

**FLUKE®**

**Calibration**

# 5522A

Multi-Product Calibrator

## Specifications

**4TECT**

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## General Specifications

The following tables list the 5522A specifications. All specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5522A has been turned off. For example, if the 5522A 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  $\pm 5^\circ\text{C}$  ( $t_{cal}$  is the ambient temperature when the 5522A was adjusted), the temperature coefficient as stated in the General Specifications must be applied.

The specifications also assume the Calibrator is zeroed every 7 days or whenever the ambient temperature changes more than  $5^\circ\text{C}$ . The tightest ohms specifications are maintained with a zero cal every 12 hours within  $\pm 1^\circ\text{C}$  of use.

Also see additional specifications for information on extended specifications for ac voltage and current.

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

**Settling Time** .....  $<5$  seconds for all functions and ranges except as noted.

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

### Temperature

Operating .....  $0^\circ\text{C}$  to  $50^\circ\text{C}$

Calibration ( $t_{cal}$ ) .....  $15^\circ\text{C}$  to  $35^\circ\text{C}$

Storage .....  $-20^\circ$  to  $70^\circ\text{C}$ ; The DC current ranges 0 to 1.09999 A and 1.1 A to 2.99999 A are sensitive to storage temperatures  $>50^\circ\text{C}$ . If the 5522A is stored  $>50^\circ\text{C}$  for longer 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  $\pm 5^\circ\text{C}$  is 10 % of the stated specification per  $^\circ\text{C}$ .

### Relative Humidity

Operating .....  $<80\%$  to  $30^\circ\text{C}$ ,  $<70\%$  to  $40^\circ\text{C}$ ,  $<40\%$  to  $50^\circ\text{C}$

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 ..... 0 to 3050 m (10 000 ft)

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

**Safety** ..... IEC 61010-1: Overvoltage CAT II, Pollution Degree 2

**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  $\pm 300\text{ V}$  peak.

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

### Electromagnetic Compatibility (EMC)

IEC 61326-1 ..... (**Controlled** EM environment); CISPR 11, Group 1, Class A

Group 1 equipment ..... Group 1 has intentionally generated and/or use conductively coupled radio-frequency energy which is necessary for the internal functioning of the equipment itself.

Class A equipment ..... *Class A equipment is equipment suitable for use in all establishments other than domestic and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes. Caution - There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted and radiated disturbances.*

*Emissions which exceed the levels required by CISPR 11 can occur when the equipment is connected to a test object.*

USA (FCC) ..... 47 CFR 15 subpart B, this product is considered an exempt device per clause 15.103

Korea (KCC) ..... Class A Equipment (Industrial Broadcasting & Communication Equipment)

*This product meets requirements for industrial (Class A) electromagnetic wave equipment and the seller or user should take notice of it. This equipment is intended for use in business environments and not to be used in homes.*

If used in areas with electromagnetic fields of 1 V/m to 3 V/m from 0.08 GHz to 1 GHz, resistance outputs have a floor adder of  $0.508\ \Omega$ . 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 3 m.

|  |   |
|--|---|
| <b>Line Power</b> .....                      | Line Voltage (selectable): 100 V, 120 V, 220 V, 240 V<br>Line Frequency: 47 Hz to 63 Hz<br>Line Voltage Variation: $\pm 10\%$ about line voltage setting<br>For optimal performance at full dual outputs (for example, 1000 V, 20 A) choose a line voltage setting that is $\pm 7.5\%$ from nominal.  |
| <b>Power Consumption</b> .....               | 600 VA  |
| <b>Dimensions (HxWxL)</b> .....              | 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.   |
| <b>Weight (without options)</b> .....        | 22 kg (49 lb)   |
| <b>Absolute Uncertainty Definition</b> ..... | The 5522A 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 5522A for the temperature range indicated. |
| <b>Specification Confidence Level</b> .....  | 99 %  |

## Detailed Specifications

### DC Voltage

| Range   | Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$<br>$\pm(\text{ppm of output} + \mu\text{V})$ |           | Stability  | Resolution $\mu\text{V}$ | Max Burden <sup>[1]</sup> |
|---|---|-----------|--|--------------------------|---------------------------|
|   | 90 days   | 1 year    | 24 hours, $\pm 1^\circ\text{C}$<br>$\pm(\text{ppm of output} + \mu\text{V})$ |                          |                           |
| 0 to 329.9999 mV  | 15 + 1  | 20 + 1    | 3 + 1  | 0.1                      | 65 $\Omega$               |
| 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 to 329.9999 V  | 15 + 150  | 18 + 150  | 2.5 + 100  | 100                      | 5 mA                      |
| 100 to 1020.000 V   | 15 + 1500   | 18 + 1500 | 3 + 300  | 1000                     | 5 mA                      |
| <b>Auxiliary Output (dual output mode only) <sup>[2]</sup></b>  |   |           |  |                          |                           |
| 0 to 329.9999 mV  | 300 + 350   | 400 + 350 | 30 + 100   | 1                        | 5 mA                      |
| 0.33 to 3.299999 V  | 300 + 350   | 400 + 350 | 30 + 100   | 10                       | 5 mA                      |
| 3.3 to 7 V  | 300 + 350   | 400 + 350 | 30 + 100   | 100                      | 5 mA                      |
| <b>TC Simulate and Measure in Linear 10 <math>\mu\text{V}/^\circ\text{C}</math> and 1 <math>\text{mV}/^\circ\text{C}</math> modes <sup>[3]</sup></b>  |   |           |  |                          |                           |
| 0 to 329.9999 mV  | 40 + 3  | 50 + 3    | 5 + 2  | 0.1                      | 10 $\Omega$               |
| <sup>[1]</sup> Remote sensing is not provided. Output resistance is $< 5\text{ m}\Omega$ for outputs $\geq 0.33\text{ V}$ . The AUX output has an output resistance of $< 1\text{ }\Omega$ . TC simulation has an output impedance of $10\text{ }\Omega \pm 1\text{ }\Omega$ .<br><sup>[2]</sup> Two channels of dc voltage output are provided.<br><sup>[3]</sup> 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<br>$\pm(\text{ppm of output} + \text{floor})$ | Bandwidth 10 Hz to 10 kHz rms |
| 0 to 329.9999 mV   | 0 + 1 $\mu\text{V}$   | 6 $\mu\text{V}$               |
| 0 to 3.299999 V  | 0 + 10 $\mu\text{V}$  | 60 $\mu\text{V}$              |
| 0 to 32.99999 V  | 0 + 100 $\mu\text{V}$   | 600 $\mu\text{V}$             |
| 30 to 329.9999 V   | 10 + 1 mV   | 20 mV                         |
| 100 to 1020.000 V  | 10 + 5 mV   | 20 mV                         |
| <b>Auxiliary Output (dual output mode only) <sup>[1]</sup></b> |   |                               |
| 0 to 329.9999 mV   | 0 + 5 $\mu\text{V}$   | 20 $\mu\text{V}$              |
| 0.33 to 3.299999 V   | 0 + 20 $\mu\text{V}$  | 200 $\mu\text{V}$             |
| 3.3 to 7 V   | 0 + 100 $\mu\text{V}$   | 1000 $\mu\text{V}$            |
| <sup>[1]</sup> Two channels of dc voltage output are provided. |   |                               |

