with pliers and pull it straight out of its connector.
3. Turn the line-voltage selector assembly to the necessary voltage and reinsert.
4. Make sure to use the correct fuse for the selected line voltage (100 V/120 V, use 5 A/250 V slow blow, 220 V/240 V, use 2.5 A/250 V slow blow). To install the fuse compartment, push it into position until the tab locks.

Connect to Line Power

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury:

- **Do not use a two-conductor mains power cord unless you install a protective ground wire to the Product ground terminal before you operate the Product.**
- **Do not use an extension cord or adapter plug.**

Make sure that the Product is grounded before use. The calibrator is shipped with the correct line-power plug for the country of purchase. If it is necessary to use a different type, refer to Table 3 and Figure 4 for a list and illustration of the line-power plug types available from Fluke Calibration.

After you make sure that the line voltage selection is set correctly and that the correct fuse for that line voltage is installed, connect the calibrator to a correctly-grounded three-prong outlet.

Select Line Frequency

The calibrator is shipped from the factory for nominal operation at 60 Hz line frequency. If you use 50 Hz line voltage, reconfigure the Calibrator for optimal performance at 50 Hz. To do this:

1. From the front panel, go into SETUP, INSTMT SETUP, OTHER SETUP.
2. Push the softkey below MAINS to change the selection to 50 Hz.
3. Store the change.

After a correct instrument warmup (on for 30 minutes or longer), you must zero the complete instrument again. See the section on “Zero the Calibrator” in Chapter 4 of the Operators Manual.

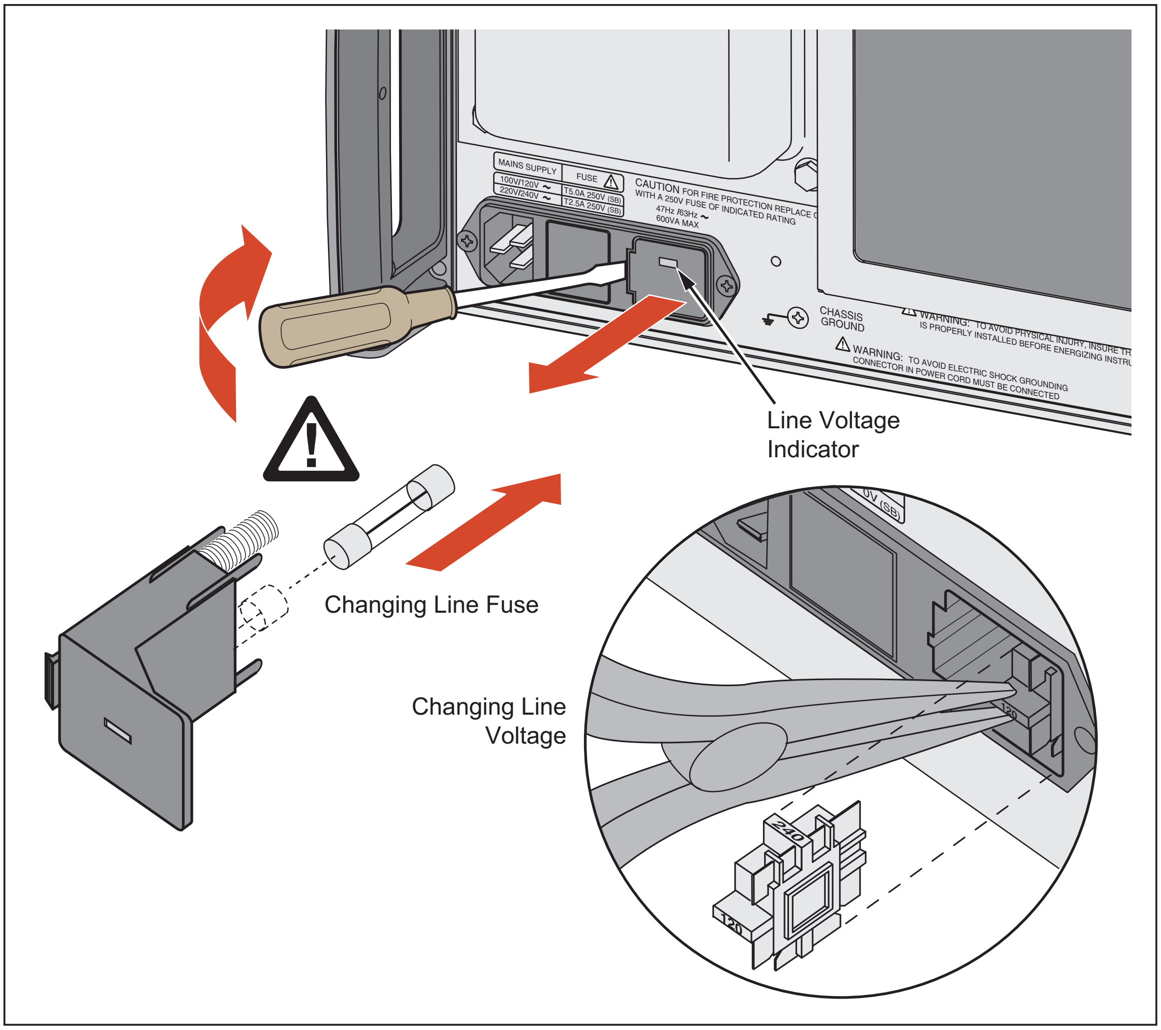


Figure 3. Access the Fuse and Select Line Voltage

Table 3. Mains-Power Cord Types Available from Fluke Calibration

Type	Voltage/Current	Fluke Calibration Option Number
North America	120 V/15 A	LC-1
North America	240 V/15 A	LC-2
Universal Euro	220 V/15 A	LC-3
United Kingdom	240 V/13 A	LC-4
Switzerland	220 V/10 A	LC-5
Australia	240 V/10 A	LC-6
South Africa	240 V/5 A	LC-7

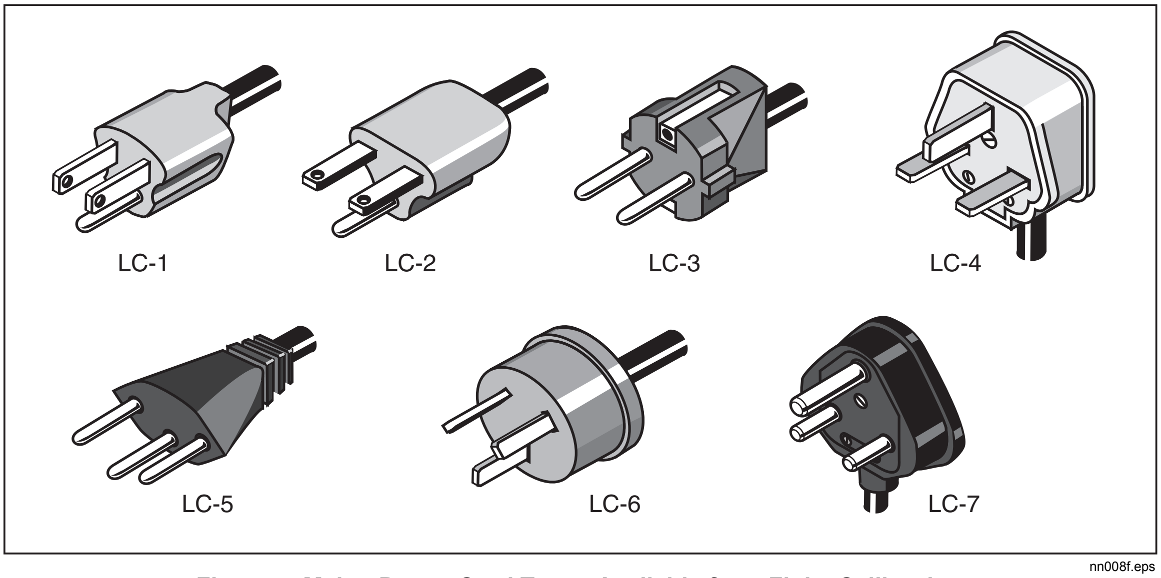


Figure 4. Mains-Power Cord Types Available from Fluke Calibration

Placement

You can put the Product on a bench top or install it in a standard-width 24 inch (61 cm) depth equipment rack. For bench-top use, the Calibrator has a non-slip feet. To install the Calibrator in an equipment rack, use the 5502A Rack-Mount Kit, Model Y5537. Instructions to install the Calibrator into a rack come with the kit.

Airflow Considerations

⚠⚠ Warning

For safe operation and maintenance of the Product, make sure that the space around the Product meets minimum requirements.

Baffles put cool air from the fan into the chassis to internally dissipate heat when the Calibrator is in operation. The accuracy and dependability of all internal parts of the calibrator are enhanced by a cool internal temperature. You can increase the life of the Calibrator and enhance its performance by these rules:

- The area around the air filter must be a minimum 3 inches from close walls or rack enclosures.
- The exhaust perforations on the sides of the Calibrator must be clear of blockage.
- The air that gets to the Calibrator must be at room temperature. Make sure the exhaust air from other instruments does not enter into the fan inlet.
- Clean the air filter after 30 days or more frequently if the calibrator is operated in a dusty environment. (See the "Maintenance" chapter of the Operators Manual for instructions to clean the air filter.)

