

Manual Supplement

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This supplement contains information necessary to ensure the accuracy of the above manual.
This manual is distributed as an electronic manual on the following CD-ROM:

CD Title:	5502A
CD Rev. & Date:	11/2012
CD PN:	4155227

Change #1, 561, 562, 564

On pages 1-7 through 1-27, replace the entire **Specifications** section with:

General Specifications

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

All specifications apply for the temperature and time period indicated. For temperatures outside of $t_{cal} \pm 5\text{ }^{\circ}\text{C}$ (t_{cal} is the ambient temperature when the 5502A was calibrated), the temperature coefficient as stated in the General Specifications must be applied.

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

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

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

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

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

Temperature

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

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

Storage $-20\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$; The DC current ranges 0 to 1.09999 A and 1.1 A to 2.99999 A are sensitive to storage temperatures above $50\text{ }^{\circ}\text{C}$. If the 5502A is stored above $50\text{ }^{\circ}\text{C}$ 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 $t_{cal} \pm 5\text{ }^{\circ}\text{C}$ is 10 % of the stated specification per $^{\circ}\text{C}$.

Relative Humidity

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

Storage $<95\text{ }%$, 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 3050 m (10 000 ft) maximum at $\leq 120\text{ V}$ line voltage operation

2,000 m (6 500 ft) maximum at $> 120\text{ V}$ line voltage operation

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

International IEC 61326-1: Controlled Electromagnetic Environment; IEC 61326-2-1

CISPR 11: Group 1, Class A

Group 1: Equipment has intentionally generated and/or uses conductively-coupled radio frequency energy that is necessary for the internal function of the equipment itself.

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

Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

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

The equipment may not meet the immunity requirements of this standard when test leads and/or test probes are connected.

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.

- Line Power** Line Voltage (selectable): 100 V, 120 V, 220 V, 240 V
 Line Frequency: 47 Hz to 63 Hz
 Line Voltage Variation: $\pm 10\%$ about line voltage setting. For optimal performance at full dual outputs (e.g. 1000 V, 20 A) choose a line voltage setting that is $\pm 7.5\%$ from nominal.
- Power Consumption** 600 VA
- Dimensions (HxWxL)** 17.8 cm x 43.2 cm x 47.3 cm (7 in x 17 in x 18.6 in) Standard rack width and rack increment, plus 1.5 cm (0.6 in) for feet on bottom of unit.
- Weight (without options)** 22 kg (49 lb)
- Absolute Uncertainty Definition** The 5502A specifications include stability, temperature coefficient, linearity, line and load regulation, and the traceability of the external standards used for calibration. You do not need to add anything to determine the total specification of the 5502A for the temperature range indicated.
- Specification Confidence Level** 99 %

Detailed Specifications

DC Voltage

Range	Absolute Uncertainty, tcal $\pm 5\text{ }^\circ\text{C}$ $\pm(\%$ of output + μV)		Stability	Resolution (μV)	Max Burden ^[1]
	90 Day	1 Year	24 hours, $\pm 1\text{ }^\circ\text{C}$ $\pm(\text{ppm}$ 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 32.999999 V	0.004 + 50	0.005 + 50	4 + 30	10	10 mA
30 to 329.9999 V	0.0045 + 500	0.0055 + 500	4.5 + 300	100	5 mA
100 to 1020.000 V	0.0045 + 1500	0.0055 + 1500	4.5 + 900	1000	5 mA
Auxiliary Output (dual output mode only) ^[2]					
0 to 329.999 mV	0.03 + 350	0.04 + 350	30 + 100	1	5 mA
0.33 to 3.29999 V	0.03 + 350	0.04 + 350	30 + 100	10	5 mA
3.3 to 7 V	0.03 + 350	0.04 + 350	30 + 100	100	5 mA
TC Simulate and Measure in Linear 10 $\mu\text{V}/^\circ\text{C}$ and 1 $\text{mV}/^\circ\text{C}$ modes ^[3]					
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 $< 5\text{ m}\Omega$ 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 $10\text{ }\Omega \pm 1\text{ }\Omega$. [2] Two channels of dc voltage output are provided. [3] TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.					