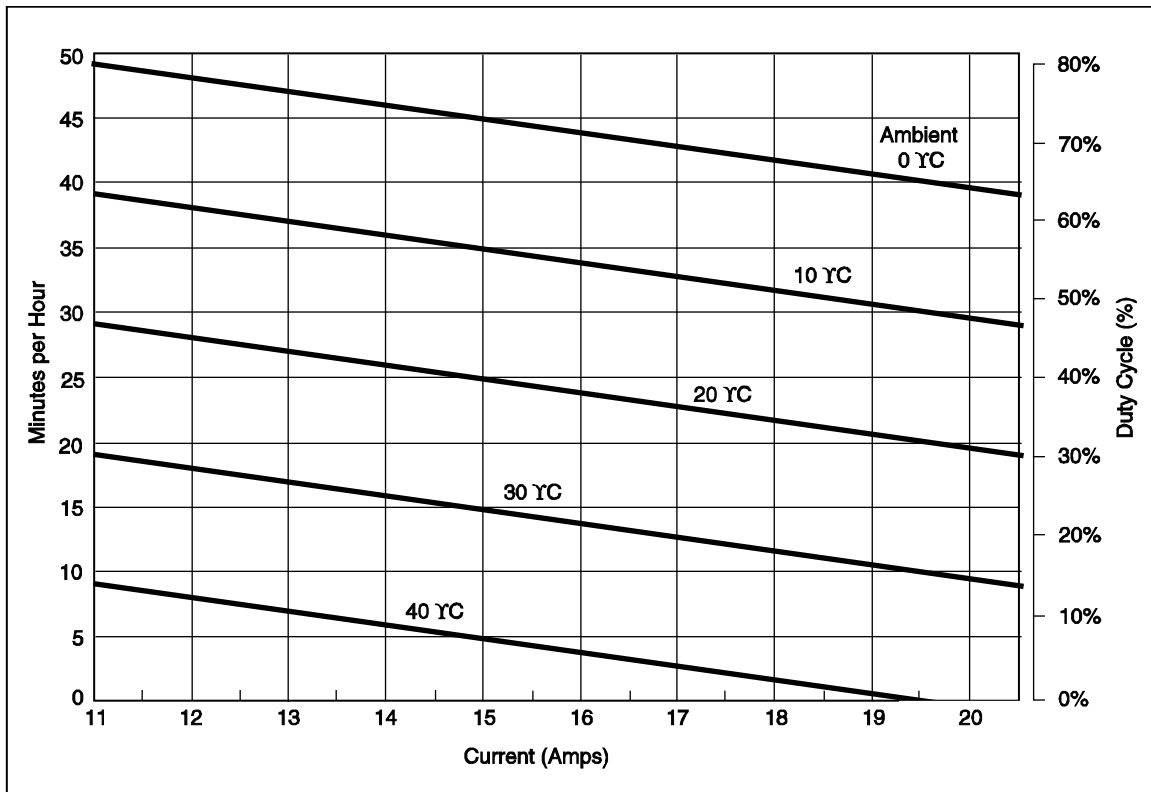
**DC Current**

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

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure below. 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 5522A is outputting currents between 5 A and 11 A 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 5522A 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 <sup>[1]</sup>                  | Absolute Uncertainty, tcal $\pm 5^\circ\text{C} \pm (\text{ppm of output} + \text{floor})$ <sup>[2]</sup> |        |   |                              | Resolution $\Omega$ | Allowable Current <sup>[3]</sup> |
|---------------------------------------|---|--------|---|------------------------------|---------------------|----------------------------------|
|                                       | ppm of output   |        | Floor ( $\Omega$ )<br>Time and temp since ohms zero cal |                              |                     |                                  |
|                                       | 90 days   | 1 year | 12 hrs $\pm 1^\circ\text{C}$                            | 7 days $\pm 5^\circ\text{C}$ |                     |                                  |
| 0 to 10.9999 $\Omega$                 | 35  | 40     | 0.001   | 0.01                         | 0.0001              | 4 mA to 125 mA                   |
| 11 to 32.9999 $\Omega$                | 25  | 30     | 0.0015  | 0.015                        | 0.0001              | 4 mA to 125 mA                   |
| 33 to 109.9999 $\Omega$               | 22  | 28     | 0.0014  | 0.015                        | 0.0001              | 3 mA to 70 mA                    |
| 110 $\Omega$ to 329.9999 $\Omega$     | 22  | 28     | 0.002   | 0.02                         | 0.0001              | 1 mA to 40 mA                    |
| 330 $\Omega$ to 1.099999 k $\Omega$   | 22  | 28     | 0.002   | 0.02                         | 0.001               | 1 mA to 13.5 mA                  |
| 1.1 to 3.299999 k $\Omega$            | 22  | 28     | 0.02  | 0.2                          | 0.001               | 100 $\mu\text{A}$ to 4.5 mA      |
| 3.3 to 10.99999 k $\Omega$            | 22  | 28     | 0.02  | 0.1                          | 0.01                | 100 $\mu\text{A}$ to 1.35 mA     |
| 11 to 32.99999 k $\Omega$             | 22  | 28     | 0.2   | 1                            | 0.01                | 10 $\mu\text{A}$ to 0.45 mA      |
| 33 to 109.9999 k $\Omega$             | 22  | 28     | 0.2   | 1                            | 0.1                 | 10 $\mu\text{A}$ to 0.135 mA     |
| 110 to 329.99999 k $\Omega$           | 25  | 32     | 2   | 10                           | 0.1                 | 1 $\mu\text{A}$ to 0.045 mA      |
| 330 k $\Omega$ to 1.099999 M $\Omega$ | 25  | 32     | 2   | 10                           | 1                   | 1 $\mu\text{A}$ to 0.0135 mA     |
| 1.1 to 3.299999 M $\Omega$            | 40  | 60     | 30  | 150                          | 1                   | 250 nA to 4.5 $\mu\text{A}$      |
| 3.3 to 10.99999 M $\Omega$            | 110   | 130    | 50  | 250                          | 10                  | 250 nA to 1.35 $\mu\text{A}$     |
| 11 to 32.99999 M $\Omega$             | 200   | 250    | 2500  | 2500                         | 10                  | 25 nA to 450 nA                  |
| 33 to 109.9999 M $\Omega$             | 400   | 500    | 3000  | 3000                         | 100                 | 25 nA to 135 nA                  |
| 110 to 329.9999 M $\Omega$            | 2500  | 3000   | 100000  | 100000                       | 1000                | 2.5 nA to 45 nA                  |
| 330 to 1100 M $\Omega$                | 12000   | 15000  | 500000  | 500000                       | 10000               | 1 nA to 13 nA                    |