Instruction Manuals

The 5502A Manual Set includes:

- *5502A Operators Manual* on included CD-ROM (PN 4155227)
- *5502A Getting Started* (PN 4155209)

One of each manual above comes with the instrument. Refer to the Fluke Calibration Catalog or speak to a Fluke Calibration sales representative (see "Contact Fluke Calibration") if more printed copies are necessary. The manuals are also available on the Fluke Calibration website.

5502A Getting Started Manual

This *5502A Getting Started* contains a brief introduction to the 5502A Manual Set, instructions on how to get your calibrator prepared for operation and a complete set of specifications.

5502A Operators Manual

The *5502A Operators Manual* supplies complete information to install the Calibrator and operate it from the front-panel keys and in remote configurations. The manual also has a glossary of calibration, specifications, and error-code information. The Operators Manual includes:

- Installation
- Controls and features, front-panel operation
- Remote operation (IEEE-488 bus or serial port remote control)
- Serial port operation (print, show, or transfer data, and setup for serial port remote control)
- Operator maintenance, with verification and calibration procedures
- Accessories
- SC600 and SC300 oscilloscope calibration options

General Specifications

The following tables list the 5502A specifications. All specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5502A has been turned off. (For example, if the 5502A has been turned off for 5 minutes, the warm-up period is 10 minutes.)

All specifications apply for the temperature and time period indicated. For temperatures outside of tcal ±5 °C (tcal is the ambient temperature when the 5502A was calibrated), the temperature coefficient as stated in the General Specifications must be applied.

The specifications also assume the Calibrator is zeroed every seven days or whenever the ambient temperature changes more than 5 °C. The tightest ohms specifications are maintained with a zero cal every 12 hours within ±1 °C of use.

Also see additional specifications later in this chapter for information on extended specifications for ac voltage and current.

Warmup Time .... Twice the time since last warmed up, to a maximum of 30 minutes.

Settling Time .... Less than 5 seconds for all functions and ranges except as noted.

Standard Interfaces .... IEEE-488 (GPIB), RS-232

Temperature

Operating .... 0 °C to 50 °C

Calibration (tcal)........ 15 °C to 35 °C

Storage .... -20 °C to +70 °C; The DC current ranges 0 to 1.09999 A and 1.1 A to 2.99999 A are sensitive to storage temperatures above 50 °C. If the 5502A is stored above 50 °C for greater than 30 minutes, these ranges must be re-calibrated. Otherwise, the 90 day and 1 year uncertainties of these ranges double.

Temperature Coefficient........ Temperature coefficient for temperatures outside of tcal ±5 °C is 10 % of the stated specification per °C.

Relative Humidity

Operating .... <80 % to 30 °C, <70 % to 40 °C, <40 % to 50 °C

Storage .... <95 %, non-condensing. After long periods of storage at high humidity, a drying-out period (with power on) of at least one week may be required.

Altitude

Operating .... 3,050 m (10,000 ft) maximum

Non-operating .... 12,200 m (40,000 ft) maximum

Safety .... Complies with EN/IEC 61010-1:2001, CAN/CSA-C22.2 No. 61010-1-04, ANSI/UL 61010-1:2004;

Output Terminal Electrical Overload Protection Provides reverse-power protection, immediate output disconnection, and/or fuse protection on the output terminals for all functions. This protection is for applied external voltages up to ±300 V peak.

Analog Low Isolation........ 20 V normal operation, 400 V peak transient

EMC .... Complies with EN/IEC 61326-1:2006, EN/IEC 61326-2-1:2006 for controlled EM environments under the following conditions. If used in areas with Electromagnetic fields of 1 to 3 V/m from 0.08-1GHz, resistance outputs have a floor adder of 0.508 Ω Performance not specified above 3 V/m. This instrument may be susceptible to electro-static discharge (ESD) to the binding posts. Good static awareness practices should be followed when handling this and other pieces of electronic equipment. Additionally this instrument may be susceptible to electrical fast transients on the mains terminals. If any disturbances in operation are observed, it is recommended that the rear panel chassis ground terminal be connected to a known good earth ground with a low inductance ground strap. Note that a mains power outlet while providing a suitable ground for protection against electric shock hazard may not provide an adequate ground to properly drain away conducted rf disturbances and may in fact be the source of the disturbance. This instrument was certified for EMC performance with data I/O cables not in excess of 3m.

Line Power........ Line Voltage (selectable): 100 V, 120 V, 220 V, 240 V

Line Frequency: 47 Hz to 63 Hz

Line Voltage Variation: ±10 % about line voltage setting. For optimal performance at full dual outputs (e.g. 1000 V, 20 A) choose a ling voltage setting that is ±7.5 % from nominal.

Power Consumption .... 600 VA

Dimensions (HxWxL) .... 17.8 cm x 43.2 cm x 47.3 cm (7 in x 17 in x 18.6 in) Standard rack width and rack increment, plus 1.5 cm (0.6 in) for feet on bottom of unit.

Weight (without options) .... 22 kg (49 lb)

Absolute Uncertainty Definition .... The 5502A specifications include stability, temperature coefficient, linearity, line and load regulation, and the traceability of the external standards used for calibration. You do not need to add anything to determine the total specification of the 5502A for the temperature range indicated.

Specification Confidence Level .... 99 %

Detailed Specifications

DC Voltage

Range	Absolute Uncertainty, tcal ± 5 °C ±(% of output + µV)		Stability	Resolution (µV)	Max Burden [1]
	90 Day	1 Year	24 hours, ± 1 °C ±(ppm of output + µV)		
0 to 329.9999 mV	0.005 + 3	0.006 + 3	5 + 1	0.1	65 Ω
0 to 3.299999 V	0.004 + 5	0.005 + 5	4 + 3	1	10 mA
0 to 32.99999 V	0.004 + 50	0.005 + 50	4 + 30	10	10 mA
30 to 329.9999 V	0.0045 + 500	0.0055 + 500	4.5 + 300	100	5 mA
100 to 1020.000 V	0.0045 + 1500	0.0055 + 1500	4.5 + 900	1000	5 mA
Auxiliary Output (dual output mode only) [2]					
0 to 329.999 mV	0.03 + 350	0.04 + 350	30 + 100	1	5 mA
0.33 to 3.29999 V	0.03 + 350	0.04 + 350	30 + 100	10	5 mA
3.3 to 7 V	0.03 + 350	0.04 + 350	30 + 100	100	5 mA
TC Simulate and Measure in Linear 10 µV/°C and 1 mV/°C modes [3]					
0 to 329.999 mV	0.005 + 3	0.006 + 3	5 + 1	0.1	10 Ω

[1] Remote sensing is not provided. Output resistance is < 5 mΩ for outputs ≥ 0.33 V. The AUX output has an output resistance of <1 Ω. TC simulation has an output impedance of 10 Ω ± 1 Ω.

[2] Two channels of dc voltage output are provided.

[3] TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p ±(ppm of output + floor in µV)	Bandwidth 10 Hz to 10 kHz rms
0 to 329.9999 mV	0 + 1	6 µV
0 to 3. 3.299999 V	0 + 10	60 µV
0 to 32.99999 V	0 + 100	600 µV
30 to 329.9999 V	10 + 1000	20 mV
100 to 1020.000 V	10 + 5000	20 mV
Auxiliary Output (dual output mode only) [1]		
0 to 329.999 mV	0 + 5 µV	20 µV
0.33 to 3.29999 V	0 + 20 µV	300 µV
3.3 to 7 V	0 + 100 µV	1000 µV

[1] Two channels of dc voltage output are provided.