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p $\pm(\text{ppm}$ 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 32.999999 V	0 + 100	600 μV
30 to 329.9999 V	10 + 1000	20 mV
100 to 1020.000 V	10 + 5000	20 mV
Auxiliary Output (dual output mode only) ^[1]		
0 to 329.999 mV	0 + 5 μV	20 μV
0.33 to 3.29999 V	0 + 20 μV	200 μV
3.3 to 7 V	0 + 100 μV	1000 μV
[1] Two channels of dc voltage output are provided.		

DC Current

Range	Absolute Uncertainty, tcal ±5 °C ±(% of output +µA)		Resolution	Max Compliance Voltage V	Max Inductive Load mH
	90 Day	1 Year			
0 to 329.999 µA	0.012 + 0.02	0.015 + 0.02	1 nA	10	400
0 to 3.29999 mA	0.010 + 0.05	0.013 + 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 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 1 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

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

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

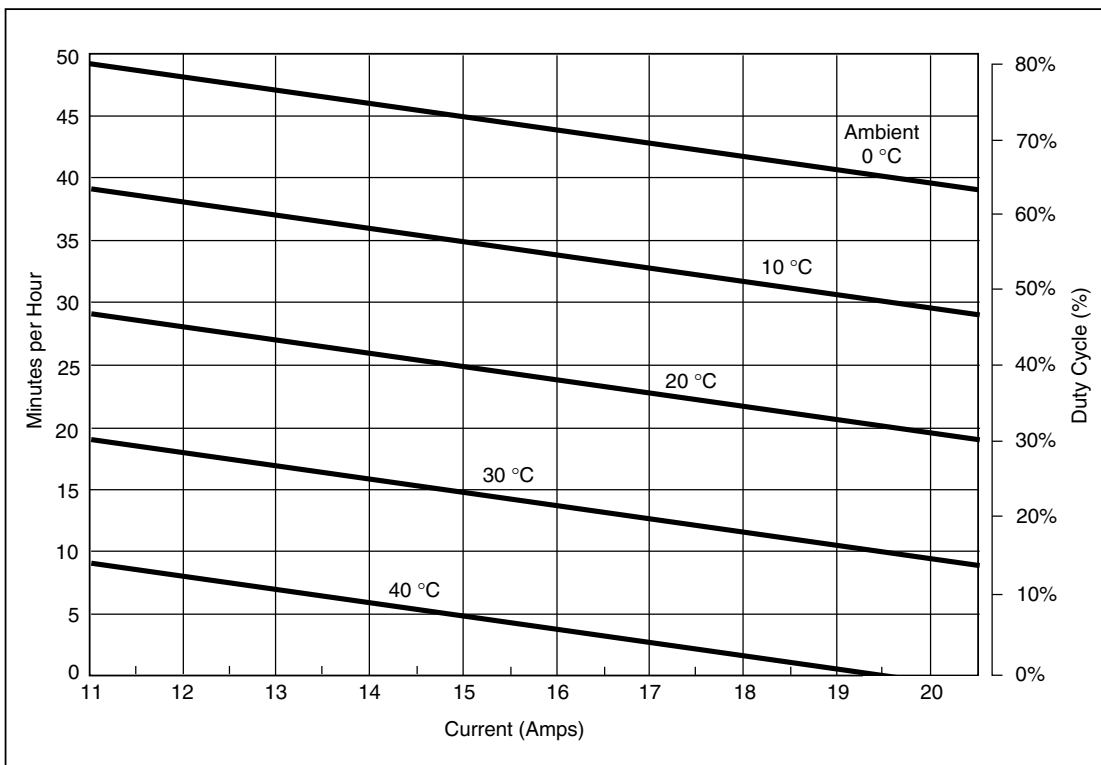


Figure 1. Allowable Duration of Current >11 A

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	4 mA to 125 mA
11 to 32.999 Ω	0.009	0.012	0.0015	0.015	0.001	4 mA to 125 mA
33 to 109.999 Ω	0.007	0.009	0.0014	0.015	0.001	3 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 13.5 mA
1.1 to 3.29999 kΩ	0.007	0.009	0.02	0.2	0.01	100 μA to 4.5 mA
3.3 to 10.9999 kΩ	0.007	0.009	0.02	0.1	0.1	100 μA to 1.35 mA
11 to 32.9999 kΩ	0.007	0.009	0.2	1	0.1	10 μA to 0.45 mA
33 to 109.999 kΩ	0.008	0.011	0.2	1	1	10 μA to 0.135 mA
110 to 329.999 kΩ	0.009	0.012	2	10	1	1 μA to 0.045 μA
330 kΩ to 1.09999 MΩ	0.011	0.015	2	10	10	1 μA to 0.0135 μA
1.1 to 3.29999 MΩ	0.011	0.015	30	150	10	250 nA to 4.5 μA
3.3 to 10.9999 MΩ	0.045	0.06	50	250	100	250 nA to 1.35 μA
11 to 32.9999 MΩ	0.075	0.1	2500	2500	100	25 nA to 450 nA
33 to 109.999 MΩ	0.4	0.5	3000	3000	1000	25 nA to 135 nA
110 to 329.999 MΩ	0.4	0.5	100000	100000	1000	2.5 nA to 45 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) × I_{min}/I_{actual}. For example, a 50 μA stimulus measuring 100 Ω has a floor specification of: 0.0014 Ω × 3 mA/50 μA = 0.084 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 6 mA for 45 to 65 Hz	0.15 + 30 mV
	1 kHz to 5 kHz	0.064 + 20000	0.080 + 20000			0.07 + 30 mV
	5 kHz to 10 kHz	0.075 + 20000	0.090 + 20000			0.07 + 30 mV

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

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

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

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

Note

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

AC Current (Sine Wave)