[1] Continuously variable from 0  $\Omega$  to 1.1 G $\Omega$ .

[2] Applies for 4-WIRE compensation only. For 2-WIRE and 2-WIRE COMP, add an additional amount to the floor specification as calculated by: (5  $\mu\text{V}$  divided by the stimulus current in amps). For example, in 2-WIRE mode, at 1 k $\Omega$  the floor specification within 12 hours of an ohms zero cal for a measurement current of 1 mA is:  $0.002 \Omega + (5 \mu\text{V} / 1 \text{ mA}) = (0.002 + 0.005) \Omega = 0.007 \Omega$ .

[3] For currents lower than shown, the floor adder increases by  $\text{Floor}(\text{new}) = \text{Floor}(\text{old}) \times I_{\text{min}}/I_{\text{actual}}$ . For example, a 50  $\mu\text{A}$  stimulus measuring 100  $\Omega$  has a floor specification of:  $0.0014 \Omega \times 3 \text{ mA}/50 \mu\text{A} = 0.084 \Omega$  assuming an ohms zero calibration within 12 hours.

**AC Voltage (Sine Wave)**

| Range  | Frequency          | Absolute Uncertainty,<br>tcal $\pm 5$ °C<br>$\pm$ (ppm of output + $\mu$ V) |              | Resolution  | Max Burden  | Max Distortion and Noise<br>10 Hz to 5 MHz<br>Bandwidth<br>$\pm$ (% of output + floor) |
|--|--------------------|---|--------------|-------------|---|--|
|  |                    | 90 days   | 1 year       |             |   |  |
| Normal Output  |                    |   |              |             |   |  |
| 1.0 mV to<br>32.999 mV   | 10 Hz to 45 Hz     | 600 + 6   | 800 + 6      | 1 $\mu$ V   | 65 $\Omega$                                       | 0.15 + 90 $\mu$ V  |
|  | 45 Hz to 10 kHz    | 120 + 6   | 150 + 6      |             |   | 0.035 + 90 $\mu$ V   |
|  | 10 kHz to 20 kHz   | 160 + 6   | 200 + 6      |             |   | 0.06 + 90 $\mu$ V  |
|  | 20 kHz to 50 kHz   | 800 + 6   | 1000 + 6     |             |   | 0.15 + 90 $\mu$ V  |
|  | 50 kHz to 100 kHz  | 3000 + 12   | 3500 + 12    |             |   | 0.25 + 90 $\mu$ V  |
|  | 100 kHz to 500 kHz | 6000 + 50   | 8000 + 50    |             |   | 0.3 + 90 $\mu$ V <sup>[1]</sup>  |
| 33 mV to<br>329.999 mV   | 10 Hz to 45 Hz     | 250 + 8   | 300 + 8      | 1 $\mu$ V   | 65 $\Omega$                                       | 0.15 + 90 $\mu$ V  |
|  | 45 Hz to 10 kHz    | 140 + 8   | 145 + 8      |             |   | 0.035 + 90 $\mu$ V   |
|  | 10 kHz to 20 kHz   | 150 + 8   | 160 + 8      |             |   | 0.06 + 90 $\mu$ V  |
|  | 20 kHz to 50 kHz   | 300 + 8   | 350 + 8      |             |   | 0.15 + 90 $\mu$ V  |
|  | 50 kHz to 100 kHz  | 600 + 32  | 800 + 32     |             |   | 0.20 + 90 $\mu$ V  |
|  | 100 kHz to 500 kHz | 1600 + 70   | 2000 + 70    |             |   | 0.20 + 90 $\mu$ V <sup>[1]</sup>   |
| 0.33 V to<br>3.29999 V   | 10 Hz to 45 Hz     | 250 + 50  | 300 + 50     | 10 $\mu$ V  | 10 mA   | 0.15 + 200 $\mu$ V   |
|  | 45 Hz to 10 kHz    | 140 + 60  | 150 + 60     |             |   | 0.035 + 200 $\mu$ V  |
|  | 10 kHz to 20 kHz   | 160 + 60  | 190 + 60     |             |   | 0.06 + 200 $\mu$ V   |
|  | 20 kHz to 50 kHz   | 250 + 50  | 300 + 50     |             |   | 0.15 + 200 $\mu$ V   |
|  | 50 kHz to 100 kHz  | 550 + 125   | 700 + 125    |             |   | 0.20 + 200 $\mu$ V   |
|  | 100 kHz to 500 kHz | 2000 + 600  | 2400 + 600   |             |   | 0.20 + 200 $\mu$ V <sup>[1]</sup>  |
| 3.3 V to<br>32.9999 V  | 10 Hz to 45 Hz     | 250 + 650   | 300 + 650    | 100 $\mu$ V | 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<br>329.999 V   | 45 Hz to 1 kHz     | 150 + 2000  | 190 + 2000   | 1 mV        | 5 mA,<br>except<br>20 mA for<br>45 Hz to<br>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<br>1020 V   | 45 Hz to 1 kHz     | 250 + 10000   | 300 + 10000  | 10 mV       | 2 mA,<br>except 6 mA<br>for 45 Hz to<br>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   |
| <p>[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.</p> <p>Note</p> <p>Remote sensing is not provided. Output resistance is &lt;5 m<math>\Omega</math> for outputs <math>\geq</math>0.33 V. The AUX output resistance is &lt;1 <math>\Omega</math>. The maximum load capacitance is 500 pF, subject to the maximum burden current limits</p> |                    |   |              |             |   |  |