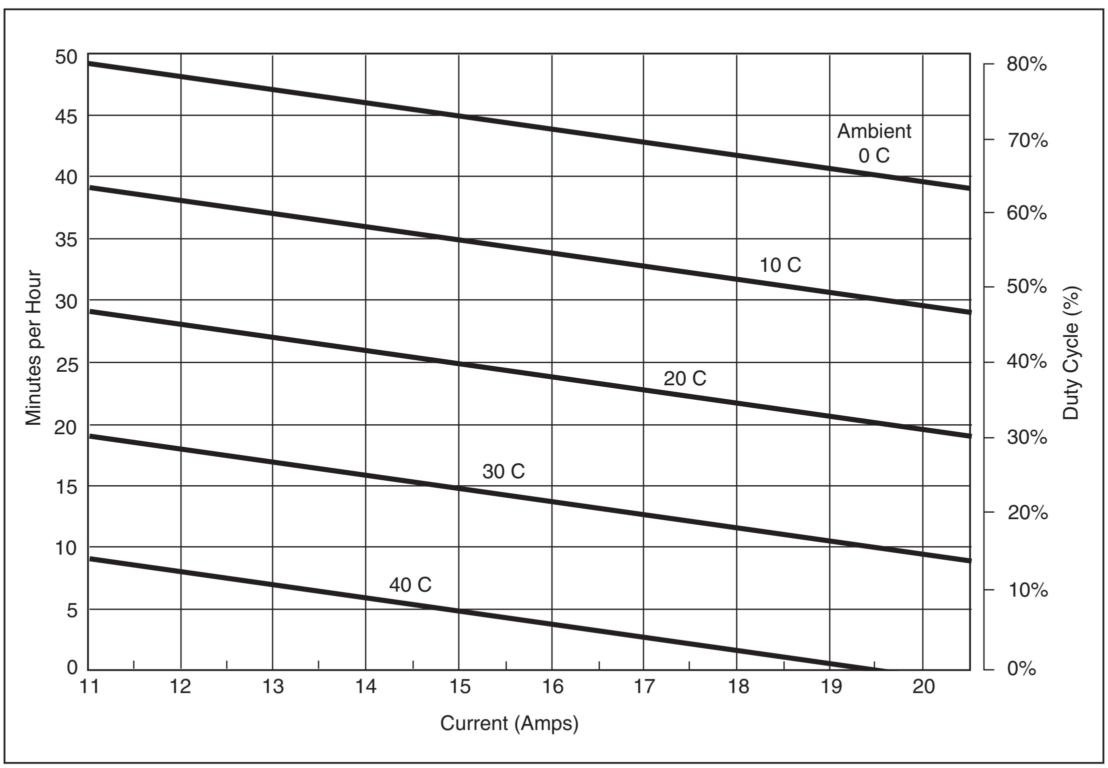
DC Current

Range	Absolute Uncertainty, tcal ±5 °C ±(% of output +µA)		Resolution	Max Compliance Voltage V	Max Inductive Load mH
	90 Day	1 Year			
0 to 329.999 µA	0.012 + 0.02	0.015 + 0.02	1 nA	10	400
0 to 3.29999 mA	0.010 + 0.05	0.010 + 0.05	0.01 µA	10	
0 to 32.9999 mA	0.008 + 0.25	0.010 + 0.25	0.1 µA	7	
0 to 329.999 mA	0.008 + 3.3	0.010 + 2.5	1 µA	7	
0 to 1.09999 A	0.023 + 44	0.038 + 44	10 µA	6	
1.1 to 2.99999 A	0.030 + 44	0.038 + 44	10 µA	6	
0 to 10.9999 A (20 A Range)	0.038 + 500	0.060 + 500	100 µA	4	
11 to 20.5 A [1]	0.080 + 750 [2]	0.10 + 750 [2]	100 µA	4	

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure 3. The current may be provided Formula 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amperes. For example, 17 A, at 23 °C could be provided for 60-23-17 = 20 minutes each hour. When the 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 3 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

[2] Floor specification is 1500 µA within 30 seconds of selecting operate. For operating times >30 seconds, the floor specification is 750 µA.

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p	Bandwidth 10 Hz to 10 kHz rms
0 to 329.999 µA	2 nA	20 nA
0 to 3.29999 mA	20 nA	200 nA
0 to 32.9999 mA	200 nA	2.0 µA
0 to 329.999 mA	2000 nA	20 µA
0 to 2.99999 A	20 µA	1 mA
0 to 20.5 A	200 µA	10 mA



nn326f.eps

Figure 5. Allowable Duration of Current >11 A

Resistance

Range [1]	Absolute Uncertainty, tcal ±5 °C ±(% of output + floor) [2]				Resolution (Ω)	Allowable Current [3] (A)
	% of output		Floor (Ω) Time and temp since ohms zero cal			
	90 Day	1 Year	12 hrs ±1 °C	7 days ±5 °C		
0 to 10.999 Ω	0.009	0.012	0.001	0. 01	0.001	1 mA to 125 mA
11 to 32.999 Ω	0.009	0.012	0.0015	0.015	0.001	1 mA to 125 mA
33 to 109.999 Ω	0.007	0.009	0.0014	0.015	0.001	1 mA to 70 mA
110 to 329.999 Ω	0.007	0.009	0.002	0.02	0.001	1 mA to 40 mA
330 to 1.09999 kΩ	0.007	0.009	0.002	0.02	0.01	1 mA to 18 mA
1.1 to 3.29999 kΩ	0.007	0.009	0.02	0.2	0.01	100 µA to 5 mA
3.3 to 10.9999 kΩ	0.007	0.009	0.02	0.1	0.1	100 µA to 1.8 mA
11 to 32.9999 kΩ	0.007	0.009	0.2	1	0.1	10 µA to .5 mA
33 to 109.999 kΩ	0.008	0.011	0.2	1	1	10 µA to 0.18 mA
110 to 329.999 kΩ	0.009	0.012	2	10	1	1 µA to 50 µA
330 kΩ to 1.09999 MΩ	0.011	0.015	2	10	10	1 µA to 18 µA
1.1 to 3.29999 MΩ	0.011	0.015	30	150	10	250 nA to 5 µA
3.3 to 10.9999 MΩ	0.045	0.06	50	250	100	250 nA to 1.8 µA
11 to 32.9999 MΩ	0.075	0.1	2500	2500	100	25 nA to 500 nA
33 to 109.999 MΩ	0.4	0.5	3000	3000	1000	25 nA to 180 nA
110 to 329.999 MΩ	0.4	0.5	100000	100000	1000	2.5 nA to 50 nA
330 to 1100.00 MΩ	1.2	1.5	500000	500000	10000	1 nA to 13 nA

[1] Continuously variable from 0 Ω to 1.1 GΩ.

[2] Applies for 4-WIRE compensation only. For 2-WIRE and 2-WIRE COMP, add 5 µV per amp of stimulus current to the floor specification. For example, in 2-WIRE mode, at 1 kΩ the floor specification within 12 hours of an ohms zero cal for a measurement current of 1 mA is: 0.002 Ω + 5 µV / 1 mA = (0.002 + 0.005) Ω = 0.007 Ω.

[3] Do not exceed the largest current for each range. For currents lower than shown, the floor adder increases by $Floor_{(new)} = Floor_{(old)} \times I_{min}/I_{actual}$. For example, a 50 µA stimulus measuring 100 Ω has a floor specification of: 0.0014 Ω x 1 mA/50 µA = 0.028 Ω, assuming an ohms zero calibration within 12 hours.

AC Voltage (Sine Wave)

Range	Frequency	Absolute Uncertainty, tcal ±5 °C ±(% of output + µV)		Resolution	Max Burden	Max Distortion and Noise 10 Hz to 5 MHz Bandwidth ±(% of output + floor)
		90 Day	1 Year			
1.0 to 32.999 mV	10 Hz to 45 Hz	0.120 + 20	0.150 + 20	1 µV	65 Ω	0.15 + 90 µV
	45 Hz to 10 kHz	0.080 + 20	0.100 + 20			0.035 + 90 µV
	10 kHz to 20 kHz	0.120 + 20	0.150 + 20			0.06 + 90 µV
	20 kHz to 50 kHz	0.160 + 20	0.200 + 20			0.15 + 90 µV
	50 kHz to 100 kHz	0.300 + 33	0.350 + 33			0.25 + 90 µV
	100 kHz to 500 kHz	0.750 + 60	1.000 + 60			0.3 + 90 µV [1]
33 mV to 329.999 mV	10 Hz to 45 Hz	0.042 + 20	0.050 + 20	1 µV	65 Ω	0.15 + 90 µV
	45 Hz to 10 kHz	0.029 + 20	0.030 + 20			0.035 + 90 µV
	10 kHz to 20 kHz	0.066 + 20	0.070 + 20			0.06 + 90 µV
	20 kHz to 50 kHz	0.086 + 40	0.100 + 40			0.15 + 90 µV
	50 kHz to 100 kHz	0.173 + 170	0.230 + 170			0.2 + 90 µV
	100 kHz to 500 kHz	0.400 + 330	0.500 + 330			0.2 + 90 µV [1]
0.33 V to 3.29999 V	10 Hz to 45 Hz	0.042 + 60	0.050 + 60	10 µV	10 mA	0.15 + 200 µV
	45 Hz to 10 kHz	0.028 + 60	0.030 + 60			0.035 + 200 µV
	10 kHz to 20 kHz	0.059 + 60	0.070 + 60			0.06 + 200 µV
	20 kHz to 50 kHz	0.083 + 60	0.100 + 60			0.15 + 200 µV
	50 kHz to 100 kHz	0.181 + 200	0.230 + 200			0.2 + 200 µV
	100 kHz to 500 kHz	0.417 + 900	0.500 + 900			0.2 + 200 µV [1]
3.3 V to 32.9999 V	10 Hz to 45 Hz	0.042 + 800	0.050 + 800	100 µV	10 mA	0.15 + 2 mV
	45 Hz to 10 kHz	0.025 + 600	0.030 + 600			0.035 + 2 mV
	10 kHz to 20 kHz	0.064 + 600	0.070 + 600			0.08 + 2 mV
	20 kHz to 50 kHz	0.086 + 600	0.100 + 600			0.2 + 2 mV
	50 kHz to 100 kHz	0.192 + 2000	0.230 + 2000			0.5 + 2 mV
33 V to 329.999 V	45 Hz to 1 kHz	0.039 + 3000	0.050 + 3000	1 mV	5 mA, except 20 mA for 45 Hz to 65 Hz	0.15 + 10 mV
	1 kHz to 10 kHz	0.064 + 9000	0.080 + 9000			0.05 +10 mV
	10 kHz to 20 kHz	0.079 + 9000	0.090 + 9000			0.6 + 10 mV
	20 kHz to 50 kHz	0.096 + 9000	0.120 + 9000			0.8 + 10 mV
	50 kHz to 100 kHz	0.192 + 80000	0.240 + 80000			1 + 10 mV
330 V to 1020 V	45 Hz to 1 kHz	0.042 + 20000	0.050 + 20000	10 mV	2 mA, except 20 mA for 45 to 65 Hz	0.15 + 30 mV
	1 kHz to 5 kHz	0.064 + 20000	0.080 + 20000			0.07 + 30 mV
	5 kHz to 10 kHz	0.075 + 20000	0.090 + 20000			0.07 + 30 mV

