FLUKE®

5520A

Multi-Product Calibrator

Getting Started

PN 2075585
March 2003

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Safety Information

This Calibrator complies with IEC publication 1010-1 (1992-1), Safety Requirements for Electrical Measuring, Control and Laboratory Equipment, and ANSI/ISA-S82.01-1994, and CAN/CSA-C22.2 No. 1010.1-92. This manual contains information, warnings, and cautions that must be followed to ensure safe operation and to maintain the Calibrator in a safe condition. Use of this Calibrator in a manner not specified herein may impair the protection provided by the Calibrator.

This Calibrator is designed for IEC 1010-1 Installation Category II use. It is not designed for connection to circuits rated over 4800 VA.

Warning statements identify conditions or practices that could result in personal injury or loss of life.

Caution statements identify conditions or practices that could result in damage to equipment.

SYMBOLS MARKED ON THE CALIBRATOR

WARNING Risk of electric shock. Refer to the manual (see the Index for references).

GROUND Ground terminal to chassis (earth).

Attention Refer to the manual (see the Index for references). This symbol indicates that information about usage of a feature is contained in the manual.

AC POWER SOURCE

The Calibrator is intended to operate from an ac power source that will not apply more than 264V ac rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is required for safe operation.

USE THE PROPER FUSE

To avoid fire hazard, use only the specified replacement fuse:

- For 100 V or 120 V operation, use a 5A/250V time delay fuse (Fluke PN 109215).
- For 220 V or 240 V operation, use a 2.5A/250V time delay fuse (Fluke PN 851931).

GROUNDING THE CALIBRATOR

The Calibrator uses controlled overvoltage techniques that require the Calibrator to be grounded whenever normal mode or common mode ac voltages or transient voltages may occur. The enclosure must be grounded through the grounding conductor of the power cord, or through the rear panel CHASSIS GROUND binding post.

USE THE PROPER POWER CORD

Use only the power cord and connector appropriate for the voltage and plug configuration in your country.

Use only a power cord that is in good condition.

Refer power cord and connector changes to qualified service personnel.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate the Calibrator in an atmosphere of explosive gas.

CHECK INSULATION RATINGS

Verify that the voltage applied to the unit under test does not exceed the insulation rating of the UUT and the interconnecting cables.

DO NOT REMOVE COVER DURING OPERATION

To avoid personal injury or death, do not remove the Calibrator cover without first removing the power source connected to the rear panel. Do not operate the Calibrator without the cover properly installed. Normal calibration is accomplished with the cover closed. Access procedures and the warnings for such procedures are contained in the Service Manual. Service procedures are for qualified service personnel only.

DO NOT ATTEMPT TO OPERATE IF PROTECTION MAY BE IMPAIRED

If the Calibrator appears damaged or operates abnormally, protection may be impaired. Do not attempt to operate the Calibrator under these conditions. Refer all questions of proper Calibrator operation to qualified service personnel.

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Getting Started

Introduction

⚠⚠ Warning

If the 5520A Multi-Function Calibrator is operated in any way not specified by this manual or other documentation provided by Fluke, the protection provided by the Calibrator may be impaired.

The 5520A Multi-Function Calibrator (referred to throughout this manual as either "the 5520A Calibrator" or "the Calibrator") is a fully programmable precision source of the following:

- DC voltage from 0 V to ±1000 V.
- AC voltage from 1 mV to 1000 V, with output from 10 Hz to 500 kHz.
- AC current from 100 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 190 pF to 110 mF.
- Simulated output for eight types of Resistance Temperature Detectors (RTDs).
- Simulated output for eleven types of thermocouples.

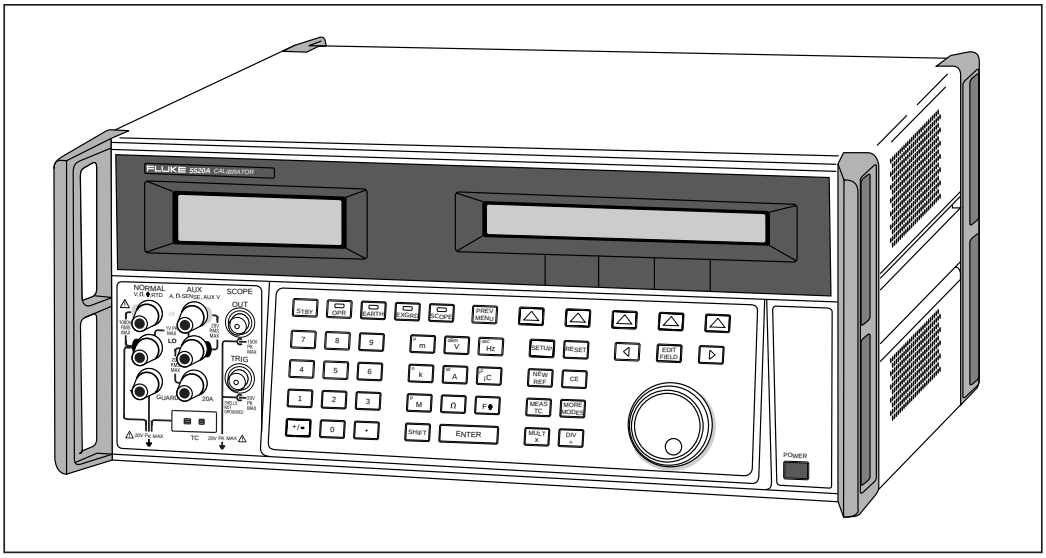

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Figure 1. 5520A Multi-Function Calibrator

Features of the 5520A Calibrator include the following:

- Automatic meter error calculation.
- MULT X and DIV ÷ keys that change the output value to pre-determined cardinal values for various functions.
- Programmable entry limits that prevent invalid amounts from being entered.
- Simultaneous output of voltage and current, up to an equivalent of 20.9 kW.
- Pressure measurement when used with Fluke 700 Series pressure modules.
- 10 MHz reference input and output. Use this to input a high-accuracy 10 MHz reference to transfer the frequency accuracy to the 5520A, or to synchronize one or more additional 5520As to a master 5520A.
- Simultaneous output of two voltages.
- Extended bandwidth mode outputs multiple waveforms down to 0.01 Hz, and sine waves to 2 MHz.
- Variable phase signal output.
- Standard IEEE-488 (GPIB) interface, complying with ANSI/IEEE Standards 488.1-1987 and 488.2-1987.
- EIA Standard RS-232-C serial data interface for printing, displaying, or transferring internally stored calibration constants, and for remote control of the 5520A.
- Pass-through RS-232-C serial data interface for communicating with the Unit Under Test (UUT).

Operation Overview

The 5520A Calibrator may be operated at the front panel in the local mode, or remotely using RS-232 or IEEE-488 ports. For remote operations, several software options are available to integrate 5520A operation into a wide variety of calibration requirements.

Local Operation

Typical local operations include front panel connections to the Unit Under Test (UUT), and then manual keystroke entries at the front panel to place the calibrator in the desired output mode. The front panel layout facilitates hand movements from left to right, and multiply and divide keys make it easy to step up or down at the press of a single key. You can also review 5520A Calibrator specifications at the push of two buttons. The backlit liquid crystal display is easy to read from many different viewing angles and lighting conditions, and the large, easy-to-read keys are color-coded and provide 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 (Figure 2). Each port is dedicated to serial data communications for operating and controlling the 5520A during calibration procedures. For complete information on remote operations, see Chapter 5 in the Operators Manual.