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

| Range   | Frequency <sup>[1]</sup> | Absolute Uncertainty,<br>tcal $\pm 5$ °C<br>$\pm$ (% of output + $\mu$ V) |            | Resolution  | Max<br>Burden | Max Distortion and<br>Noise<br>10 Hz to 5 MHz<br>Bandwidth<br>$\pm$ (% of output +<br>floor) |
|---|--------------------------|---|------------|-------------|---------------|--|
|   |                          | 90 days   | 1 year     |             |               |  |
| AUX Output  |                          |   |            |             |               |  |
| 10 mV to<br>329.999 mV  | 10 Hz to 20 Hz           | 0.15 + 370  | 0.2 + 370  | 1 $\mu$ V   | 5 mA          | 0.2 + 200 $\mu$ V  |
|   | 20 Hz to 45 Hz           | 0.08 + 370  | 0.1 + 370  |             |               | 0.06 + 200 $\mu$ V   |
|   | 45 Hz to 1 kHz           | 0.08 + 370  | 0.1 + 370  |             |               | 0.08 + 200 $\mu$ V   |
|   | 1 kHz to 5 kHz           | 0.15 + 450  | 0.2 + 450  |             |               | 0.3 + 200 $\mu$ V  |
|   | 5 kHz to 10 kHz          | 0.3 + 450   | 0.4 + 450  |             |               | 0.6 + 200 $\mu$ V  |
|   | 10 kHz to 30 kHz         | 4.0 + 900   | 5.0 + 900  |             |               | 1 + 200 $\mu$ V  |
| 0.33 V to<br>3.29999 V  | 10 Hz to 20 Hz           | 0.15 + 450  | 0.2 + 450  | 10 $\mu$ V  | 5 mA          | 0.2 + 200 $\mu$ V  |
|   | 20 Hz to 45 Hz           | 0.08 + 450  | 0.1 + 450  |             |               | 0.06 + 200 $\mu$ V   |
|   | 45 Hz to 1 kHz           | 0.07 + 450  | 0.09 + 450 |             |               | 0.08 + 200 $\mu$ V   |
|   | 1 kHz to 5 kHz           | 0.15 + 1400   | 0.2 + 1400 |             |               | 0.3 + 200 $\mu$ V  |
|   | 5 kHz to 10 kHz          | 0.3 + 1400  | 0.4 + 1400 |             |               | 0.6 + 200 $\mu$ V  |
|   | 10 kHz to 30 kHz         | 4.0 + 2800  | 5.0 + 2800 |             |               | 1 + 200 $\mu$ V  |
| 3.3 V to 5 V  | 10 Hz to 20 Hz           | 0.15 + 450  | 0.2 + 450  | 100 $\mu$ V | 5 mA          | 0.2 + 200 $\mu$ V  |
|   | 20 Hz to 45 Hz           | 0.08 + 450  | 0.1 + 450  |             |               | 0.06 + 200 $\mu$ V   |
|   | 45 Hz to 1 kHz           | 0.07 + 450  | 0.09 + 450 |             |               | 0.08 + 200 $\mu$ V   |
|   | 1 kHz to 5 kHz           | 0.15 + 1400   | 0.2 + 1400 |             |               | 0.3 + +200 $\mu$ V   |
|   | 5 kHz to 10 kHz          | 0.3 + 1400  | 0.4 + 1400 |             |               | 0.6 + 200 $\mu$ V  |
| <p>[1] There are two channels of voltage output. The maximum frequency of the dual output is 30 kHz.</p> <p>Note</p> <p>Remote sensing is not provided. Output resistance is &lt;5 m<math>\Omega</math> for outputs <math>\geq</math>0.33 V. The AUX output resistance is &lt;1 <math>\Omega</math>. The maximum load capacitance is 500 pF, subject to the maximum burden current limits</p> |                          |   |            |             |               |  |

