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Calibration

# 5502E Multi-Product Calibrator

The economical way to calibrate meters, clamps, thermometers and more

## Technical Data

### A complete solution with a high return on your investment

To compete in today's world market, you need to be able to accurately and cost effectively measure up to world standards. International standards such as ISO 17025 and ISO 9000, as well as safety, nuclear, environmental, and other regulations require a wide variety of electronic test tools to be calibrated traceable to nationally recognized standards.

If you need to calibrate digital multimeters, clamps, thermometers and other electronic test instruments to comply with quality standards, the Fluke Calibration 5502E offers an accurate and economical solution. It calibrates a wide variety of electronic test tools with a single, easy-to-use instrument.

### The functions you need for wide workload coverage

The 5502E has a wide range of outputs available from a single calibration source. These include dc and ac voltages up to 1020 V, dc and ac current up to 20.5 A directly or 1025 A (using the 5500A/COIL 50-turn current coil accessory) and variable resistances up to 1100 MΩ.


Using the 52120A Transconductance amplifier, the 5502E's output current is extended from 20.5 to 120 A; and with the use of 25 and 50 turn coils, it can calibrate instruments requiring currents up to 6000 A.

The 5502E also provides continuously variable capacitance values up to 110 mF. For temperature calibration applications, thermocouples and RTDs are simulated and thermocouple signals can be measured. It also generates digitally synthesized extended bandwidth sine, truncated sine, triangle and square waveforms. The 5502E gives you broad workload coverage in one economically-priced package.

### Choose the Fluke Calibration 5502E for easy, economical calibration of:

- Handheld digital multimeters (analog and digital) to 4.5 digits
- Bench multimeters (to 4.5 digits)
- Clamp meters
- Panel meters
- Electronic thermometers
- Chart recorders
- XY recorders
- Data loggers

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## Easy-to-use operation

While the Fluke Calibration 5502E calibrator helps you do more work, it also makes it easier to get work done. Its intuitive design makes operating it as natural as turning on a light switch, reducing references to the manual. For most tasks, your hand moves from the left to right, keeping you from having to make long, illogical or uncomfortable movements. Most functions require minimal keystrokes.

The 5502E is also easy on your budget because no additional fixtures are required and you can use it with conventional test leads.

## Automate calibration for documented, consistency efficiency

With standards like ISO 17025 and ISO 9000, there is a lot more to calibration than just making measurements. You also have documentation, control and reporting requirements to meet.

Optional Microsoft Windows® based Fluke Calibration metrology software simplifies the documentation of your procedures, adequacy and traceability. It also collects and reports calibration results information and helps you to consistently, quickly and efficiently calibrate a wide variety of instruments. With it your entire calibration process—from creating and executing procedures through results data collection and reporting—can be automated.

## Metrology software training

New Fluke Calibration customers can get up to speed quickly by attending training. Classroom, online, and CD-ROM based training is available to meet a wide variety of learning preferences and budgets. Visit the training center at www.flukecal.com/training for a current list of classes and schedules.

## 5502E performance at a glance

| Function | Range |
|---|---|
| DC voltage | 0 to ± 1020 V |
| AC voltage | 1 mV to 1020 V, 10 Hz to 500 kHz |
| VoltxHertz | 1000 V @ 10 kHz/33 V@100 kHz |
| DC current | 0 A to ± 20.5 A |
| AC current | 29 µA to 20.5 A, 10 Hz to 30 kHz |
| Waveforms | Sine, square, triangle, truncated sine |
| Resistance | 0 Ω to 1100 MΩ |
| Capacitance | 220 pF to 110 mF |
| Thermocouple (source and measure temperatures) | B, C, E, J, K, L, N, R, S, T, U, 10 µV/°C, 10 µV/Deg C and 1 mV/°C |
| RTD | PT-385-100 Ω, Pt 3926-100 Ω, Pt 3916-100 Ω, Pt 385-200 Ω, Pt 385-500 Ω, Pt 385 1000 Ω, PtNi 385-120 Ω, (Ni120), Cu 427 10 Ω |
| Frequency | .01 Hz to 2 MHz |
| Interfaces | RS-232, IEEE-488 |