The SERIAL 1 FROM HOST serial data port connects a host terminal or personal computer to the 5520A. You have several choices for sending commands to the 5520A: you can enter commands from a terminal (or a PC running a terminal program), you can write your own programs using BASIC, or you can run optional Windows-based software such as 5500/CAL or MET/CAL. The 5500/CAL software includes more than 200 example procedures covering a wide range of test tools the 5520A can calibrate. (See Chapter 6 in the Operators Manual for a discussion of the RS-232 commands.)

The SERIAL 2 TO UUT serial data port connects a UUT to a PC or terminal via the 5520A (see Figure 2). This “pass-through” configuration eliminates 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 in the Operators Manual for a discussion of the UUT_* commands. The SERIAL 2 TO UUT port is also used to connect to the Fluke 700 series pressure modules.

Remote Operation (IEEE-488)

The 5520A rear panel IEEE-488 port is a fully programmable parallel interface bus meeting standard IEEE-488.1 and supplemental standard IEEE-488.2. Under the remote control of an instrument controller, the 5520A Calibrator operates exclusively as a “talker/listener.” You can write your own programs using the IEEE-488 command set or run the optional Windows-based MET/CAL software. (See Chapter 6 in the Operators Manual for a discussion of the commands available for IEEE-488 operation.)

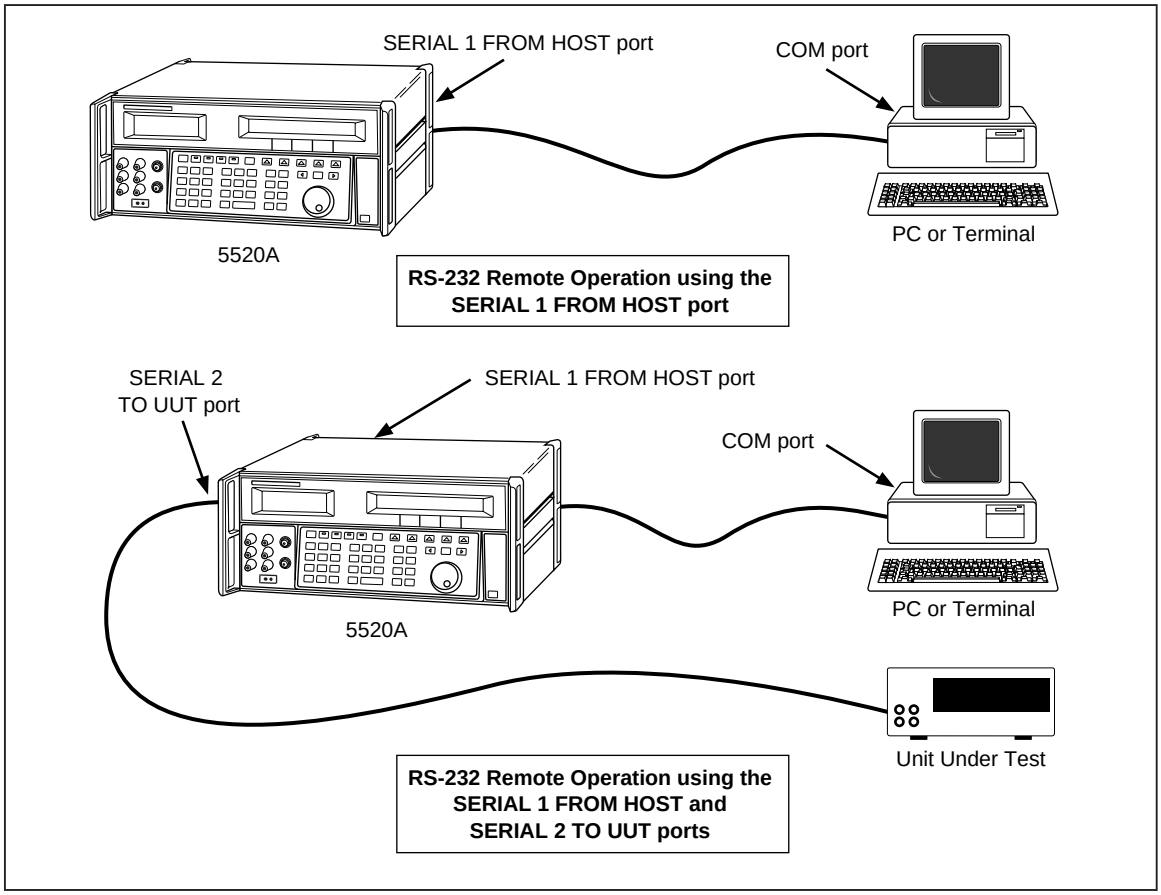

Figure 2. RS-232 Remote Connections

Where to Go from Here

To locate specific information in the Operators Manual (provided as a pdf file on the CD-ROM) refer to the following list:

- Unpacking and setup: Chapter 2, “Preparing for Operation”
- Installation and rack mounting: Chapter 2, “Preparing for Operation,” and the rack mount kit instruction sheet
- AC line power and interface cabling: Chapter 2, “Preparing for Operation”
- Controls, indicators, and displays: Chapter 3, “Features”
- Front panel operation: Chapter 4, “Front Panel Operation”
- Cabling to a UUT (Unit Under Test): Chapter 4, “Front Panel Operation”
- Remote operation (IEEE-488 or serial): Chapter 5, “Remote Operation”
- Calibrating an Oscilloscope: Chapter 8, “Oscilloscope Calibration Options”
- Accessories to the 5520A Calibrator: Chapter 9, “Accessories”
- Performance Specifications: Chapter 1, “Introduction and Specifications”

Instruction Manuals

The 5520A manual set provides complete information for operators and service or maintenance technicians. The set includes:

- *5520A Getting Started Manual* (PN 2075585)
- *5520A Operators Guide*
    - English (PN 688754)
    - French (PN 688751)
    - German (PN 688762)
    - Italian (PN 690511)
    - Spanish (PN 688769)
    - Japanese (PN 688770)
    - Simplified Chinese (PN 688777)
- *5520A Programmers Guide* (PN 688744)
- *5520A Operators Manual* provided on CD-ROM (printed copy available for purchase under PN 688739)
- *5520A Service Manual* provided on CD-ROM (printed copy available for purchase under PN 688747)

5520A Getting Started Manual

This *5520A Getting Started Manual* contains a brief introduction to the 5520A Manual Set, instructions on how to get your calibrator prepared for operation and a complete set of specifications.

5520A Operators Manual

The *5520A Operators Manual* provides complete information for installing the 5520A Calibrator and operating it from the front panel keys and in remote configurations. This manual also provides a glossary of calibration, specifications, and error code information. The Operators Manual includes the following topics:

- Installation
- Operating controls and features, including front panel operation
- Remote operation (IEEE-488 bus or serial port remote control)
- Serial port operation (printing, displaying, or transferring data, and setting up for serial port remote control)
- Operator maintenance, including verification procedures and calibration approach for the 5520A
- Oscilloscope calibration options
- Accessories

5520A Operators Guide

The *5520A Operators Guide* contains a summary of operating instructions, and a front panel and rear panel feature reference. It is available in seven languages.