**Model 5522A**  
Product Specifications

**AC Current (Sine Wave)**

| Range                 | Frequency       | Absolute Uncertainty,<br>tcal ±5 °C<br>±(% of output + µA) |              | Compliance<br>adder ±(µA/V) | Max Distortion &<br>Noise 10 Hz to<br>100 kHz BW<br>±(% of output +<br>floor) | Max<br>Inductive<br>Load µH |
|-----------------------|-----------------|--|--------------|-----------------------------|---|-----------------------------|
|                       |                 | 90 days  | 1 year       |                             |   |                             |
| <b>LCOMP Off</b>      |                 |  |              |                             |   |                             |
| 29.00 to<br>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                        | 0.1 + 0.5 µA  |                             |
|                       | 45 Hz to 1 kHz  | 0.1 + 0.1  | 0.125 + 0.1  | 0.05                        | 0.05 + 0.5 µA   |                             |
|                       | 1 to 5 kHz      | 0.25 + 0.15  | 0.3 + 0.15   | 1.5                         | 0.5 + 0.5 µA  |                             |
|                       | 5 to 10 kHz     | 0.6 + 0.2  | 0.8 + 0.2    | 1.5                         | 1.0 + 0.5 µA  |                             |
| 0.33 to<br>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                         | 0.5 + 1.5 µA  |                             |
|                       | 5 to 10 kHz     | 0.4 + 0.3  | 0.5 + 0.3    | 1.5                         | 1.0 + 1.5 µA  |                             |
| 3.3 to<br>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                         | 0.3 + 5 µA  |                             |
|                       | 5 to 10 kHz     | 0.16 + 3   | 0.2 + 3      | 1.5                         | 0.7 + 5 µA  |                             |
| 33 to<br>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                         | 0.1 + 50 µA   |                             |
| 0.33 to<br>1.09999 A  | 10 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 to 5 kHz      | 0.5 + 1000   | 0.6 + 1000   | [2]                         | 1 + 500 µA  |                             |
|                       | 5 to 10 kHz     | 2.0 + 5000   | 2.5 + 5000   | [3]                         | 2 + 500 µA  |                             |
| 1.1 to<br>2.99999 A   | 10 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 to 5 kHz      | 0.5 + 1000   | 0.6 + 1000   | [2]                         | 1 + 500 µA  |                             |
|                       | 5 to 10 kHz     | 2.0 + 5000   | 2.5 + 5000   | [3]                         | 2 + 500 µA  |                             |
| 3 to<br>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 to 5 kHz      | 2.5 + 2000   | 3.0 + 2000   |                             | 0.8 + 3 mA  |                             |
| 11 to<br>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 60-23-17 = 20 minutes each hour. When the 5522A 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 5522A 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,<br>tcal $\pm 5$ °C<br>$\pm$ (% of output + $\mu$ A) |                            | Max Distortion &<br>Noise 10 Hz to<br>100 kHz BW<br>$\pm$ (% of output + floor) | Max<br>Inductive<br>Load $\mu$ H |
|---|-----------------|---|----------------------------|---|----------------------------------|
|   |                 | 90 days   | 1 year                     |   |                                  |
| <b>LCOMP On</b>   |                 |   |                            |   |                                  |
| 29.00 to<br>329.99 $\mu$ A  | 10 to 100 Hz    | 0.2 + 0.2   | 0.25 + 0.2                 | 0.1 + 1.0 $\mu$ A   | 400                              |
|   | 100 Hz to 1 kHz | 0.5 + 0.5   | 0.6 + 0.5                  | 0.05 + 1.0 $\mu$ A  |                                  |
| 0.33 to<br>3.29999 mA   | 10 to 100 Hz    | 0.2 + 0.3   | 0.25 + 0.3                 | 0.15 + 1.5 $\mu$ A  |                                  |
|   | 100 Hz to 1 kHz | 0.5 + 0.8   | 0.6 + 0.8                  | 0.06 + 1.5 $\mu$ A  |                                  |
| 3.3 to<br>32.9999 mA  | 10 to 100 Hz    | 0.07 + 4  | 0.08 + 4                   | 0.15 + 5 $\mu$ A  |                                  |
|   | 100 Hz to 1 kHz | 0.18 + 10   | 0.2 + 10                   | 0.05 + 5 $\mu$ A  |                                  |
| 33 to<br>329.999 mA   | 10 to 100 Hz    | 0.07 + 40   | 0.08 + 40                  | 0.15 + 50 $\mu$ A   |                                  |
|   | 100 Hz to 1 kHz | 0.18 + 100  | 0.2 + 100                  | 0.05 + 50 $\mu$ A   |                                  |
| 0.33 to<br>2.99999 A  | 10 to 100 Hz    | 0.1 + 200   | 0.12 + 200                 | 0.2 + 500 $\mu$ A   |                                  |
|   | 100 to 440 Hz   | 0.25 + 1000   | 0.3 + 1000                 | 0.25 + 500 $\mu$ A  |                                  |
| 3 to 20.5 A <sup>[1]</sup>  | 45 to 100 Hz    | 0.1 + 2000 <sup>[2]</sup>   | 0.12 + 2000 <sup>[2]</sup> | 0.1 + 0 $\mu$ A   | 400 <sup>[4]</sup>               |
|   | 100 to 440 Hz   | 0.8 + 5000 <sup>[3]</sup>   | 1.0 + 5000 <sup>[3]</sup>  | 0.5 + 0 $\mu$ A   |                                  |
| <p>[1] Duty Cycle: Currents &lt;11 A may be provided continuously. For currents &gt;11 A, see Figure 1. The current may be provided Formula <math>60 - T - I</math> 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 <math>60 - 23 - 17 = 20</math> minutes each hour. When the 5522A 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 5522A is outputting currents &lt;5 A for the "off" period first.</p> <p>[2] For currents &gt;11 A, Floor specification is 4000 <math>\mu</math>A within 30 seconds of selecting operate. For operating times &gt;30 seconds, the floor specification is 2000 <math>\mu</math>A.</p> <p>[3] For currents &gt;11 A, Floor specification is 10000 <math>\mu</math>A within 30 seconds of selecting operate. For operating times &gt;30 seconds, the floor specification is 5000 <math>\mu</math>A.</p> <p>[4] Subject to compliance voltages limits.</p> |                 |   |                            |   |                                  |

| Range  | Resolution $\mu$ A | Max Compliance Voltage V rms <sup>[1]</sup> |
|--|--------------------|---|
| 0.029 to 0.32999 mA  | 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,<br>tcal $\pm 5$ °C<br>$\pm$ (% of output + floor) <sup>[1] [2] [3]</sup> |                   | Resolution | Allowed Frequency or<br>Charge-Discharge Rate |                                 |                               |
|----------------------------|--|-------------------|------------|---|---------------------------------|-------------------------------|
|                            | 90 days  | 1 year            |            | Min and Max to<br>Meet<br>Specification       | Typical Max for<br><0.5 % Error | Typical Max for<br><1 % Error |
| 220.0 to<br>399.9 pF       | 0.38 + 10 pF   | 0.5 + 10 pF       | 0.1 pF     | 10 Hz to 10 kHz                               | 20 kHz                          | 40 kHz                        |
| 0.4 to<br>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<br>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<br>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 to<br>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 to<br>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 to<br>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 to<br>1.09999 $\mu$ F | 0.19 + 1 nF  | 0.25 + 1 nF       | 10 pF      | 10 to 600 Hz                                  | 1.5 kHz                         | 2 kHz                         |
| 1.1 to<br>3.29999 $\mu$ F  | 0.19 + 3 nF  | 0.25 + 3 nF       | 10 pF      | 10 to 300 Hz                                  | 800 Hz                          | 1 kHz                         |
| 3.3 to<br>10.9999 $\mu$ F  | 0.19 + 10 nF   | 0.25 + 10 nF      | 100 pF     | 10 to 150 Hz                                  | 450 Hz                          | 650 Hz                        |
| 11 to<br>32.9999 $\mu$ F   | 0.30 + 30 nF   | 0.40 + 30 nF      | 100 pF     | 10 to 120 Hz                                  | 250 Hz                          | 350 Hz                        |
| 33 to<br>109.999 $\mu$ F   | 0.34 + 100 nF  | 0.45 + 100 nF     | 1 nF       | 10 to 80 Hz                                   | 150 Hz                          | 200 Hz                        |
| 110 to<br>329.999 $\mu$ F  | 0.34 + 300 nF  | 0.45 + 300 nF     | 1 nF       | 0 to 50 Hz                                    | 80 Hz                           | 120 Hz                        |
| 0.33 to<br>1.09999 mF      | 0.34 + 1 $\mu$ F   | 0.45 + 1 $\mu$ F  | 10 nF      | 0 to 20 Hz                                    | 45 Hz                           | 65 Hz                         |
| 1.1 to<br>3.29999 mF       | 0.34 + 3 $\mu$ F   | 0.45 + 3 $\mu$ F  | 10 nF      | 0 to 6 Hz                                     | 30 Hz                           | 40 Hz                         |
| 3.3 to<br>10.9999 mF       | 0.34 + 10 $\mu$ F  | 0.45 + 10 $\mu$ F | 100 nF     | 0 to 2 Hz                                     | 15 Hz                           | 20 Hz                         |
| 11 to<br>32.9999 mF        | 0.7 + 30 $\mu$ F   | 0.75 + 30 $\mu$ F | 100 nF     | 0 to 0.6 Hz                                   | 7.5 Hz                          | 10 Hz                         |
| 33 to<br>110 mF            | 1.0 + 100 $\mu$ F  | 1.1 + 100 $\mu$ F | 10 $\mu$ F | 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  $\mu$ F and 100 mA for 1.1  $\mu$ F and above.  
[3] The maximum lead resistance for no additional error in 2-wire COMP mode is 10  $\Omega$ .  
[4] From 220 pF to 1.0999 nF, the temperature coefficient for temperatures outside tcal  $\pm 5$  °C is 0.15 %/ °C.