## Ordering information

### Model

| | |
|---|---|
| 5502E | Multi-Product Calibrator |
| 5502E/COIL-KIT | Multi-Product Calibrator with Current Coil |

### Accessories

| | |
|---|---|
| 5212OA | Transconductance Amplifier |
| 5500A/LEADS | Comprehensive Test Lead Kit |
| 5500A/COIL | 50-Turn Coil |
| 5522A/CARRYCASE | Rugged Carrying Case with removable front/back panels |
| 55XX/CASE | Transit Case with Wheels |
| 5500A/HNDL | Side Handle |
| Y5537 | Rack Mount Kit |

### Software

| | |
|---|---|
| MET/CAL Plus | Calibration Management Software |

**Fluke Calibration.** *Precision, performance, confidence.™*

Electrical | RF | Temperature | Pressure | Flow | Software

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# 5502E
# Multi-Product Calibrator

*Extended Specifications*

# General Specifications

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

http://www.elso.sk

**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 5502E 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<br>Line Frequency: 47 Hz to 63 Hz<br>Line Voltage Variation: ±10 % about line voltage setting. For optimal performance at full dual outputs (e.g. 1000 V, 20 A) choose a line 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 5502E 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 5502E for the temperature range indicated. |
| **Specification Confidence Level** | 99 % |

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# 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 |
| TC Simulate and Measure in Linear 10 µV/°C and 1 mV/°C modes [2] | | | | | |
| 0 to 329.9999 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] 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 3.299999 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 |

## 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 | 0.013 + 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 1. 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 5502E 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 1 is achieved only after the 5502E 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 |