5520A Programmers Guide

The *5520A Programmers Guide* contains a summary of remote commands and reference information useful in determining system status using the status byte and related registers.

5520A Service Manual

The *5520A Service Manual* includes: theory of operation, performance testing, maintenance, and calibration information.

Specifications

The following tables list the 5520A specifications. All specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5520A has been turned off. (For example, if the 5520A 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 t_{cal} ±5 °C (t_{cal} is the ambient temperature when the 5520A 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. (See "Zeroing the Calibrator" in Chapter 4 of the Operators Manual.)

Also see additional specifications later in this chapter for information on extended specifications for ac voltage and current. The dimensional outline for the 5520A Calibrator is shown in Figure 3.

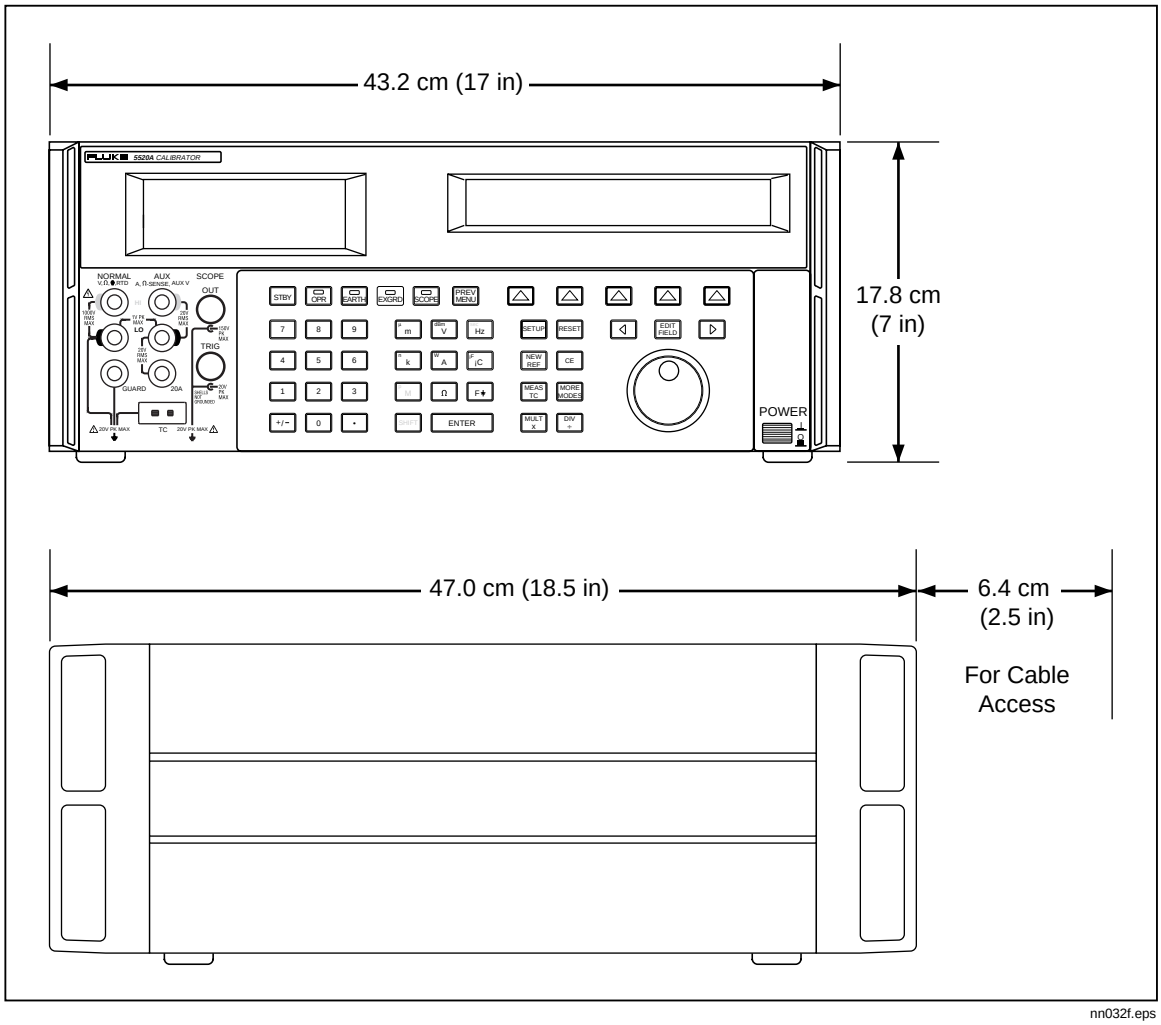

Figure 3. 5520A Calibrator Dimensional Outline

General Specifications

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, 5725A Amplifier
Temperature Performance	• Operating: 0 °C to 50 °C • Calibration (tcal): 15 °C to 35 °C • Storage: -20 °C to 70 °C [3]
Temperature Coefficient	Temperature Coefficient for temperatures outside tcal +5 °C is 0.1X/°C of the 90-day specification (or 1-year, as applicable) per °C.
Relative Humidity [1]	• Operating: <80% to 30 °C, <70% to 40 °C, <40% to 50 °C • Storage: <95%, non-condensing
Altitude	• Operating: 3,050 m (10,000 ft) maximum • Non-operating: 12,200 m (40,000 ft) maximum
Safety	Complies with IEC 1010-1 (1992-1); ANSI/ISA-S82.01-1994; CAN/CSA-C22.2 No. 1010.1-92
Analog Low Isolation	20 V
EMC	Designed to comply with FCC Rules Part 15; VFG 243/1991. If used in areas with Electromagnetic fields of 1 to 3 V/m, resistance outputs have a floor adder of 0.508•. Performance not specified above 3 V/m. This instrument may be susceptible to electro-static discharge (ESD) from direct contact to the binding posts. Good static aware practices should be followed when handling this and other pieces of electronic equipment.
Line Power [2]	• 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
Power Consumption	5500A Calibrator, 300 VA; 5725A Amplifier, 750 VA
Dimensions	5500A Calibrator: • Height: 17.8 cm (7 inches), standard rack increment, plus 1.5 cm (0.6 inch) for feet on bottom of unit; • Width: 43.2 cm (17 inches), standard rack width • Depth: 47.3 cm (18.6 inches) overall 5725A Amplifier: • Height, 13.3 cm (5.25 inches), standard rack increment, plus 1.5 cm (0.6 inch) for feet on bottom of unit; • Width, 43.2 cm (17 inches), standard rack width • Depth, 63.0 cm (24.8 inches) overall.
Weight (without options)	5500A Calibrator, 22 kg (49 lb); 5725A Amplifier 32 kg (70 pounds)
Absolute Uncertainty Definition	The 5500A 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 5520A for the temperature range indicated.
Specification Confidence Interval	99%

[1] After long periods of storage at high humidity, a drying out period (with the power on) of at least one week may be required.

[2] For optimal performance at full dual outputs (e.g. 1000 V, 20A) choose a line voltage setting that is ± 7.5% from nominal.

[3] 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 5520A 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.