Range	Frequency	Absolute Uncertainty, tcal ± 5 °C \pm (% of output + μ A)		Compliance adder $\pm(\mu$ A/V)	Max Distortion and Noise 10 Hz to 100 kHz BW \pm (% of output + floor)	Max Inductive Load μ H
		90 Day	1 Year			
LCOMP Off						
29 to 329.99 μ A	10 to 20 Hz	0.16 + 0.1	0.2 + 0.1	0.05	0.15 + 0.5 μ A	200
	20 to 45 Hz	0.12 + 0.1	0.15 + 0.1	0.05	0.10 + 0.5 μ A	
	45 Hz to 1 kHz	0.1 + 0.1	0.125 + 0.1	0.05	0.05 + 0.5 μ A	
	1 to 5 kHz	0.25 + 0.15	0.3 + 0.15	1.5	0.50 + 0.5 μ A	
	5 to 10 kHz	0.6 + 0.2	0.8 + 0.2	1.5	1.00 + 0.5 μ A	
0.33 to 3.29999 mA	10 to 20 Hz	0.16 + 0.15	0.2 + 0.15	0.05	0.15 + 1.5 μ A	200
	20 to 45 Hz	0.1 + 0.15	0.125 + 0.15	0.05	0.06 + 1.5 μ A	
	45 Hz to 1 kHz	0.08 + 0.15	0.1 + 0.15	0.05	0.02 + 1.5 μ A	
	1 to 5 kHz	0.16 + 0.2	0.2 + 0.2	1.5	0.50 + 1.5 μ A	
	5 to 10 kHz	0.4 + 0.3	0.5 + 0.3	1.5	1.00 + 1.5 μ A	
3.3 to 32.9999 mA	10 to 20 Hz	0.15 + 2	0.18 + 2	0.05	0.15 + 5 μ A	50
	20 to 45 Hz	0.075 + 2	0.09 + 2	0.05	0.05 + 5 μ A	
	45 Hz to 1 kHz	0.035 + 2	0.04 + 2	0.05	0.07 + 5 μ A	
	1 to 5 kHz	0.065 + 2	0.08 + 2	1.5	0.30 + 5 μ A	
	5 to 10 kHz	0.16 + 3	0.2 + 3	1.5	0.70 + 5 μ A	
33 to 329.999 mA	10 to 20 Hz	0.15 + 20	0.18 + 20	0.05	0.15 + 50 μ A	50
	20 to 45 Hz	0.075 + 20	0.09 + 20	0.05	0.05 + 50 μ A	
	45 Hz to 1 kHz	0.035 + 20	0.04 + 20	0.05	0.02 + 50 μ A	
	1 to 5 kHz	0.08 + 50	0.10 + 50	1.5	0.03 + 50 μ A	
	5 to 10 kHz	0.16 + 100	0.2 + 100	1.5	0.10 + 50 μ A	
0.33 to 1.09999 A	10 to 45 Hz	0.15 + 100	0.18 + 100		0.20 + 500 μ A	2.5
	45 Hz to 1 kHz	0.036 + 100	0.05 + 100		0.07 + 500 μ A	
	1 to 5 kHz	0.5 + 1000	0.6 + 1000	[2]	1.00 + 500 μ A	
	5 to 10 kHz	2.0 + 5000	2.5 + 5000	[3]	2.00 + 500 μ A	
1.1 to 2.99999 A	10 to 45 Hz	0.15 + 100	0.18 + 100		0.20 + 500 μ A	2.5
	45 Hz to 1 kHz	0.05 + 100	0.06 + 100		0.07 + 500 μ A	
	1 to 5 kHz	0.5 + 1000	0.6 + 1000	[2]	1.00 + 500 μ A	
	5 to 10 kHz	2.0 + 5000	2.5 + 5000	[3]	2.00 + 500 μ A	