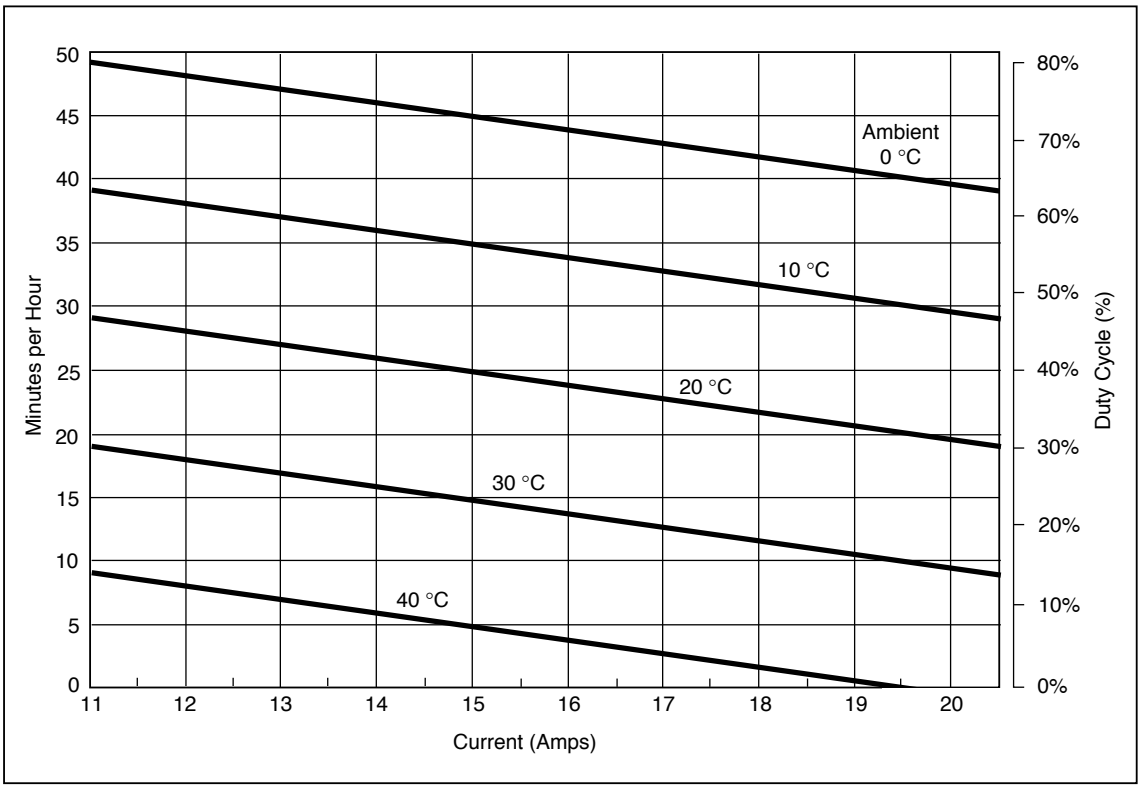


**Figure 1. Allowable Duration of Current >11 A**

## 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 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 1. 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 5502E 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 1 is achieved only after the 5502E 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 1. 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 5502E 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 1 is achieved only after the 5502E 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 10000 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] | |
|---|---|---|---|
| | | 90 Day | 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 |

| TC Type [1] | Range °C [2] | Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3] | |
|---|---|---|---|
| | | 90 Day | 1 Year |
| 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)

| RTD Type | Range °C [1] | Absolute Uncertainty tcal ±5 °C ± °C [2] | | RTD Type | Range °C [1] | Absolute Uncertainty tcal ±5 °C ± °C [2] | |
|---|---|---|---|---|---|---|---|
| | | 90 Day | 1 Year | | | 90 Day | 1 Year |
| Pt 385, 100 Ω | -200 to -80 | 0.04 | 0.05 | Pt 385, 500 Ω | -200 to -80 | 0.03 | 0.04 |
| | -80 to 0 | 0.05 | 0.05 | | -80 to 0 | 0.04 | 0.05 |
| | 0 to 100 | 0.07 | 0.07 | | 0 to 100 | 0.05 | 0.05 |
| | 100 to 300 | 0.08 | 0.09 | | 100 to 260 | 0.06 | 0.06 |
| | 300 to 400 | 0.09 | 0.10 | | 260 to 300 | 0.07 | 0.08 |
| | 400 to 630 | 0.10 | 0.12 | | 300 to 400 | 0.07 | 0.08 |
| | 630 to 800 | 0.21 | 0.23 | | 400 to 600 | 0.08 | 0.09 |
| Pt 3926, 100 Ω | -200 to -80 | 0.04 | 0.05 | | 600 to 630 | 0.09 | 0.11 |
| | -80 to 0 | 0.05 | 0.05 | Pt 385, 1000 Ω | -200 to -80 | 0.03 | 0.03 |
| | 0 to 100 | 0.07 | 0.07 | | -80 to 0 | 0.03 | 0.03 |
| | 100 to 300 | 0.08 | 0.09 | | 0 to 100 | 0.03 | 0.04 |
| | 300 to 400 | 0.09 | 0.10 | | 100 to 260 | 0.04 | 0.05 |
| | 400 to 630 | 0.10 | 0.12 | | 260 to 300 | 0.05 | 0.06 |
| Pt 3916, 100 Ω | -200 to -190 | 0.25 | 0.25 | | 300 to 400 | 0.05 | 0.07 |
| | -190 to -80 | 0.04 | 0.04 | | 400 to 600 | 0.06 | 0.07 |
| | -80 to 0 | 0.05 | 0.05 | | 600 to 630 | 0.22 | 0.23 |
| | 0 to 100 | 0.06 | 0.06 | PtNi 385, 120 Ω (Ni120) | -80 to 0 | 0.06 | 0.08 |
| | 100 to 260 | 0.06 | 0.07 | | 0 to 100 | 0.07 | 0.08 |
| | 260 to 300 | 0.07 | 0.08 | | 100 to 260 | 0.13 | 0.14 |
| | 300 to 400 | 0.08 | 0.09 | Cu 427 10 Ω [3] | -100 to 260 | 0.3 | 0.3 |
| | 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 | | | | |

[1] Resolution is 0.003 °C

[2] Applies for COMP OFF (to the 5502E Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.

[3] Based on MINCO Application Aid No. 18

# Additional Specifications

The subsequent paragraphs provide additional specifications for the 5502E 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 5502E 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 |

## 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 | |

## 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 | |
| | 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 | |
| | 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.

## 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 |

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