DC Voltage Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + µV)		Stability	Resolution µV	Max Burden [1]
	90 days	1 year	24 hours, ± 1 °C ± (ppm output + µV)		
0 to 329.9999 mV	15 + 1	20 + 1	3 + 1	0.1	50 Ω
0 to 3.299999 V	9 + 2	11 + 2	2 + 1.5	1	10 mA
0 to 32.99999 V	10 + 20	12 + 20	2 + 15	10	10 mA
30 V to 329.9999 V	15 + 150	18 + 150	2.5 + 100	100	5 mA
100 V to 1000.000 V	15 + 1500	18 + 1500	3 + 300	1000	5 mA
Auxiliary Output (dual output mode only) [2]					
0 to 329.999 mV	300 + 350	400 + 350	30 + 100	1	5 mA
0.33 V to 3.29999 V	300 + 350	400 + 350	30 + 100	10	5 mA
3.3 V to 7 V	300 + 350	400 + 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	40 + 3	50 + 3	5 + 2	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 output + floor)	Bandwidth 10 Hz to 10 kHz rms
0 to 329.9999 mV	0 + 1 µV	6 µV
0 to 3.299999 V	0 + 10 µV	60 µV
0 to 32.99999 V	0 + 100 µV	600 µV
30 to 329.9999 V	10 + 1 mV	20 mV
100 to 1000.000 V	10 + 5 mV	20 mV
Auxiliary Output (dual output mode only) [1]		
0 to 329.999 mV	0 + 5 µV	20 µV
0.33 V to 3.29.999 V	0 + 20 µV	200 µV
3.3 V to 7 V	0 + 100 µV	1000 µV

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

DC Current Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + µA)		Resolution	Max Compliance Voltage V	Max Inductive Load mH
	90 days	1 year			
0 to 329.999 mA	120 + 0.02	150 + 0.02	1 nA	10	400
0 to 3.29999 mA	80 + 0.05	100 + 0.05	0.01 mA	10	
0 to 32.9999 mA	80 + 0.25	100 + 0.25	0.1 mA	7	
0 to 329.999 mA	80 + 2.5	100 + 2.5	1 mA	7	
0 to 1.09999 A	160 + 40	200 + 40	10 mA	6	
1.1 to 2.99999 A	300 + 40	380 + 40	10 mA	6	
0 to 10.9999 A (20 A Range)	380 + 500	500 + 500	100 mA	4	
11 to 20.5 A [1]	800 + 750 [2]	1000 + 750 [2]	100 mA	4	

[1] Duty Cycle: Currents < 11 A may be provided continuously. For currents >11 A, see Figure 1-4. 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 amperes. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour.

[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

DC Current Specifications *(cont)*

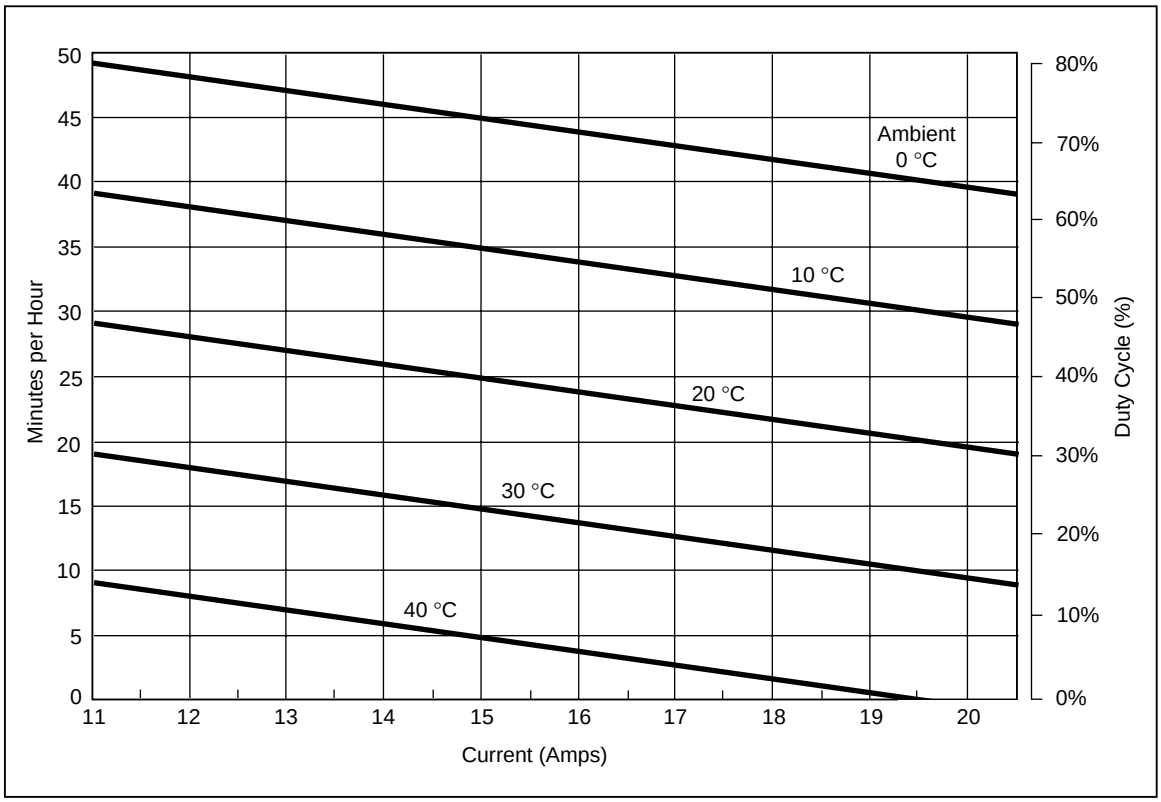

Figure 4. Allowable Duration of Current >11 A

Resistance Specifications

Range [1]	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + floor) [2]				Resolution Ω	Allowable Current [3]
	ppm of output		Floor Time & temp since ohms zero cal			
	90 days	1 year	12 hrs ± 1 °C	7 days ± 5 °C		
0 to 10.9999 Ω	35	40	0.001	0. 01	0.0001	1 mA to 125 mA
11 Ω to 32.9999 Ω	25	30	0.0015	0.015	0.0001	1 mA to 125 mA
33 Ω to 109.9999 Ω	22	28	0.0014	0.015	0.0001	1 mA to 70 mA
110 Ω to 329.9999 Ω	22	28	0.002	0.02	0.0001	1 mA to 40 mA
330 Ω to 1.099999 kΩ	22	28	0.002	0.02	0.001	1 mA to 18 mA
1.1 kΩ to 3.299999 kΩ	22	28	0.02	0.2	0.001	100 µA to 5 mA
3.3 kΩ to 10.99999 kΩ	22	28	0.02	0.1	0.01	100 µA to 1.8 mA
11 kΩ to 32.99999 kΩ	22	28	0.2	1	0.01	10 µA to 0.5 mA
33 kΩ to 109.9999 kΩ	22	28	0.2	1	0. 1	10 µA to 0.18 mA
110 kΩ to 329.9999 kΩ	25	32	2	10	0.1	1 µA to 0.05 mA
330 kΩ to 1.099999 MΩ	25	32	2	10	1	1 µA to 0.018 mA
1.1 MΩ to 3.299999 MΩ	40	60	30	150	1	250 nA to 5 µA
3.3 MΩ to 10.99999 MΩ	110	130	50	250	10	250 nA to 1.8 µA
11 MΩ to 32.99999 MΩ	200	250	2500	2500	10	25 nA to 500 nA
33 MΩ to 109.9999 MΩ	400	500	3000	3000	100	25 nA to 180 nA
110 MΩ to 329.9999 MΩ	2500	3000	100000	100000	1000	2.5 nA to 50 nA
330 MΩ to 1100 MΩ	12000	15000	500000	500000	10000	1 nA to 13 nA

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

[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 = (0.022 + 0.005) Ω =0.007Ω.