[1] Max Distortion for 100 kHz to 200 kHz. For 200 kHz to 500 kHz, the maximum distortion is 0.9 % of output + floor as shown.

Note

Remote sensing is not provided. Output resistance is <5 mΩ for outputs ≥0.33 V. The AUX output resistance is <1 Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.

AC Voltage (Sine Wave) (cont.)

AUX (Auxiliary Output) [dual output mode only]						
Range	Frequency [1]	Absolute Uncertainty, tcal ±5 °C ±(% of output + µV)		Resolution	Max Burden	Max Distortion and Noise 10 Hz to 5 MHz Bandwidth ±(% of output + floor)
		90 Day	1 Year			
1.0 to 329.999 mV	10 to 20 Hz	0.15 + 370	0.20 + 370	1 µV	5 mA	0.20 + 200 µV
	20 to 45 Hz	0.08 + 370	0.10 + 370			0.06 + 200 µV
	45 to 1 kHz	0.08 + 370	0.10 + 370			0.08 + 200 µV
	1 to 5 kHz	0.15 + 450	0.20 + 450			0.30 + 200 µV
	5 to 10 kHz	0.30 + 450	0.40 + 450			0.60 + 200 µV
	10 to 30 kHz	4.00 + 900	5.00 + 900			1.00 + 200 µV
0.33 to 3.29999 V	10 to 20 Hz	0.15 + 450	0.20 + 450	10 µV	5 mA	0.20 + 200 µV
	20 to 45 Hz	0.08 + 450	0.10 + 450			0.06 + 200 µV
	45 to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 µV
	1 to 5 kHz	0.15 + 1400	0.20 + 1400			0.30 + 200 µV
	5 to 10 kHz	0.30 + 1400	0.40 + 1400			0.60 + 200 µV
	10 to 30 kHz	4.00 + 2800	5.00 + 2800			1.00 + 200 µV
3.3 to 5 V	10 to 20 Hz	0.15 + 450	0.20 + 450	100 µV	5 mA	0.20 + 200 µV
	20 to 45 Hz	0.08 + 450	0.10 + 450			0.06 + 200 µV
	45 to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 µV
	1 to 5 kHz	0.15 + 1400	0.20 + 1400			0.30 + 200 µV
	5 to 10 kHz	0.30 + 1400	0.40 + 1400			0.60 + 200 µV

[1] There are two channels of voltage output. The maximum frequency of the dual output is 30 kHz.

Note

Remote sensing is not provided. Output resistance is <5 mΩ for outputs ≥0.33 V. The AUX output resistance is <1 Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.

AC Current (Sine Wave)

Range	Frequency	Absolute Uncertainty, tcal ±5 °C ±(% of output + µA)		Compliance adder ±(µA/V)	Max Distortion and Noise 10 Hz to 100 kHz BW ±(% of output + floor)	Max Inductive Load µH
		90 Day	1 Year			
LCOMP Off						
29 to 329.99 µA	10 to 20 Hz	0.16 + 0.1	0.2 + 0.1	0.05	0.15 + 0.5 µA	200
	20 to 45 Hz	0.12 + 0.1	0.15 + 0.1	0.05	0.10 + 0.5 µA	
	45 Hz to 1 kHz	0.1 + 0.1	0.125 + 0.1	0.05	0.05 + 0.5 µA	
	1 to 5 kHz	0.25 + 0.15	0.3 + 0.15	1.5	0.50 + 0.5 µA	
	5 to 10 kHz	0.6 + 0.2	0.8 + 0.2	1.5	1.00 + 0.5 µA	
	10 to 30 kHz	1.2 + 0.4	1.6 + 0.4	10	1.20 + 0.5 µA	
0.33 to 3.29999 mA	10 to 20 Hz	0.16 + 0.15	0.2 + 0.15	0.05	0.15 + 1.5 µA	200
	20 to 45 Hz	0.1 + 0.15	0.125 + 0.15	0.05	0.06 + 1.5 µA	
	45 Hz to 1 kHz	0.08 + 0.15	0.1 + 0.15	0.05	0.02 + 1.5 µA	
	1 to 5 kHz	0.16 + 0.2	0.2 + 0.2	1.5	0.50 + 1.5 µA	
	5 to 10 kHz	0.4 + 0.3	0.5 + 0.3	1.5	1.00 + 1.5 µA	
	10 to 30 kHz	0.8 + 0.6	1.0 + 0.6	10	1.20 + 0.5 µA	
3.3 to 32.9999 mA	10 to 20 Hz	0.15 + 2	0.18 + 2	0.05	0.15 + 5 µA	50
	20 to 45 Hz	0.075 + 2	0.09 + 2	0.05	0.05 + 5 µA	
	45 Hz to 1 kHz	0.035 + 2	0.04 + 2	0.05	0.07 + 5 µA	
	1 to 5 kHz	0.065 + 2	0.08 + 2	1.5	0.30 + 5 µA	
	5 to 10 kHz	0.16 + 3	0.2 + 3	1.5	0.70 + 5 µA	
	10 to 30 kHz	0.32 + 4	0.4 + 4	10	1.00 + 0.5 µA	
33 to 329.999 mA	10 to 20 Hz	0.15 + 20	0.18 + 20	0.05	0.15 + 50 µA	50
	20 to 45 Hz	0.075 + 20	0.09 + 20	0.05	0.05 + 50 µA	
	45 Hz to 1 kHz	0.035 + 20	0.04 + 20	0.05	0.02 + 50 µA	
	1 to 5 kHz	0.08 + 50	0.10 + 50	1.5	0.03 + 50 µA	
	5 to 10 kHz	0.16 + 100	0.2 + 100	1.5	0.10 + 50 µA	
	10 to 30 kHz	0.32 + 200	0.4 + 200	10	0.60 + 50 µA	
0.33 to 1.09999 A	10 to 45 Hz	0.15 + 100	0.18 + 100		0.20 + 500 µA	2.5
	45 Hz to 1 kHz	0.036 + 100	0.05 + 100		0.07 + 500 µA	
	1 to 5 kHz	0.5 + 1000	0.6 + 1000	[2]	1.00 + 500 µA	
	5 to 10 kHz	2.0 + 5000	2.5 + 5000	[3]	2.00 + 500 µA	
1.1 to 2.99999 A	10 to 45 Hz	0.15 + 100	0.18 + 100		0.20 + 500 µA	2.5
	45 Hz to 1 kHz	0.05 + 100	0.06 + 100		0.07 + 500 µA	
	1 to 5 kHz	0.5 + 1000	0.6 + 1000	[2]	1.00 + 500 µA	
	5 to 10 kHz	2.0 + 5000	2.5 + 5000	[3]	2.00 + 500 µA	
3 to 10.9999 A	45 to 100 Hz	0.05 + 2000	0.06 + 2000		0.2 + 3 mA	1
	100 Hz to 1 kHz	0.08 + 2000	0.10 + 2000		0.1 + 3 mA	
	1 kHz to 5 kHz	2.5 + 2000	3.0 + 2000		0.8 + 3 mA	
11 to 20.5 A [1]	45 to 100 Hz	0.1 + 5000	0.12 + 5000		0.2 + 3 mA	1
	100 Hz to 1 kHz	0.13 + 5000	0.15 + 5000		0.1 + 3 mA	
	1 to 5 kHz	2.5 + 5000	3.0 + 5000		0.8 + 3 mA	

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure 3. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amps. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour. When the 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 3 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

[2] For compliance voltages greater than 1 V, add 1 mA/V to the floor specification from 1 to 5 kHz.