**Temperature Calibration (Thermocouple)**

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

[1] Temperature standard ITS-90 or IPTS-68 is selectable.  
TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.

[2] Resolution is 0.01 °C

[3] Does not include thermocouple error

**Temperature Calibration (RTD)**

| RTD Type          | Range<br>°C [1] | Absolute Uncertainty<br>tcal ±5 °C<br>± °C [2] |            | RTD Type                      | Range<br>°C [1]   | Absolute Uncertainty<br>tcal ±5 °C<br>± °C [2] |        |
|-------------------|-----------------|--|------------|-------------------------------|-------------------|--|--------|
|                   |                 | 90 days  | 1 year     |                               |                   | 90 days  | 1 year |
| Pt 385,<br>100 Ω  | -200 to -80     | 0.04   | 0.05       | Pt 385,<br>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,<br>100 Ω | -200 to -80     | 0.04   | 0.05       |                               | Pt 385,<br>1000 Ω | 600 to 630                                     | 0.09   |
|                   | -80 to 0        | 0.05   | 0.05       | -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,<br>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,<br>120 Ω<br>(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<br>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,<br>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 5522A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.  
 [3] Based on MINCO Application Aid No. 18

**DC Power Specification Summary**

|  | Voltage Range   | Current Range        |                     |                |
|--|-----------------|----------------------|---------------------|----------------|
|  |                 | 0.33 to<br>329.99 mA | 0.33 to<br>2.9999 A | 3 to<br>20.5 A |
| Absolute Uncertainty, tcal ±5 °C, ±(% of watts output) [1] |                 |                      |                     |                |
| <b>90 days</b>   | 33 mV to 1020 V | 0.021                | 0.019 [2]           | 0.06 [2]       |
| <b>1 year</b>  | 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 "DC Voltage Specifications," "DC 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**

|   | Voltage Range    | Current Range   |                 |                 |                 |
|---|------------------|---|-----------------|-----------------|-----------------|
|   |                  | 3.3 to 8.999 mA   | 9 to 32.999 mA  | 33 to 89.99 mA  | 90 to 329.99 mA |
|   |                  | Absolute Uncertainty, tcal $\pm 5$ °C, $\pm$ (% of watts output) <sup>[1]</sup> |                 |                 |                 |
| 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            |
|   | Voltage Range    | Current Range <sup>[2]</sup>  |                 |                 |                 |
|   |                  | 0.33 to 0.8999 A  | 0.9 to 2.1999 A | 2.2 to 4.4999 A | 4.5 to 20.5 A   |
|   |                  | Absolute Uncertainty, tcal $\pm 5$ °C, $\pm$ (% of watts output) <sup>[1]</sup> |                 |                 |                 |
| 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            |
| <p>[1] To determine ac power uncertainty with more precision, see the individual "AC Voltage Specifications" and "AC Current Specifications" and "Calculating Power Uncertainty."</p> <p>[2] Add 0.02 % unless a settling time of 30 seconds is allowed for output currents &gt;10 A or for currents on the highest two current ranges within 30 seconds of an output current &gt;10 A.</p> |                  |   |                 |                 |                 |

**Power and Dual Output Limit Specifications**

| Frequency  | Voltages (NORMAL)  | Currents            | Voltages (AUX)   | Power Factor (PF) |
|--|--------------------|---------------------|------------------|-------------------|
| dc   | 0 to $\pm 1020$ V  | 0 to $\pm 20.5$ A   | 0 to $\pm 7$ V   | —                 |
| 10 to 45 Hz  | 33 mV to 32.9999 V | 3.3 mA to 2.99999 A | 10 mV to 5 V     | 0 to 1            |
| 45 to 65 Hz  | 33 mV to 1020 V    | 3.3 mA to 20.5 A    | 10 mV to 5 V     | 0 to 1            |
| 65 to 500 Hz   | 330 mV to 1020 V   | 33 mA to 2.99999 A  | 100 mV to 5 V    | 0 to 1            |
| 65 to 500 Hz   | 3.3 to 1020 V      | 33 mA to 20.5 A     | 100 mV to 5 V    | 0 to 1            |
| 500 Hz to 1 kHz  | 330 mV to 1020 V   | 33 mA to 20.5 A     | 100 mV to 5 V    | 0 to 1            |
| 1 to 5 kHz   | 3.3 to 500 V       | 33 mA to 2.99999 A  | 100 mV to 5 V    | 0 to 1            |
| 5 to 10 kHz  | 3.3 to 250 V       | 33 to 329.99 mA     | 1 to 5 V         | 0 to 1            |
| 10 to 30 kHz   | 3.3 V to 250 V     | 33 mA to 329.99 mA  | 1 V to 3.29999 V | 0 to 1            |
| <p>Notes</p> <p>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.</p> <p>The phase adjustment range for dual ac outputs is <math>0^\circ</math> to <math>\pm 179.99^\circ</math>. The phase resolution for dual ac outputs is 0.01 degree.</p> |                    |                     |                  |                   |