[3] 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) Specifications

NORMAL (Normal Output)						
Range	**Frequency**	**Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + µV)**		**Resolution**	**Max Burden**	**Max Distortion and Noise 10 Hz to 5 MHz Bandwidth ± (% output + floor)**
		90 days	**1 year**			
1.0 mV to 32.999 mV	10 Hz to 45 Hz	600 + 6	800 + 6	1 µV	50 Ω	0.15 + 90 µV
	45 Hz to 10 kHz	120 + 6	150 + 6			0.035 + 90 µV
	10 kHz to 20 kHz	160 + 6	200 + 6			0.06 + 90 µV
	20 kHz to 50 kHz	800 + 6	1000 + 6			0.15 + 90 µV
	50 kHz to 100 kHz	3000 + 12	3500 + 12			0.25 + 90 µV
	100 kHz to 500 kHz	6000 + 50	8000 + 50			0.3 + 90 µV [1]
33 mV to 329.999 mV	10 Hz to 45 Hz	250 + 8	300 + 8	1 µV	50 Ω	0.15 + 90 µV
	45 Hz to 10 kHz	140 + 8	145 + 8			0.035 + 90 µV
	10 kHz to 20 kHz	150 + 8	160 + 8			0.06 + 90 µV
	20 kHz to 50 kHz	300 + 8	350 + 8			0.15 + 90 µV
	50 kHz to 100 kHz	600 + 32	800 + 32			0.20 + 90 µV
	100 kHz to 500 kHz	1600 + 70	2000 + 70			0.20 + 90 µV [1]
0.33 V to 3.29999 V	10 Hz to 45 Hz	250 + 50	300 + 50	10 µV	10 mA	0.15 + 200 µV
	45 Hz to 10 kHz	140 + 60	150 + 60			0.035 + 200 µV
	10 kHz to 20 kHz	160 + 60	190 + 60			0.06 + 200 µV
	20 kHz to 50 kHz	250 + 50	300 + 50			0.15 + 200 µV
	50 kHz to 100 kHz	550 + 125	700 + 125			0.20 + 200 µV
	100 kHz to 500 kHz	2000 + 600	2400 + 600			0.20 + 200 µV [1]
3.3 V to 32.9999 V	10 Hz to 45 Hz	250 + 650	300 + 650	100 µV	10 mA	0.15 + 2 mV
	45 Hz to 10 kHz	125 + 600	150 + 600			0.035 + 2 mV
	10 kHz to 20 kHz	220 + 600	240 + 600			0.08 + 2 mV
	20 kHz to 50 kHz	300 + 600	350 + 600			0.2 + 2 mV
	50 kHz to 100 kHz	750 + 1600	900 + 1600			0.5 + 2 mV
33 V to 329.999 V	45 Hz to 1 kHz	150 + 2000	190 + 2000	1 mV	5 mA, except 20 mA for 45 Hz to 65 Hz	0.15 + 10 mV
	1 kHz to 10 kHz	160 + 6000	200 + 6000			0.05 + 10 mV
	10 kHz to 20 kHz	220 + 6000	250 + 6000			0.6 + 10 mV
	20 kHz to 50 kHz	240 + 6000	300 + 6000			0.8 + 10 mV
	50 kHz to 100 kHz	1600 + 50000	2000 + 50000			1.0 + 10 mV
330 V to 1020 V	45 Hz to 1 kHz	250 + 10000	300 + 10000	10 mV	2 mA, except 6 mA for 45 Hz to 65 Hz	0.15 + 30 mV
	1 kHz to 5 kHz	200 + 10000	250 + 10000			0.07 + 30 mV
	5 kHz to 10 kHz	250 + 10000	300 + 10000			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 < 1Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.

AC Voltage (Sine Wave) Specifications *(cont)*

AUX (Auxiliary Output) [dual output mode only] [1]						
		Absolute Uncertainty, tcal ± 5 °C ± (% of output + µV)				Max Distortion and Noise 10 Hz to 100 kHz Bandwidth
Range	Frequency	90 days	1 year	Res-olution	Max Burden	± (% output + floor)
10 mV to 329.999 mV	10 Hz to 20 Hz	0.15 + 370	0.2 + 370	1 µV	5 mA	0.2 + 200 µV
	20 Hz to 45 Hz	0.08 + 370	0.1 + 370			0.06 + 200 µV
	45 Hz to 1 kHz	0.08 + 370	0.1 + 370			0.08 + 200 µV
	1 kHz to 5 kHz	0.15 + 450	0.2 + 450			0.3 + 200 µV
	5 kHz to 10 kHz	0.3 + 450	0.4 + 450			0.6 + 200 µV
	10 kHz to 30 kHz	4.0 + 900	5.0 + 900			1 + 200 µV
0.33 V to 3.29999 V	10 Hz to 20 Hz	0.15 + 450	0.2 + 450	10 µV	5 mA	0.2 + 200 µV
	20 Hz to 45 Hz	0.08 + 450	0.1 + 450			0.06 + 200 µV
	45 Hz to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 µV
	1 kHz to 5 kHz	0.15 + 1400	0.2 + 1400			0.3 + 200 µV
	5 kHz to 10 kHz	0.3 + 1400	0.4 + 1400			0.6 + 200 µV
	10 kHz to 30 kHz	4.0 + 2800	5.0 + 2800			1 + 200 µV
3.3 V to 5 V	10 Hz to 20 Hz	0.15 + 450	0.2 + 450	100 µV	5 mA	0.2 + 200 µV
	20 Hz to 45 Hz	0.08 + 450	0.1 + 450			0.06 + 200 µV
	45 Hz to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 µV
	1 kHz to 5 kHz	0.15 + 1400	0.2 + 1400			0.3 + 200 µV
	5 kHz to 10 kHz	0.3 +1400	0.4 + 1400			0.6 + 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 < 1Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits

AC Current (Sine Wave) Specifications

LCOMP off						
Range	**Frequency**	**Absolute Uncertainty, tcal ± 5 °C ± (% of output + µA)**		**Compliance adder ± (µA/V)**	**Max Distortion & Noise 10 Hz to 100 kHz BW ± (% output + floor)**	**Max Inductive Load**
		90 days	**1 year**			**µH**
29.00 µA to 329.99 µA	10 Hz to 20 Hz	0.16 + 0.1	0.2 + 0.1	0.05	0.15 + 0.5 µA	200
	20 Hz to 45 Hz	0.12 + 0.1	0.15 + 0.1	0.05	0.1 + 0.5 µA	
	45 Hz to 1 kHz	0.1 + 0.1	0.125 + 0.1	0.05	0.05 + 0.5 µA	
	1 kHz to 5 kHz	0.25 + 0.15	0.3 + 0.15	1.5	0.5 + 0.5 µA	
	5 kHz to 10 kHz	0.6 + 0.2	0.8 + 0.2	1.5	1.0 + 0.5 µA	
	10 kHz to 30 kHz	1.2 + 0.4	1.6 + 0.4	10	1.2 + 0.5 µA	
0.33 mA to 3.2999 mA	10 Hz to 20 Hz	0.16 + 0.15	0.2 + 0.15	0.05	0.15 + 1.5 µA	200
	20 Hz 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 kHz to 5 kHz	0.16 + 0.2	0.2 + 0.2	1.5	0.5 + 1.5 µA	
	5 kHz to 10 kHz	0.4 + 0.3	0.5 + 0.3	1.5	1.0 + 1.5 µA	
	10 kHz to 30 kHz	0.8 + 0.6	1.0 + 0.6	10	1.2 + 0.5 µA	
3.3 mA to 32.999 mA	10 Hz to 20 Hz	0.15 + 2	0.18 + 2	0.05	0.15 + 5 µA	50
	20 Hz 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 kHz to 5 kHz	0.065 + 2	0.08 + 2	1.5	0.3 + 5 µA	
	5 kHz to 10 kHz	0.16 + 3	0.2 + 3	1.5	0.7 + 5 µA	
	10 kHz to 30 kHz	0.32 + 4	0.4 + 4	10	1.0 + 0.5 µA	
33 mA to 329.99 mA	10 Hz to 20 Hz	0.15 +20	0.18 + 20	0.05	0.15 + 50 µA	50
	20 Hz 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 kHz to 5 kHz	0.08 + 50	0.10 + 50	1.5	0.03 + 50 µA	
	5 kHz to 10 kHz	0.16 + 100	0.2 + 100	1.5	0.1 + 50 µA	
	10 kHz to 30 kHz	0.32 + 200	0.4 + 200	10	0.6 + 50 µA	
0.33 A to 1.09999 A	10 Hz to 45 Hz	0.15 + 100	0.18 + 100		0.2 + 500 µA	2.5
	45 Hz to 1 kHz	0.036 + 100	0.05 + 100		0.07 + 500 µA	
	1 kHz to 5 kHz	0.5 + 1000	0.6 + 1000	[3]	1 + 500 µA	
	5 kHz to 10 kHz	2.0 + 5000	2.5 + 5000	[4]	2 + 500 µA	
1.1 A to 2.99999 A	10 Hz to 45 Hz	0.15 + 100	0.18 + 100		0.2 + 500 µA	2.5
	45 Hz to 1 kHz	0.05 + 100	0.06 + 100		0.07 + 500 µA	
	1 kHz to 5 kHz	0.5 + 1000	0.6 + 1000	[3]	1 + 500 µA	
	5 kHz to 10 kHz	2.0 + 5000	2.5 + 5000	[4]	2 + 500 µA	
3 A to 10.9999 A	45 Hz to 100 Hz	0.05 + 2000	0.06 + 2000		0.2 + 3 mA	1
	100 kHz 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	
11A to 20.5 A [2]	45 Hz 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 kHz to 5 kHz	2.5 + 5000	3.0 + 5000		0.8 + 3 mA	

[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.

[2] Duty Cycle: Currents < 11 A may be provided continuously. For currents > 11 A, see Figure 1-4. 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.

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

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

AC Current (Sine Wave) Specifications *(cont)*

LCOMP on					
Range	**Frequency**	**Absolute Uncertainty, tcal ± 5 °C ± (% of output + µA)**		**Max Distortion & Noise, 10 Hz to 100 kHz BW ± (% output + µA)**	**Max Inductive Load µH**
		90 days	**1 year**		
29.00 µA to	10 Hz to 100 Hz	0.2 + 0.2	0.25 + 0.2	0.1 + 1.0	400
329.99 µA	100 Hz to 1 kHz	0.5 + 0.5	0.6 + 0.5	0.05 + 1.0	
0.33 mA to	10 Hz to 100 Hz	0.2 + 0.3	0.25 + 0.3	0.15 + 1.5	
3.2999 mA	100 Hz to 1 kHz	0.5 + 0.8	0.6 + 0.8	0.06 + 1.5	
3.3 mA to	10 Hz to 100 Hz	0.07 + 4	0.08 + 4	0.15 + 5	
32.999 mA	100 Hz to 1 kHz	0.18 + 10	0.2 + 10	0.05 + 5	
33 mA to	10 Hz to 100 Hz	0.07 + 40	0.08 + 40	0.15 + 50	
329.99 mA	100 Hz to 1 kHz	0.18 + 100	0.2 + 100	0.05 + 50	
0.33 A to	10 Hz to 100 Hz	0.1 + 200	0.12 + 200	0.2 + 500	
2.99999 A	100 to 440 Hz	0.25 + 1000	0.3 + 1000	0.25 + 500	
3 A to 20.5 A	10 Hz to 100 Hz	0.1 + 2000 [2]	0.12 + 2000 [2]	0.1 + 0	400 [4]
[1]	100 Hz to 1 kHz	0.8 + 5000 [3]	1.0 + 5000 [3]	0.5 + 0	

[1] Duty Cycle: Currents < 11 A may be provided continuously. For currents >11 A, see Figure 1-4. 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 amperes. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour.

[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**
0.029 mA to 0.32999 mA	0.01	7
0.33 mA to 3.29999 mA	0.01	7
3.3 mA to 32.9999 mA	0.1	5
33 mA to 329.999 mA	1	5
0.33 A to 2.99999 A	10	4
3 A to 20.5 A	100	3

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

Capacitance Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (% of output + floor)		Res-olution	Allowed Frequency or Charge-Discharge Rate		
	90 days	1 year		Min and Max to Meet Specification	Typical Max for <0.5% Error	Typical Max for <1% Error
0.19 nF to 0.3999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	20 kHz	40 kHz
0.4 nF 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 nF 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 nF to 10.9999 nF	0.19 + 0.01 nF	0.25 + 0.01 nF	0.1 pF	10 Hz to 1 kHz	20 kHz	25 kHz
11 nF to 32.9999 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	0.1 pF	10 Hz to 1 kHz	8 kHz	10 kHz
33 nF to 109.999 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	1 pF	10 Hz to 1 kHz	4 kHz	6 kHz
110 nF to 329.999 nF	0.19 + 0.3 nF	0.25 + 0.3 nF	1 pF	10 Hz to 1 kHz	2.5 kHz	3.5 kHz
0.33 µF to 1.09999 µF	0.19 + 1 nF	0.25 + 1 nF	10 pF	10 Hz to 600 Hz	1.5 kHz	2 kHz
1.1 µF to 3.29999 µF	0.19 + 3 nF	0.25 + 3 nF	10 pF	10 Hz to 300 Hz	800 Hz	1 kHz
3.3 µF to 10.9999 µF	0.19 + 10 nF	0.25 + 10 nF	100 pF	10 Hz to 150 Hz	450 Hz	650 Hz
11 µF to 32.9999 µF	0.30 + 30 nF	0.40 + 30 nF	100 pF	10 Hz to 120 Hz	250 Hz	350 Hz
33 µF to 109.999 µF	0.34 + 100 nF	0.45 + 100 nF	1 nF	10 Hz to 80 Hz	150 Hz	200 Hz
110 µF to 329.999 µF	0.34 + 300 nF	0.45 + 300 nF	1 nF	0 to 50 Hz	80 Hz	120 Hz
0.33 µF to 1.09999mF	0.34 + 1 µF	0.45 + 1 µF	10 nF	0 to 20 Hz	45 Hz	65 Hz
1.1 mF to 3.2999 mF	0.34 + 3 µF	0.45 + 3 µF	10 nF	0 to 6 Hz	30 Hz	40 Hz
3.3 mF to 10.9999 mF	0.34 + 10 µF	0.45 + 10 µF	100 nF	0 to 2 Hz	15 Hz	20 Hz
11 mF to 32.9999 mF	0.7 + 30 µF	0.75 + 30 µF	100 nF	0 to 0.6 Hz	7.5 Hz	10 Hz
33 mF to 110 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 190 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) Specifications