[3] For compliance voltages greater than 1 V, add 5 mA/V to the floor specification from 5 to 10 kHz.

AC Current (Sine Wave) (cont.)

Range	Frequency	Absolute Uncertainty, tcal ±5 °C ±(% of output + µA)		Max Distortion and Noise 10 Hz to 100 kHz BW ±(% of output + floor)	Max Inductive Load
		90 Day	1 Year		
LCOMP On					
29 to 329.99 µA	10 to 100 Hz	0.20 + 0.2	0.25 + 0.2	0.1 + 1.0 µA	400 µH
	100 Hz to 1 kHz	0.50 + 0.5	0.60 + 0.5	0.05 + 1.0 µA	
330 µA to 3.29999 mA	10 to 100 Hz	0.20 + 0.3	0.25 + 0.3	0.15 + 1.5 µA	
	100 Hz to 1 kHz	0.50 + 0.8	0.60 + 0.8	0.06 + 1.5 µA	
3.3 to 32.9999 mA	10 to 100 Hz	0.07 + 4	0.08 + 4	0.15 + 5 µA	
	100 Hz to 1 kHz	0.18 + 10	0.20 + 10	0.05 + 5 µA	
33 to 329.999 mA	10 to 100 Hz	0.07 + 40	0.08 + 40	0.15 + 50 µA	
	100 Hz to 1 kHz	0.18 + 100	0.20 + 100	0.05 + 50 µA	
330 mA to 2.99999 A	10 to 100 Hz	0.10 + 200	0.12 + 200	0.2 + 500 µA	
	100 to 440 Hz	0.25 + 1000	0.30 + 1000	0.25 + 500 µA	
3.3 A to 20.5 A [1]	45 to 100 Hz	0.10 + 2000 [2]	0.12 + 2000 [2]	0.1 + 0 µA	400 µH [4]
	100 to 440 Hz	0.80 + 5000 [3]	1.00 + 5000 [3]	0.5 + 0 µA	

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure 3. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amps. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour. When the 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 3 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

[2] For currents >11 A, Floor specification is 4000 µA within 30 seconds of selecting operate. For operating times >30 seconds, the floor specification is 2000 µA.

[3] For currents >11 A, Floor specification is 1000 µA within 30 seconds of selecting operate. For operating times >30 seconds, the floor specification is 5000 µA.

[4] Subject to compliance voltages limits.

Range	Resolution µA	Max Compliance Voltage V rms [1]
29 to 329.99 µA	0.01	7
0.33 to 3.29999 mA	0.01	7
3.3 to 32.9999 mA	0.1	5
33 to 329.999 mA	1	5
0.33 to 2.99999 A	10	4
3 to 20.5 A	100	3

[1] Subject to specification adder for compliance voltages greater than 1 V rms.

Capacitance

Range	Absolute Uncertainty, tcal ±5 °C ±(% of output + floor) [1] [2] [3]		Resolution	Allowed Frequency or Charge-Discharge Rate		
	90 Day	1 Year		Min and Max to Meet Specification	Typical Max for <0.5 % Error	Typical Max for <1 % Error
220.0 to 399.9 pF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	20 kHz	40 kHz
0.4 to 1.0999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	30 kHz	50 kHz
1.1 to 3.2999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 3 kHz	30 kHz	50 kHz
3.3 to 10.999 nF	0.19 + 0.01 nF	0.25 + 0.01 nF	1 pF	10 Hz to 1 kHz	20 kHz	25 kHz
11 to 32.999 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	1 pF	10 Hz to 1 kHz	8 kHz	10 kHz
33 to 109.99 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	10 pF	10 Hz to 1 kHz	4 kHz	6 kHz
110 to 329.99 nF	0.19 + 0.3 nF	0.25 + 0.3 nF	10 pF	10 Hz to 1 kHz	2.5 kHz	3.5 kHz
0.33 to 1.0999 µF	0.19 + 1 nF	0.25 + 1 nF	100 pF	10 to 600 Hz	1.5 kHz	2 kHz
1.1 to 3.2999 µF	0.19 + 3 nF	0.25 + 3 nF	100 pF	10 to 300 Hz	800 Hz	1 kHz
3.3 to 10.999 µF	0.19 + 10 nF	0.25 + 10 nF	1 nF	10 to 150 Hz	450 Hz	650 Hz
11 to 32.999 µF	0.30 + 30 nF	0.40 + 30 nF	1 nF	10 to 120 Hz	250 Hz	350 Hz
33 to 109.99 µF	0.34 + 100 nF	0.45 + 100 nF	10 nF	10 to 80 Hz	150 Hz	200 Hz
110 to 329.99 µF	0.34 + 300 nF	0.45 + 300 nF	10 nF	0 to 50 Hz	80 Hz	120 Hz
0.33 to 1.0999 mF	0.34 + 1 µF	0.45 + 1 µF	100 nF	0 to 20 Hz	45 Hz	65 Hz
1.1 to 3.2999 mF	0.34 + 3 µF	0.45 + 3 µF	100 nF	0 to 6 Hz	30 Hz	40 Hz
3.3 to 10.999 mF	0.34 + 10 µF	0.45 + 10 µF	1 µF	0 to 2 Hz	15 Hz	20 Hz
11 to 32.999 mF	0.7 + 30 µF	0.75 + 30 µF	1 µF	0 to 0.6 Hz	7.5 Hz	10 Hz
33 to 110.00 mF	1.0 + 100 µF	1.1 + 100 µF	10 µF	0 to 0.2 Hz	3 Hz	5 Hz

[1] The output is continuously variable from 220 pF to 110 mF.

[2] Specifications apply to both dc charge/discharge capacitance meters and ac RCL meters. The maximum allowable peak voltage is 3 V. The maximum allowable peak current is 150 mA, with an rms limitation of 30 mA below 1.1 µF and 100 mA for 1.1 µF and above.

[3] The maximum lead resistance for no additional error in 2-wire COMP mode is 10 Ω.

Temperature Calibration (Thermocouple)

TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]		TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]	
		90 Day	1 Year			90 Day	1 Year
B	600 to 800	0.42	0.44	L	-200 to -100	0.37	0.37
	800 to 1000	0.34	0.34		-100 to 800	0.26	0.26
	1000 to 1550	0.30	0.30		800 to 900	0.17	0.17
	1550 to 1820	0.26	0.33	N	-200 to -100	0.30	0.40
C	0 to 150	0.23	0.30		-100 to -25	0.17	0.22
	150 to 650	0.19	0.26		-25 to 120	0.15	0.19
	650 to 1000	0.23	0.31		120 to 410	0.14	0.18
	1000 to 1800	0.38	0.50		410 to 1300	0.21	0.27
	1800 to 2316	0.63	0.84	R	0 to 250	0.48	0.57
E	-250 to -100	0.38	0.50		250 to 400	0.28	0.35
	-100 to -25	0.12	0.16		400 to 1000	0.26	0.33
	-25 to 350	0.10	0.14		1000 to 1767	0.30	0.40
	350 to 650	0.12	0.16	S	0 to 250	0.47	0.47
	650 to 1000	0.16	0.21		250 to 1000	0.30	0.36
J	-210 to -100	0.20	0.27		1000 to 1400	0.28	0.37
	-100 to -30	0.12	0.16		1400 to 1767	0.34	0.46
	-30 to 150	0.10	0.14	T	-250 to -150	0.48	0.63
	150 to 760	0.13	0.17		-150 to 0	0.18	0.24
	760 to 1200	0.18	0.23		0 to 120	0.12	0.16
K	-200 to -100	0.25	0.33		120 to 400	0.10	0.14
	-100 to -25	0.14	0.18	U	-200 to 0	0.56	0.56
	-25 to 120	0.12	0.16		0 to 600	0.27	0.27
	120 to 1000	0.19	0.26				
	1000 to 1372	0.30	0.40				

[1] Temperature standard ITS-90 or IPTS-68 is selectable.
TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.
[2] Resolution is 0.01 °C
[3] Does not include thermocouple error

Temperature Calibration (RTD)

RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2]	
		90 Day	1 Year
Pt 385, 100 Ω	-200 to -80	0.04	0.05
	-80 to 0	0.05	0.05
	0 to 100	0.07	0.07
	100 to 300	0.08	0.09
	300 to 400	0.09	0.10
	400 to 630	0.10	0.12
	630 to 800	0.21	0.23
Pt 3926, 100 Ω	-200 to -80	0.04	0.05
	-80 to 0	0.05	0.05
	0 to 100	0.07	0.07
	100 to 300	0.08	0.09
	300 to 400	0.09	0.10
	400 to 630	0.10	0.12
Pt 3916, 100 Ω	-200 to -190	0.25	0.25
	-190 to -80	0.04	0.04
	-80 to 0	0.05	0.05
	0 to 100	0.06	0.06
	100 to 260	0.06	0.07
	260 to 300	0.07	0.08
	300 to 400	0.08	0.09
	400 to 600	0.08	0.10
	600 to 630	0.21	0.23
Pt 385, 200 Ω	-200 to -80	0.03	0.04
	-80 to 0	0.03	0.04
	0 to 100	0.04	0.04
	100 to 260	0.04	0.05
	260 to 300	0.11	0.12
	300 to 400	0.12	0.13
	400 to 600	0.12	0.14
	600 to 630	0.14	0.16

RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2]	
		90 Day	1 Year
Pt 385, 500 Ω	-200 to -80	0.03	0.04
	-80 to 0	0.04	0.05
	0 to 100	0.05	0.05
	100 to 260	0.06	0.06
	260 to 300	0.07	0.08
	300 to 400	0.07	0.08
	400 to 600	0.08	0.09
	600 to 630	0.09	0.11
Pt 385, 1000 Ω	-200 to -80	0.03	0.03
	-80 to 0	0.03	0.03
	0 to 100	0.03	0.04
	100 to 260	0.04	0.05
	260 to 300	0.05	0.06
	300 to 400	0.05	0.07
	400 to 600	0.06	0.07
	600 to 630	0.22	0.23
PtNi 385, 120 Ω (Ni120)	-80 to 0	0.06	0.08
	0 to 100	0.07	0.08
	100 to 260	0.13	0.14
Cu 427 10 Ω [3]	-100 to 260	0.3	0.3

[1] Resolution is 0.003 °C
[2] Applies for COMP OFF (to the 5502A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.
[3] Based on MINCO Application Aid No. 18

Phase

1-Year Absolute Uncertainty, tcal ±5 °C, (Δ Φ °)					
Frequency (Hz)					
10 to 65 Hz	65 to 500 Hz	500 Hz to 1 kHz	1 to 5 kHz	5 to 10 kHz	10 to 30 kHz
0.15 °	0.9 °	2 °	6 °	10 °	15 °

Note
See Power and Dual Output Limit Specifications for applicable outputs.

Phase (Φ) Watts	Phase (Φ) VARs	PF	Power Uncertainty Adder due to Phase Error				
			10 to 65 Hz	65 to 500 Hz	500 Hz to 1 kHz	1 to 5 kHz	5 to 10 kHz
			0.00 %	0.01 %	0.06 %	0.55 %	1.52 %
5 °	85 °	0.996	0.02 %	0.15 %	0.37 %	1.46 %	3.04 %
10 °	80 °	0.985	0.05 %	0.29 %	0.68 %	2.39 %	4.58 %
15 °	75 °	0.966	0.07 %	0.43 %	1.00 %	3.35 %	6.17 %
20 °	70 °	0.940	0.10 %	0.58 %	1.33 %	4.35 %	7.84 %
25 °	65 °	0.906	0.12 %	0.74 %	1.69 %	5.42 %	9.62 %
30 °	60 °	0.866	0.15 %	0.92 %	2.08 %	6.58 %	11.54 %
35 °	55 °	0.819	0.18 %	1.11 %	2.50 %	7.87 %	13.68 %
40 °	50 °	0.766	0.22 %	1.33 %	2.99 %	9.32 %	16.09 %
45 °	45 °	0.707	0.26 %	1.58 %	3.55 %	11.00 %	18.88 %
50 °	40 °	0.643	0.31 %	1.88 %	4.22 %	13.01 %	22.21 %
55 °	35 °	0.574	0.37 %	2.26 %	5.05 %	15.48 %	26.32 %
60 °	30 °	0.500	0.45 %	2.73 %	6.11 %	18.65 %	31.60 %
65 °	25 °	0.423	0.56 %	3.38 %	7.55 %	22.96 %	38.76 %
70 °	20 °	0.342	0.72 %	4.33 %	9.65 %	29.27 %	49.23 %
75 °	15 °	0.259	0.98 %	5.87 %	13.09 %	39.56 %	66.33 %
80 °	10 °	0.174	1.49 %	8.92 %	19.85 %	59.83 %	100.00 %
85 °	5 °	0.087	2.99 %	17.97 %	39.95 %		
90 °	0 °	0.000	—	—			

To calculate exact ac watts power adders due to phase uncertainty for values not shown, use the subsequent formula:

$$Adder(\%) = 100(1 - \frac{Cos(\Phi + \Delta\Phi)}{Cos(\Phi)})$$

For example: For a PF of .9205 (Φ = 23) and a phase uncertainty of $\Delta\Phi =$ 0.15, the ac watts power adder is:

$$Adder(\%) = 100(1 - \frac{Cos(23 + .15)}{Cos(23)}) = 0.11\%$$

AC and DC Power Specifications

Power is simulated through the controlled simultaneous outputs of voltage and current from the Calibrator. While the amplitude and frequency ranges of the outputs are broad, there are certain combinations of voltage and current where the specifications are valid. In general these are for all dc voltages and currents, and AC voltages of 30 mV to 1020 V, ac currents from 33 mA to 20.5 A, for frequencies from 10 Hz to 30 kHz. Operation outside of these areas, within the overall calibrator capabilities, is possible, but it is not specified. The table and figure below illustrate the specified areas where power and dual output are possible.

Specification Limits for Power and Dual Output Operation

Frequency	Voltages (NORMAL)	Currents	Voltages (AUX)	Power Factor (PF)
dc	0 to ±1020 V	0 to ±20.5 A	0 to ±7 V	—
10 to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.99999 A	10 mV to 5 V	0 to 1
45 to 65 Hz	33 mV to 1020 V	3.3 mA to 20.5 A	10 mV to 5 V	0 to 1
65 to 500 Hz	330 mV to 1020 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
65 to 500 Hz	3.3 to 1020 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
500 Hz to 1 kHz	330 mV to 1020 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
1 to 5 kHz	3.3 to 500 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
5 to 10 kHz	3.3 to 250 V	33 to 329.99 mA	1 to 5 V	0 to 1
10 to 30 kHz	3.3 V to 250 V	33 mA to 329.99 mA	1 V to 3.29999 V	0 to 1

Notes

The range of voltages and currents shown in “DC Voltage Specifications,” “DC Current Specifications,” “AC Voltage (Sine Wave) Specifications,” and “AC Current (Sine Wave) Specifications” are available in the power and dual output modes (except minimum current for ac power is 0.33 mA). Only those limits shown in this table and illustrated in the following figure are specified.

See “Calculate Power Uncertainty” to determine the uncertainty at these points.

The phase adjustment range for dual ac outputs is 0 ° to ±179.99 °. The phase resolution for dual ac outputs is 0.01 °.

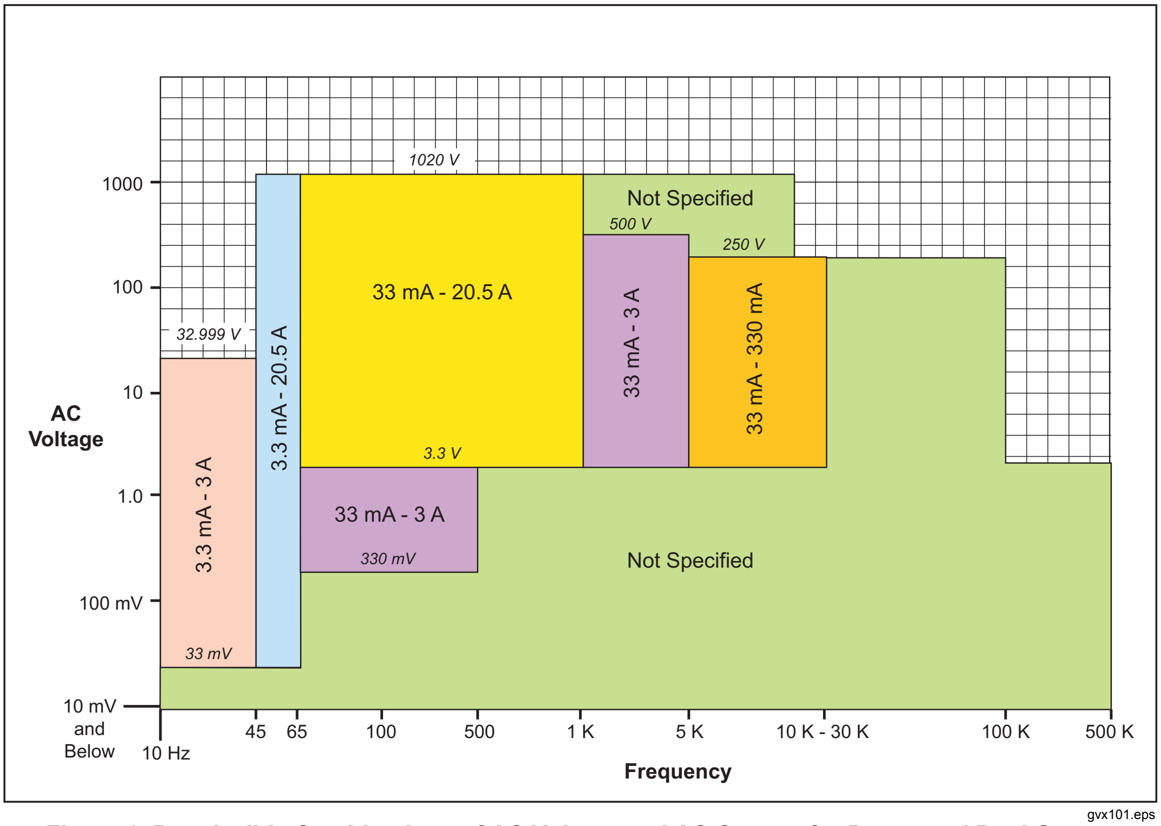


Figure 6. Permissible Combinations of AC Voltage and AC Current for Power and Dual Output