**Phase**

| 1-Year Absolute Uncertainty, tcal $\pm 5$ °C, ( $\Delta \Phi$ °)                          |              |                 |            |             |              |
|---|--------------|-----------------|------------|-------------|--------------|
| 10 to 65 Hz   | 65 to 500 Hz | 500 Hz to 1 kHz | 1 to 5 kHz | 5 to 10 kHz | 10 to 30 kHz |
| 0.10 °  | 0.25 °       | 0.5 °           | 2.5 °      | 5 °         | 10 °         |
| <p>Note</p> <p>See Power and Dual Output Limit Specifications for applicable outputs.</p> |              |                 |            |             |              |

| Phase ( $\Phi$ ) Watts | Phase ( $\Phi$ ) VARs | PF    | Power Uncertainty Adder due to Phase Error |              |                 |            |             |              |
|------------------------|-----------------------|-------|--|--------------|-----------------|------------|-------------|--------------|
|                        |                       |       | 10 to 65 Hz                                | 65 to 500 Hz | 500 Hz to 1 kHz | 1 to 5 kHz | 5 to 10 kHz | 10 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 %      |

**Model 5522A**  
Product Specifications

|      |      |       |        |        |        |         |         |          |
|------|------|-------|--------|--------|--------|---------|---------|----------|
| 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 | —      | —      | —      | —       | —       | —        |

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

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

For example: At 60 Hz, for a PF of .9205 ( $\Phi = 23$ ) and a phase uncertainty of  $\Delta\Phi = 0.10$ , the ac Watts power adder is:

$$Adder(\%) = 100 \left( 1 - \frac{\cos(23 + .10)}{\cos(23)} \right) = 0.074\%$$

**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 
$$U_{\text{power}} = \sqrt{U_{\text{voltage}}^2 + U_{\text{current}}^2 + U_{\text{PFadder}}^2}$$

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

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 1 year specifications):

**Example 1** Output: 100 V, 1 A, 60 Hz, Power Factor = 1.0 ( $\Phi=0$ ).

**Voltage Uncertainty** Uncertainty for 100 V at 60 Hz is 190 ppm + 2 mV, totaling:  
 $100 \text{ V} \times 190 \times 10^{-6} = 19 \text{ mV}$  added to 2 mV = 21 mV. Expressed in percent:  
 $21 \text{ mV}/100 \text{ V} \times 100 = \underline{0.021\%}$  (see "AC Voltage (Sine Wave) Specifications").

**Current Uncertainty** Uncertainty for 1 A is 0.05 % 100  $\mu\text{A}$ , totaling:  
 $1 \text{ A} \times 0.0005 = 500 \mu\text{A}$  added to 100  $\mu\text{A} = 0.6 \text{ mA}$ . Expressed in percent:  
 $0.6 \text{ mA}/1 \text{ A} \times 100 = \underline{0.06\%}$  (see "AC Current (Sine Waves) Specifications").

**PF Adder** Watts Adder for PF = 1 ( $\Phi=0$ ) at 60 Hz is 0% (see "Phase Specifications").

Total Watts Output Uncertainty =  $U_{\text{power}} = \sqrt{0.021^2 + 0.06^2 + 0^2} = 0.064\%$

**Example 2** Output: 100 V, 1 A, 400 Hz, Power Factor = 0.5 ( $\Phi=60$ )

**Voltage Uncertainty** Uncertainty for 100 V at 400 Hz is, 190 ppm + 2 mV, totaling:  
 $100 \text{ V} \times 190 \times 10^{-6} = 19 \text{ mV}$  added to 2 mV = 21 mV. Expressed in percent:  
 $21 \text{ mV}/100 \text{ V} \times 100 = \underline{0.021\%}$  (see "AC Voltage (Sine Wave) Specifications").

**Current Uncertainty** Uncertainty for 1 A is 0.05 % 100  $\mu\text{A}$ , totaling:  
 $1 \text{ A} \times 0.0005 = 500 \mu\text{A}$  added to 100  $\mu\text{A} = 0.6 \text{ mA}$ . Expressed in percent:  
 $0.6 \text{ mA}/1 \text{ A} \times 100 = \underline{0.06\%}$  (see "AC Current (Sine Waves) Specifications").

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

Total Watts Output Uncertainty =  $U_{\text{power}} = \sqrt{0.021^2 + 0.06^2 + 0.76^2} = 0.76\%$

**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 ( $\Phi=80$ )

**Voltage Uncertainty** Uncertainty for 100 V at 60 Hz is, 190 ppm + 2 mV, totaling:  
 $100 \text{ V} \times 190 \times 10^{-6} = 19 \text{ mV}$  added to 2 mV = 21 mV. Expressed in percent:  
 $21 \text{ mV}/100 \text{ V} \times 100 = \underline{0.021\%}$  (see "AC Voltage (Sine Wave) Specifications").

**Current Uncertainty** Uncertainty for 1 A is 0.05 % 100  $\mu\text{A}$ , totaling:  
 $1 \text{ A} \times 0.0005 = 500 \mu\text{A}$  added to 100  $\mu\text{A} = 0.6 \text{ mA}$ . Expressed in percent:  
 $0.6 \text{ mA}/1 \text{ A} \times 100 = \underline{0.06\%}$  (see "AC Current (Sine Waves) Specifications").

**VARs Adder** VARs Adder for  $\Phi=80$  at 60 Hz is 0.03% (see "Phase Specifications").

Total VARS Output Uncertainty =  $U_{\text{VARs}} = \sqrt{0.021^2 + 0.06^2 + 0.03^2} = 0.070\%$

## Additional Specifications

The following paragraphs provide additional specifications for the 5522A 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 5522A 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 | Jitter |
|---------------------|------------|---|--------|
| 0.01 to 119.99 Hz   | 0.01 Hz    | 2.5 ppm +5 µHz <sup>[1]</sup>           | 100 ns |
| 120.0 to 1199.9 Hz  | 0.1 Hz     |   |        |
| 1.200 to 11.999 kHz | 1.0 Hz     |   |        |
| 12.00 to 119.99 kHz | 10 Hz      |   |        |
| 120.0 to 1199.9 kHz | 100 Hz     |   |        |
| 1.200 to 2.000 MHz  | 1 kHz      |   |        |

[1] With REF CLK set to ext, the frequency uncertainty of the 5522A 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 (2<sup>nd</sup> to 50<sup>th</sup>)

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

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

**Phase Uncertainty** ..... Phase uncertainty for harmonic outputs is 1 ° 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 5 ° (from “Phase Specifications”). Another example, the phase uncertainty of a 50 Hz fundamental output and a 400 Hz harmonic output is 1 °.