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

[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) Specifications

RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2] 90 days	1 year
Pt 395, 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
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 5520A Calibrator front panel NORMAL terminals) and 2- wire and 4-wire compensation.
[3] Based on MINCO Application Aid No. 18

DC Power Specification Summary

		Current Range		
		0.33 mA to 329.99 mA	**0.33 A to 2.9999 A**	**3 A to 20.5 A**
	Voltage Range	**Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output) [1]**		
90 days	33 mV to 1020 V	0.021	0.019 [2]	0.06 [2]
1 year	33 mV to 1020 V	0.023	0.022 [2]	0.07 [2]

[1] To determine dc power uncertainty with more precision, see the individual "AC Voltage Specifications," "AC Current Specifications," and "Calculating Power Uncertainty."

[2] 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.

AC Power (45 Hz to 65 Hz) Specification Summary, PF=1

		Current Range			
		3.3 mA to 8.999 mA	**9 mA to 32.999 mA**	**33 mA to 89.99 mA**	**90 mA to 329.99 mA**
	Voltage Range	**Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output) [1]**			
90 days	33 to 329.999 mV	0.13	0.09	0.13	0.09
	330 mV to 1020 V	0.11	0.07	0.11	0.07
1 year	33 to 329.999 mV	0.14	0.10	0.14	0.10
	330 mV to 1020 V	0.12	0.08	0.12	0.08
		Current Range [2]			
		0.33 A to 0.8999 A	**0.9 A to 2.1999 A**	**2.2 A to 4.4999 A**	**4.5 A to 20.5 A**
	Voltage Range	**Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output) [1]**			
90 days	33 to 329.999 mV	0.12	0.10	0.12	0.10
	330 mV to 1020 V	0.10	0.08	0.11	0.09
1 year	33 to 329.999 mV	0.13	0.11	0.13	0.11
	330 mV to 1020 V	0.11	0.09	0.12	0.10

[1] To determine ac power uncertainty with more precision, see the individual "DC Voltage Specifications" and "DC Current Specifications" and "Calculating Power Uncertainty."

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

Power and Dual Output Limit Specifications

Frequency	Voltages (NORMAL)	Currents	Voltages (AUX)	Power Factor (PF)
dc	0 to ±1020 V	0 to ± 20.5 A	0 to ± 7 V	—
10 Hz 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 Hz to 65 Hz	33 mV to 1000 V	3.3 mA to 20.5 A	10 mV to 5 V	0 to 1
65 Hz to 500 Hz	330 mV to 1000 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
65 Hz to 500 Hz	3.3 V to 1000 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
500 Hz to 1 kHz	330 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	1
1 kHz to 5 kHz	3.3 V to 1000 V [1]	33 mA to 2.99999 A	100 mV to 5 V [1]	1
5 kHz to 10 kHz	3.3 V to 1000 V [2]	33 mA to 329.99 mA	1 V to 5 V [2]	1

[1] In dual voltage output mode, voltage is limited to 3.3 V to 500 V in the NORMAL output.

[2] In dual voltage output mode, voltage is limited to 3.3 V to 250 V in the NORMAL output.

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). However, only those limits shown in this table are specified. See “Calculating 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°.

Phase Specifications

1-Year Absolute Uncertainty, tcal ± 5 °C, (Δ Φ °)					
10 Hz to 65 Hz	**65 Hz to 500 Hz**	**500 Hz to 1 kHz**	**1 kHz to 5 kHz**	**5 kHz to 10 kHz**	**10 kHz to 30 kHz**
0.10°	0.25°	0.5°	2.5°	5°	10°

Phase (Φ) Watts	Phase (Φ) VARs	PF	Power Uncertainty Adder due to Phase Error					
			10 Hz to 65 Hz	**65 Hz to 500 Hz**	**500 Hz to 1 kHz**	**1 kHz to 5 kHz**	**5 kHz to 10 kHz**	**10 kHz to 30 kHz**
0°	90°	1.000	0.00%	0.00%	0.00%	0.10%	0.38%	1.52%
10°	80°	0.985	0.03%	0.08%	0.16%	0.86%	1.92%	4.58%
20°	70°	0.940	0.06%	0.16%	0.32%	1.68%	3.55%	7.84%
30°	60°	0.866	0.10%	0.25%	0.51%	2.61%	5.41%	11.54%
40°	50°	0.766	0.15%	0.37%	0.74%	3.76%	7.69%	16.09%
50°	40°	0.643	0.21%	0.52%	1.04%	5.29%	10.77%	22.21%
60°	30°	0.500	0.30%	0.76%	1.52%	7.65%	15.48%	31.60%
70°	20°	0.342	0.48%	1.20%	2.40%	12.08%	24.33%	49.23%
80°	10°	0.174	0.99%	2.48%	4.95%	24.83%	49.81%	100.00%
90°	0°	0.000	—	—	—	—	—	—

Note

1. To calculate exact ac watts power adders due to phase uncertainty for values not shown, use the following 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: $Adder(\%) = 100(1 - \frac{Cos(23+.15)}{Cos(23)}) = 0.11\%$

Calculating 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 power factor parameters:

Watts uncertainty $U_{\text{power}} = \sqrt{U^2_{\text{voltage}} + U^2_{\text{current}} + U^2_{\text{PFadder}}}$

VARs uncertainty $U_{\text{VARs}} = \sqrt{U^2_{\text{voltage}} + U^2_{\text{current}} + U^2_{\text{VARsadder}}}$

Because there are an infinite number of combinations, you should calculate the actual ac power uncertainty for your selected parameters. The method of calculation is best shown in the following examples (using 90-day specifications):

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

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 150 ppm + 2 mV, totaling:
100 V x 190 x 10^{-6} = 15 mV added to 2 mV = 17 mV. Expressed in percent:
17 mV/100 V x 100 = 0.017% (see "AC Voltage (Sine Wave) Specifications").

Current Uncertainty Uncertainty for 1 A is 0.036% + 100 µA, totaling:
1 A x 0.00036 = 360 µA added to 100 µA = 0.46 mA. Expressed in percent:
0.46 mA/1 A x 100 = 0.046% (see "AC Current (Sine Waves) Specifications").