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	
<p>[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 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 1 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.</p> <p>[2] For compliance voltages greater than 1 V, add 1 mA/V to the floor specification from 1 to 5 kHz.</p> <p>[3] For compliance voltages greater than 1 V, add 5 mA/V to the floor specification from 5 to 10 kHz.</p>						

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	
<p>[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 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 1 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.</p> <p>[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.</p> <p>[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.</p> <p>[4] Subject to compliance voltages limits.</p>					

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 $\pm(\% \text{ of output} + \text{floor})$ [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 μ F	0.19 + 1 nF	0.25 + 1 nF	100 pF	10 to 600 Hz	1.5 kHz	2 kHz
1.1 to 3.2999 μ F	0.19 + 3 nF	0.25 + 3 nF	100 pF	10 to 300 Hz	800 Hz	1 kHz
3.3 to 10.999 μ F	0.19 + 10 nF	0.25 + 10 nF	1 nF	10 to 150 Hz	450 Hz	650 Hz
11 to 32.999 μ F	0.30 + 30 nF	0.40 + 30 nF	1 nF	10 to 120 Hz	250 Hz	350 Hz
33 to 109.99 μ F	0.34 + 100 nF	0.45 + 100 nF	10 nF	10 to 80 Hz	150 Hz	200 Hz
110 to 329.99 μ F	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 μ F	0.45 + 1 μ F	100 nF	0 to 20 Hz	45 Hz	65 Hz
1.1 to 3.2999 mF	0.34 + 3 μ F	0.45 + 3 μ F	100 nF	0 to 6 Hz	30 Hz	40 Hz
3.3 to 10.999 mF	0.34 + 10 μ F	0.45 + 10 μ F	1 μ F	0 to 2 Hz	15 Hz	20 Hz
11 to 32.999 mF	0.7 + 30 μ F	0.75 + 30 μ F	1 μ F	0 to 0.6 Hz	7.5 Hz	10 Hz
33 to 110.00 mF	1.0 + 100 μ F	1.1 + 100 μ F	10 μ 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 μ F and 100 mA for 1.1 μ F and above.