#### Example of determining Amplitude Uncertainty in a Dual Output Harmonic Mode

**What are the amplitude uncertainties for the following dual outputs?**

NORMAL (Fundamental) Output:

100 V, 100 Hz ..... From “AC Voltage (Sine Wave) 90 Day Specifications” the single output specification for 100 V, 100 Hz, is 0.015 % + 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) 90 Day 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**

| Range                                      | Frequency          | 1-Year Absolute Uncertainty<br>tcal $\pm 5^\circ\text{C}$ | Max Voltage Resolution  |
|--|--------------------|---|-------------------------|
| <b>Normal Channel (Single Output Mode)</b> |                    |   |                         |
| 1.0 to 33 mV                               | 0.01 to 9.99 Hz    | $\pm(5.0\% \text{ of output} + 0.5\% \text{ of range})$   | 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                                  |                         |
| <b>Auxiliary Output (Dual Output Mode)</b> |                    |   |                         |
| 10 to 330 mV                               | 0.01 to 9.99 Hz    | $\pm(5.0\% \text{ of output} + 0.5\% \text{ of range})$   | Three digits            |
| 0.4 to 5 V                                 |                    |   | Two digits              |

**AC Voltage (Non-Sine Wave)**

| Triangle Wave & Truncated Sine Range, p-p <sup>[1]</sup>  | Frequency                    | 1-Year Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ , $\pm(\% \text{ of output} + \% \text{ of range})$ <sup>[2]</sup> | Max Voltage Resolution   |
|---|------------------------------|--|--------------------------|
| <b>Normal Channel (Single Output Mode)</b>  |                              |  |                          |
| 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 <sup>[3]</sup> | 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 <sup>[3]</sup> | 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 <sup>[3]</sup> | 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 <sup>[3]</sup> | 5.0 + 0.5  |                          |
| <b>Auxiliary Output (Dual Output Mode)</b>  |                              |  |                          |
| 29 to 929.999 mV  | 0.01 to 10 Hz                | 5.0 + 0.5  | Two digits on each range |
|   | 10 to 45 Hz                  | 0.25 + 0.5   | Six digits on each range |
|   | 45 Hz to 1 kHz               | 0.25 + 0.25  |                          |
|   | 1 to 10 kHz                  | 5.0 + 0.5  |                          |
| 0.93 to 9.29999 V   | 0.01 to 10 Hz                | 5.0 + 0.5  | Two digits on each range |
|   | 10 to 45 Hz                  | 0.25 + 0.5   | Six digits on each range |
|   | 45 Hz to 1 kHz               | 0.25 + 0.25  |                          |
|   | 1 to 10 kHz                  | 5.0 + 0.5  |                          |
| <p>[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.</p> <p>[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.</p> <p>[3] Uncertainty for Truncated Sine outputs is typical over this frequency band.</p> |                              |  |                          |



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

| Square Wave Range (p-p) <sup>[1]</sup>   | Frequency                  | 1-Year Absolute Uncertainty, tcal ±5 °C, ±(% of output + % of range) <sup>[2]</sup> | Max Voltage Resolution   |
|--|----------------------------|---|--------------------------|
| <b>Normal Channel (Single Output Mode)</b>   |                            |   |                          |
| 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   |                          |
| <b>Auxiliary Output (Dual Output Mode)</b>   |                            |   |                          |
| 29 to 659.999 mV   | 0.01 to 10 Hz              | 5.0 + 0.5   | Two digits on each range |
|  | 10 to 45 Hz                | 0.25 + 0.5  | Six digits on each range |
|  | 45 Hz to 1 kHz             | 0.25 + 0.25   |                          |
|  | 1 to 10 kHz <sup>[3]</sup> | 5.0 + 0.5   |                          |
| 0.66 to 6.59999 V  | 0.01 to 10 Hz              | 5.0 + 0.5   | Two digits on each range |
|  | 10 to 45 Hz                | 0.25 + 0.5  | Six digits on each range |
|  | 45 Hz to 1 kHz             | 0.25 + 0.25   |                          |
|  | 1 to 10 kHz <sup>[3]</sup> | 5.0 + 0.5   |                          |
| <p>[1] To convert p-p to rms for square wave, multiply the p-p value by 0.5.</p> <p>[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.</p> <p>[3] Limited to 1 kHz for Auxiliary outputs ≥6.6 V p-p.</p> |                            |   |                          |

**AC Voltage, DC Offset**

| Range <sup>[1]</sup> (Normal Channel)                | Offset Range <sup>[2]</sup> | Max Peak Signal | 1-Year Absolute Uncertainty, tcal ±5 °C <sup>[3]</sup> ±(% of dc output + floor) |
|--|-----------------------------|-----------------|--|
| <b>Sine Waves (rms)</b>                              |                             |                 |  |
| 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  |
| <b>Triangle Waves and Truncated Sine Waves (p-p)</b> |                             |                 |  |
| 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  |
| <b>Square Waves (p-p)</b>                            |                             |                 |  |
| 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 $\mu$ V  |
| 0.66 to 6.59999 V  | 0 to 5 V    | 8 V    | 0.1 + 6600 $\mu$ V |
| 6.6 to 66.0000 V   | 0 to 50 V   | 55 V   | 0.1 + 66 mV        |
| <p>[1] Offsets are not allowed on ranges above the highest range shown above.</p> <p>[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 <math>\pm 50</math> V to not exceed the 55 V maximum peak signal. The maximum offset values shown above are for the minimum outputs in each range.</p> <p>[3] For frequencies 0.01 to 10 Hz, and 500 kHz to 2 MHz, the offset uncertainty is 5 % of output, <math>\pm 1</math> % of the offset range.</p> |             |        |                    |

### 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 $\mu$ s               | <10 $\mu$ s to 1 % of final value | <2 %                      | 1 % to 99 % <3.3 V p-p.<br>0.01 Hz to 100 kHz | $\pm(0.02$ % of period + 100 ns), 50 % duty cycle<br>$\pm(0.05$ % 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 $\pm 5$ $^{\circ}$ C $\pm$ (% 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   |                        |
| [1] Frequency limited to 1 kHz with LCOMP on. |                |  |                        |

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

| Square Wave Range p-p                         | Frequency      | 1-Year Absolute Uncertainty tcal $\pm 5$ $^{\circ}$ C $\pm$ (% 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   |                        |
| [1] Frequency limited to 1 kHz with LCOMP on. |                |  |                        |

### AC Current, Square Wave Characteristics (typical)

| Range           | LCOMP | Risetime   | Settling Time                    | Overshoot                 |
|-----------------|-------|------------|----------------------------------|---------------------------|
| I <6 A @ 400 Hz | off   | 25 $\mu$ s | 40 $\mu$ s 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 |