Calculate the Uncertainty Specifications of Power and Dual Output Settings

Overall uncertainty for power output in watts (or VARs) is based on the root sum square (rss) of the individual uncertainties in percent for the selected voltage, current, and, if AC power, the phase parameters:

Watts uncertainty $$U_{\text{power}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{Current}} + U^2_{\text{Phase}}}$$

VARs uncertainty $$U_{\text{VARs}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{Current}} + U^2_{\text{Phase}}}$$

Dual Output uncertainty $$U_{\text{Dual}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{AuxVoltage}} + U^2_{\text{Phase}}}$$

Because there are an infinite number of combinations, you must calculate the actual ac power uncertainty for your selected parameters. The results of this method of calculation are shown in the subsequent example. These examples are at various selected calibrator settings (with 1-year specifications):

Examples of Specified Power Uncertainties at Various Output Settings:

Selected Output Settings						Absolute Uncertainty as specified for tcal ±5 °C, ±(% of output setting)			Power Absolute Unceraintyy ±(% of Watts)[1]
Voltage Setting (Volts)	Current Setting (Amps)	Frequency Hz	Phase Setting (units of PF)	Phase Setting (Degrees)	Selected Power (Watts)	$U_{Voltage}$	$U_{Current}$	U_{Phase}	U_{Power}
+10.000	+0.500.000	DC	[redacted]	[redacted]	5	0.00550 %	0.04680 %	[redacted]	0.047 %
15.000	+2.0000	DC	[redacted]	[redacted]	30	0.00533 %	0.03220 %	[redacted]	0.033 %
100.000	+20.000	DC	[redacted]	[redacted]	2000	0.00600 %	0.10375 %	[redacted]	0.104 %
1000.00	20.000	DC	[redacted]	[redacted]	20000	0.00565 %	0.10375 %	[redacted]	0.104 %
120.000	1.00000	60	1	0.0	120	0.05250 %	0.06000 %	0.000 %	0.080 %
120.000	1.00000	60	0.766	40.0	91.92	0.05250 %	0.06000 %	0.220 %	0.234 %
240.000	1.00000	50	1	0.0	240	0.05125 %	0.06000 %	0.000 %	0.079 %
240.000	1.00000	50	0.766	40.0	183.84	0.05125 %	0.06000 %	0.220 %	0.234 %
1000.00	20	55	1	0.0	20000	0.05200 %	0.14500 %	0.000 %	0.154 %
1000.00	20	55	0.766	40.0	15320	0.05200 %	0.14500 %	0.220 %	0.269 %
1000.00	20	55	-0.906	-25.0	18120	0.05200 %	0.14500 %	0.122 %	0.196 %
100	0.30	30000	1	0.0	30.0	0.12900 %	0.4667 %	3.407 %	3.442 %
100	0.30	30000	0.766	40.0	22.98	0.12900 %	0.4667 %	25.128 %	25.133 %

[1] Add 0.02 % unless a settling time of 30 seconds is allowed for output currents >10 A or for currents on the highest two current ranges within 30 seconds of an output current >10 A.

Calculate Power Uncertainty

Overall uncertainty for power output in watts (or VARs) is based on the root sum square (RSS) of the individual uncertainties in percent for the selected voltage, current, and phase parameters:

Watts uncertainty $U_{\text{Power}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{Current}} + U^2_{\text{Phase}}}$

VARs uncertainty $U_{\text{VARs}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{Current}} + U^2_{\text{Phase}}}$

Because there are an infinite number of combinations, you must calculate the actual ac power uncertainty for your selected parameters. The method of calculation is best shown in the subsequent examples (with 1-year specifications):

Example 1 Output: 100 V, 1 A, 60 Hz, Power Factor = 1.0 (Φ=0).

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.050 % + 3 mV, totaling: 100 V x .0.0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = 0.053 % (see “AC Voltage (Sine Wave) Specifications”).

Current Uncertainty Uncertainty for 1 A at 60 Hz is 0.05 % +100 μA, totaling: 1 A x 0.0005 = 500 μA added to 100 μA = 0.6 mA. Expressed in percent: 0. 6 mA/1 A x 100 = 0.06 % (see “AC Current (Sine Waves) Specifications”).

Phase Uncertainty (Watts) Adder for PF = 1 (Φ=0) at 60 Hz is 0 % (see “Phase Specifications”).

Total Power Uncertainty = $U_{\text{power}} = \sqrt{0.053^2 + 0.06^2 + 0^2} = 0.080\%$

Example 2 Output: 100 V, 1 A, 400 Hz, Power Factor = 0.5 (Φ=60)

Voltage Uncertainty Uncertainty for 100 V at 400 Hz is 0.050% + 3 mV, totaling: 100 V x .0.0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = 0.053 % (see “AC Voltage (Sine Wave) Specifications”).

Current Uncertainty Uncertainty for 1 A at 400 Hz is 0.05 % +100 μA, totaling: 1 A x 0.0005 = 500 μA added to 100 μA = 0.6 mA. Expressed in percent: 0. 6 mA/1 A x 100 = 0.06 % (see “AC Current (Sine Waves) Specifications”).

Phase Uncertainty (Watts) Adder for PF = 0.5 (Φ=60) at 400 Hz is 2.73 % (see “Phase Specifications”).

Total Power Uncertainty = $U_{\text{power}} = \sqrt{0.021^2 + 0.06^2 + 2.73^2} = 2.73\%$

VARs When the Power Factor approaches 0.0, the Watts output uncertainty becomes unrealistic because the dominant characteristic is the VARs (volts-amps-reactive) output. In these cases, calculate the Total VARs Output Uncertainty, as shown in example 3:

Example 3 Output: 100 V, 1 A, 60 Hz, Power Factor = 0.174 (Φ=80)

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.050% + 3 mV, totaling: 100 V x .0.0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = 0.053 % (see “AC Voltage (Sine Wave) Specifications”).

Current Uncertainty Uncertainty for 1 A at 60 Hz is 0.05 % +100 μA, totaling: 1 A x 0.0005 = 500 μA added to 100 μA = 0.6 mA. Expressed in percent: 0. 6 mA/1 A x 100 = 0.06 % (see “AC Current (Sine Waves) Specifications”).

Phase Uncertainty (VARs) Adder for Φ=80 at 60 Hz is 0.05 % (see "Phase Specifications").

Total VARS Uncertainty = $U_{VARs} = \sqrt{0.053^2 + 0.06^2 + 0.05^2} = 0.094\,\%$

Additional Specifications

The subsequent paragraphs provide additional specifications for the 5502A Calibrator ac voltage and ac current functions. These specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5502A has been turned off. All extended range specifications are based on performing the internal zero-cal function at weekly intervals, or when the ambient temperature changes by more than 5 °C.

Frequency

Frequency Range	Resolution	1-Year Absolute Uncertainty, tcal ±5 °C ±(ppm + mHz)	Jitter
0.01 to 119.99 Hz	0.01 Hz	25 + 1	2 µs
120.0 to 1199.9 Hz	0.1 Hz	25 + 1	2 µs
1.2 to 11.999 kHz	1 Hz	25 + 1	2 µs
12 to 119.99 kHz	10 Hz	25 + 15	140 ns
120.0 to 1199.9 kHz	100 Hz	25 + 15	140 ns
1.2 to 2.000 MHz	1 kHz	25 + 15	140 ns

Harmonics (2^{nd} to 50^{th})

Fundamental Frequency [1]	Voltages NORMAL Terminals	Currents	Voltages AUX Terminals	Amplitude Uncertainty
10 to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.99999 A	10 mV to 5 V	Same % of output as the equivalent single output, but twice the floor adder.
45 to 65 Hz	33 mV to 1020 V	3.3 mA to 20.5 A	10 mV to 5 V	
65 to 500 Hz	33 mV to 1020 V	33 mA to 20.5 A	100 mV to 5 V	
500 Hz to 5 kHz	330 mV to 1020 V	33 mA to 20.5 A	100 mV to 5 V	
5 to 10 kHz	3.3 to 1020 V	33 to 329.9999 mA	100 mV to 5 V	
10 to 30 kHz	3.3 to 1020 V	33 to 329.9999 mA	100 mV to 3.29999 V	

[1] The maximum frequency of the harmonic output is 30 kHz (10 kHz for 3.3 to 5 V on the Aux terminals). For example, if the fundamental output is 5 kHz, the maximum selection is the 6th harmonic (30 kHz). All harmonic frequencies (2nd to 50th) are available for fundamental outputs between 10 Hz and 600 Hz (200 Hz for 3.3 to 5 V on the Aux terminals).