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

Total Watts Output Uncertainty = $U_{\text{power}} = \sqrt{0.017^2 + 0.046^2 + 0^2} = 0.049\%$

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, 150 ppm + 2 mV, totaling:
100 V x 190 x 10^{-6} = 15 mV added to 2 mV = 17 mV. Expressed in percent:
17 mV/100 V x 100 = 0.017% (see "AC Voltage (Sine Wave) Specifications").

Current Uncertainty Uncertainty for 1 A is 0.036% + 100 µA, totaling:
1 A x 0.00036 = 360 µA added to 100 µA = 0.46 mA. Expressed in percent:
0.46 mA/1A x 100 = 0.046% (see "AC Current (Sine Waves) Specifications").

PF Adder Watts Adder for PF = 0.5 (Φ=60) at 400 Hz is 0.76% (see "Phase Specifications").

Total Watts Output Uncertainty = $U_{\text{power}} = \sqrt{0.017^2 + 0.046^2 + 0.76^2} = 0.76\%$

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 400 Hz is, 150 ppm + 2 mV, totaling:
100 V x 190 x 10^{-6} = 15 mV added to 2 mV = 17 mV. Expressed in percent:
17 mV/100 V x 100 = 0.017% (see "AC Voltage (Sine Wave) Specifications").

Current Uncertainty Uncertainty for 1 A is 0.036% + 100 µA, totaling:
1 A x 0.00036 = 360 µA added to 100 µA = 0.46 mA. Expressed in percent:
0.46 mA/1 A x 100 = 0.046% (see "AC Current (Sine Waves) Specifications").

VARs Adder VARs Adder for Φ = 80 at 60 Hz is 0.02% (see "Phase Specifications").

Total VARS Output Uncertainty = $U_{\text{VARs}} = \sqrt{0.017^2 + 0.046^2 + 0.03^2} = 0.058\%$

Additional Specifications

The following paragraphs provide additional specifications for the 5520A 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 5520A 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. (See the *5520A Operators Manual*, Chapter 4, "Front Panel Operation.")

Frequency Specifications

Frequency Range	Resolution	1-Year Absolute Uncertainty, tcal ± 5°C	Jitter
0.01 Hz to 119.99 Hz	0.01 Hz	2.5 ppm ± 5 µHz [1]	100 nS
120.0 Hz to 1199.9 Hz	0.1 Hz		
1.200 kHz to 11.999 kHz	1.0 Hz		
12.00 kHz to 119.99 kHz	10 Hz		
120.0 kHz to 1199.9 kHz	100 Hz		
1.200 MHz to 2.000 MHz	1 kHz		

[1] With REF CLK set to ext, the frequency uncertainty of the 5520A is the uncertainty of the external 10 MHz clock ±5 µHz. The amplitude of the 10 MHz external reference clock signal should be between 1 V and 5 V p-p.

Harmonics (2nd to 50th) Specifications

Fundamental Frequency [1]	Voltages NORMAL Terminals	Currents	Voltages AUX Terminals	Amplitude Uncertainty
10 Hz 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
45 Hz to 65 Hz	33 mV to 1000 V	3.3 mA to 20.5 A	10 mV to 5 V	the equivalent
65 Hz to 500 Hz	33 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	single output, but twice the
500 Hz to 5 kHz	330 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	floor adder.
5 kHz to 10 kHz	3.3 V to 1000 V	33 mA to 329.9999 mA	100 mV to 5 V	
10 kHz to 30 kHz	3.3 V to 1000 V	33 mA 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 V to 5 V). 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 V to 5 V).

Note

1. 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 60 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) Specifications" the single output specification for 100 V, 100 Hz, is 0.015% + 2 mV. For the dual output in this example, the specification is 0.015% + 4 mV as the 0.015% is the same and the floor is twice the value (2 x 2 mV).

AUX (50th Harmonic) Output: 100 mV, 5 kHz

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

AC Voltage (Sine Wave) Extended Bandwidth Specifications

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

AC Voltage (Non-Sine Wave) Specifications

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 mV to 93 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 20 kHz	0.5 + 0.25	
	20 kHz to 100 kHz [3]	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
93 mV to 14 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz 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.

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 mV To 66 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 20 kHz	0.5 + 0.25	
	20 kHz to 100 kHz	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
66 mV To 14 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz [3]	5.0 + 0.5	

[1] To convert p-p to rms for square wave, multiply the p-p value by 0.5000000.
[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 Specifications

Range [1] (Normal Channel)	Offset Range [2]	Max Peak Signal	1-Year Absolute Offset Uncertainty, tcal ± 5 °C [3] ± (% dc output + floor)
Sine Waves (rms)			
3.3 mV to 32.999 mV	0 to 50 mV	80 mV	0.1 + 33 µV
33 mV to 329.999 mV	0 to 500 mV	800 mV	0.1 + 330 µV
0.33 mV to 3.29999 V	0 to 5 V	8 V	0.1 + 3300 µV
3.3 V to 32.9999 V	0 to 50 V	55 V	0.1 + 33 mV
Triangle Waves and Truncated Sine Waves (p-p)			
9.3 mV to 92.999 mV	0 to 50 mV	80 mV	0.1 + 93 µV
93 mV to 929.999 mV	0 to 500 mV	800 mV	0.1 + 930 µV
0.93 mV to 9.29999 V	0 to 5 V	8 V	0.1 + 9300 µV
9.3 mV to 92.9999 V	0 to 50 V	55 V	0.1 + 93 mV
Square Waves (p-p)			
6.6 mV to 65.999 mV	0 to 50 mV	80 mV	0.1 + 66 µV
66 mV to 659.999 mV	0 to 500 mV	800 mV	0.1 + 660 µV
0.66 mV to 6.59999 V	0 to 5 V	8 V	0.1 + 6600 µV
6.6 mV to 65.9999 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 Hz 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	± (0.8% of period +100 ns) ± (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 (Sine Wave) Extended Bandwidth Specifications

Range	Frequency	1-Year Absolute Uncertainty tcal ± 5 °C ± (% of output + % of range)	Max Current Resolution
All current ranges, <330 mA	0.01 Hz to 10 Hz	5.0 + 0.5	2 digits

AC Current (Non-Sine Wave) Specifications

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 mA to 0.92999 mA [1]	0.01 Hz o 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
0.93 mA to 9.29999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
9.3 mA to 92.9999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
93 mA to 929.999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 kHz to 10 kHz	10 + 2	
0.93 A to 8.49999 A	10 Hz to 45 Hz	0.5 + 1.0	Six digits
	45 Hz to 1kHz	0.5 + 0.5	
	1 kHz to 10 kHz	10 + 2	
8.5 A to 57 A [2]	45 Hz 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) Specifications (cont)

Square Wave Range p-p	**Frequency**	**1-Year Absolute Uncertainty, tcal ± 5 °C, ± (% of output + % of range)**	**Max Current Resolution**
0.047 mA to 0.65999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
0.66 mA to 6.59999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 +0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
6.6 mA to 65.9999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
66 mA to 659.999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 kHz to 10 kHz	10 + 2	
0.66 A to 5.99999 A [2]	10 Hz to 45 Hz	0.5 + 1.0	
	45 Hz to 1 kHz	0.5 + 0.5	
	1 kHz to 10 kHz	10 + 2	
6 A to 41 A [2]	45 Hz 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