Phase Uncertainty.. Phase uncertainty for harmonic outputs is 1 degree or the phase uncertainty shown in "Phase Specifications" for the particular output, whichever is greater. For example, the phase uncertainty of a 400 Hz fundamental output and 10 kHz harmonic output is 10 ° (from "Phase Specifications"). Another example, the phase uncertainty of a 50 Hz fundamental output and a 400 Hz harmonic output is 1 degree.

Example of determining Amplitude Uncertainty in a Dual Output Harmonic Mode

What are the amplitude uncertainties for the following dual outputs?

NORMAL (Fundamental) Output:

100 V, 100 Hz .... From "AC Voltage (Sine Wave) 90 Day Specifications" the single output specification for 100 V, 100 Hz, is 0.039 % + 3 mV. For the dual output in this example, the specification is 0.039 % + 6 mV as the 0.039 % is the same, and the floor is twice the value (2 x 3 mV).

AUX (50th Harmonic) Output:

100 mV, 5 kHz .... From "AC Voltage (Sine Wave) 90 Day Specifications" the auxiliary output specification for 100 mV, 5 kHz, is 0.15 % + 450 µV. For the dual output in this example, the specification is 0.15 % + 900 µV as the 0.15 % is the same, and the floor is twice the value (2 x 450 µV).

AC Voltage (Sine Wave) Extended Bandwidth

Range	Frequency	1-Year Absolute Uncertainty tcal ±5 °C	Max Voltage Resolution
Normal Channel (Single Output Mode)			
1.0 to 33 mV	0.01 to 9.99 Hz	±(5.0 % of output +0.5 % of range)	Two digits, e.g., 25 mV
34 to 330 mV			Three digits
0.4 to 33 V			Two digits
0.3 to 3.3 V	500.1 kHz to 1 MHz	-10 dB at 1 MHz, typical	Two digits
	1.001 to 2 MHz	-31 dB at 2 MHz, typical	
Auxiliary Output (Dual Output Mode)			
10 to 330 mV	0.01 to 9.99 Hz	±(5.0 % of output +0.5 % of range)	Three digits
0.4 to 5 V			Two digits

AC Voltage (Non-Sine Wave)

Triangle Wave & Truncated Sine Range, p-p [1]	Frequency	1-Year Absolute Uncertainty, tcal ±5 °C, ±(% of output + % of range) [2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 to 92.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
93 to 929.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
0.93 to 9.29999 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
9.3 to 93 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
29 to 929.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	5.0 + 0.5	
0.93 to 9.29999 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	5.0 + 0.5	
9.3 to 14.0000 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	5.0 + 0.5	

[1] To convert p-p to rms for triangle wave, multiply the p-p value by 0.2886751. To convert p-p to rms for truncated sine wave, multiply the p-p value by 0.2165063.

[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.

[3] Uncertainty for Truncated Sine outputs is typical over this frequency band.

AC Voltage (Non-Sine Wave) (cont.)

Square Wave Range (p-p) [1]	Frequency	1-Year Absolute Uncertainty, tcal ±5 °C, ±(% of output + % of range) [2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 to 65.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
66 to 659.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
0.66 to 6.59999 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
6.6 to 66.0000 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
29 to 659.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz [3]	5.0 + 0.5	
0.66 to 6.59999 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz [3]	5.0 + 0.5	
6.6 to 14.0000 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz [3]	5.0 + 0.5	

[1] To convert p-p to rms for square wave, multiply the p-p value by 0.5.
[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.
[3] Limited to 1 kHz for Auxiliary outputs ≥6.6 V p-p.

AC Voltage, DC Offset

Range [1] (Normal Channel)	Offset Range [2]	Max Peak Signal	1-Year Absolute Uncertainty, tcal ±5 °C [3] ±(% of dc output + floor)
Sine Waves (rms)			
3.3 to 32.999 mV	0 to 50 mV	80 mV	0.1 + 33 μV
33 to 329.999 mV	0 to 500 mV	800 mV	0.1 + 330 μV
0.33 to 3.29999 V	0 to 5 V	8 V	0.1 + 3300 μV
3.3 to 32.9999 V	0 to 50 V	55 V	0.1 + 33 mV
Triangle Waves and Truncated Sine Waves (p-p)			
9.3 to 92.999 mV	0 to 50 mV	80 mV	0.1 + 93 μV
93 to 929.999 mV	0 to 500 mV	800 mV	0.1 + 930 μV
0.93 to 9.29999 V	0 to 5 V	8 V	0.1 + 9300 μV
9.3 to 93.0000 V	0 to 50 V	55 V	0.1 + 93 mV
Square Waves (p-p)			
6.6 to 65.999 mV	0 to 50 mV	80 mV	0.1 + 66 μV
66 to 659.999 mV	0 to 500 mV	800 mV	0.1 + 660 μV
0.66 to 6.59999 V	0 to 5 V	8 V	0.1 + 6600 μV
6.6 to 66.0000 V	0 to 50 V	55 V	0.1 + 66 mV

[1] Offsets are not allowed on ranges above the highest range shown above.

[2] The maximum offset value is determined by the difference between the peak value of the selected voltage output and the allowable maximum peak signal. For example, a 10 V p-p square wave output has a peak value of 5 V, allowing a maximum offset up to ± 50 V to not exceed the 55 V maximum peak signal. The maximum offset values shown above are for the minimum outputs in each range.

[3] For frequencies 0.01 to 10 Hz, and 500 kHz to 2 MHz, the offset uncertainty is 5 % of output, ±1 % of the offset range.

AC Voltage, Square Wave Characteristics

Risetime @ 1 kHz Typical	Settling Time @ 1 kHz Typical	Overshoot @ 1 kHz Typical	Duty Cycle Range	Duty Cycle Uncertainty
<1 μs	<10 μs to 1 % of final value	<2 %	1 % to 99 % <3.3 V p-p. 0,01 Hz to 100 kHz	±(0.02 % of period + 100 ns), 50 % duty cycle ±(0.05 % of period + 100 ns), other duty cycles from 10 % to 90 %

AC Voltage, Triangle Wave Characteristics (typical)

Linearity to 1 kHz	Aberrations
0.3 % of p-p value, from 10 % to 90 % point	<1 % of p-p value, with amplitude >50 % of range

AC Current (Non-Sine Wave)

Triangle Wave & Truncated Sine Wave Range p-p	Frequency	1-Year Absolute Uncertainty tcal ±5 °C ±(% of output + % of range)	Max Current Resolution
0.047 to 0.92999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
0.93 to 9.29999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
9.3 to 92.9999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
93 to 929.999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 to 10 kHz	10 + 2	
0.93 to 8.49999 A [2]	10 to 45 Hz	0.5 + 1.0	Six digits
	45 Hz to 1 kHz	0.5 + 0.5	
	1 to 10 kHz	10 + 2	
8.5 to 57 A [2]	45 to 500 Hz	0.5 + 0.5	
	500 Hz to 1 kHz	1.0 + 1.0	

[1] Frequency limited to 1 kHz with LCOMP on.
[2] Frequency limited to 440 Hz with LCOMP on.

AC Current (Non-Sine Wave) (cont.)

Square Wave Range p-p	Frequency	1-Year Absolute Uncertainty tcal ±5 °C ±(% of output + % of range)	Max Current Resolution
0.047 to 0.65999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
0.66 to 6.59999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
6.6 to 65.9999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
66 to 659.999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 to 10 kHz	10 + 2	
0.66 to 5.99999 A [2]	10 to 45 Hz	0.5 + 1.0	
	45 Hz to 1 kHz	0.5 + 0.5	
	1 to 10 kHz	10 + 2	
6 to 41 A [2]	45 to 500 Hz	0.5 + 0.5	
	500 Hz to 1 kHz	1.0 + 1.0	

[1] Frequency limited to 1 kHz with LCOMP on.
[2] Frequency limited to 440 Hz with LCOMP on.

AC Current, Square Wave Characteristics (typical)

Range	LCOMP	Risetime	Settling Time	Overshoot
I <6 A @ 400 Hz	off	25 µs	40 µs to 1 % of final value	<10 % for <1 V Compliance
3 A & 20 A Ranges	on	100 µs	200 µs to 1 % of final value	<10 % for <1 V Compliance

AC Current, Triangle Wave Characteristics (typical)

Linearity to 400 Hz	Aberrations
0.3 % of p-p value, from 10 % to 90 % point	<1 % of p-p value, with amplitude >50 % of range