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

Temperature Calibration (Thermocouple)

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

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

[2] Resolution is 0.01 °C

[3] Does not include thermocouple error

Temperature Calibration (RTD)

RTD Type	Range °C ^[1]	Absolute Uncertainty tcal ±5 °C ± °C ^[2]		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	Pt 385, 1000 Ω	600 to 630	0.09	0.11
	-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
Pt 3916, 100 Ω	400 to 630	0.10	0.12	PtNi 385, 120 Ω (Ni120)	260 to 300	0.05	0.06
	-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	Cu 427 10 Ω ^[3]	-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
Pt 385, 200 Ω	300 to 400	0.08	0.09				
	400 to 600	0.08	0.10				
	600 to 630	0.21	0.23				
	-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 5502A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.

[3] Based on MINCO Application Aid No. 18

Phase

1-Year Absolute Uncertainty, tcal ±5 °C, (Δ Φ °)					
Frequency (Hz)					
10 to 65 Hz	65 to 500 Hz	500 Hz to 1 kHz	1 to 5 kHz	5 to 10 kHz	10 to 30 kHz
0.15 °	0.9 °	2 °	6 °	10 °	15 °
Note See Power and Dual Output Limit Specifications for applicable outputs.					

Phase (Φ) Watts	Phase (Φ) VARs	PF	Power Uncertainty Adder due to Phase Error					
			10 to 65 Hz	65 to 500 Hz	500 Hz to 1 kHz	1 to 5 kHz	5 to 10 kHz	10 to 30 kHz
0 °	90 °	1.0	0.00 %	0.01 %	0.06 %	0.55 %	1.52 %	3.41 %
5 °	85 °	0.996	0.02 %	0.15 %	0.37 %	1.46 %	3.04 %	5.67 %
10 °	80 °	0.985	0.05 %	0.29 %	0.68 %	2.39 %	4.58 %	7.97 %
15 °	75 °	0.966	0.07 %	0.43 %	1.00 %	3.35 %	6.17 %	10.34 %
20 °	70 °	0.940	0.10 %	0.58 %	1.33 %	4.35 %	7.84 %	12.83 %
25 °	65 °	0.906	0.12 %	0.74 %	1.69 %	5.42 %	9.62 %	15.48 %
30 °	60 °	0.866	0.15 %	0.92 %	2.08 %	6.58 %	11.54 %	18.35 %
35 °	55 °	0.819	0.18 %	1.11 %	2.50 %	7.87 %	13.68 %	21.53 %
40 °	50 °	0.766	0.22 %	1.33 %	2.99 %	9.32 %	16.09 %	25.12 %
45 °	45 °	0.707	0.26 %	1.58 %	3.55 %	11.00 %	18.88 %	29.29 %
50 °	40 °	0.643	0.31 %	1.88 %	4.22 %	13.01 %	22.21 %	34.25 %
55 °	35 °	0.574	0.37 %	2.26 %	5.05 %	15.48 %	26.32 %	40.37 %
60 °	30 °	0.500	0.45 %	2.73 %	6.11 %	18.65 %	31.60 %	48.24 %
65 °	25 °	0.423	0.56 %	3.38 %	7.55 %	22.96 %	38.76 %	58.91 %
70 °	20 °	0.342	0.72 %	4.33 %	9.65 %	29.27 %	49.23 %	74.52 %
75 °	15 °	0.259	0.98 %	5.87 %	13.09 %	39.56 %	66.33 %	100.00 %
80 °	10 °	0.174	1.49 %	8.92 %	19.85 %	59.83 %	100.00 %	—
85 °	5 °	0.087	2.99 %	17.97 %	39.95 %	—	—	—
90 °	0 °	0.000	—	—	—	—	—	—

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

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

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

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

AC and DC Power Specifications

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

Specification Limits for Power and Dual Output Operation

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

Notes

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

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

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

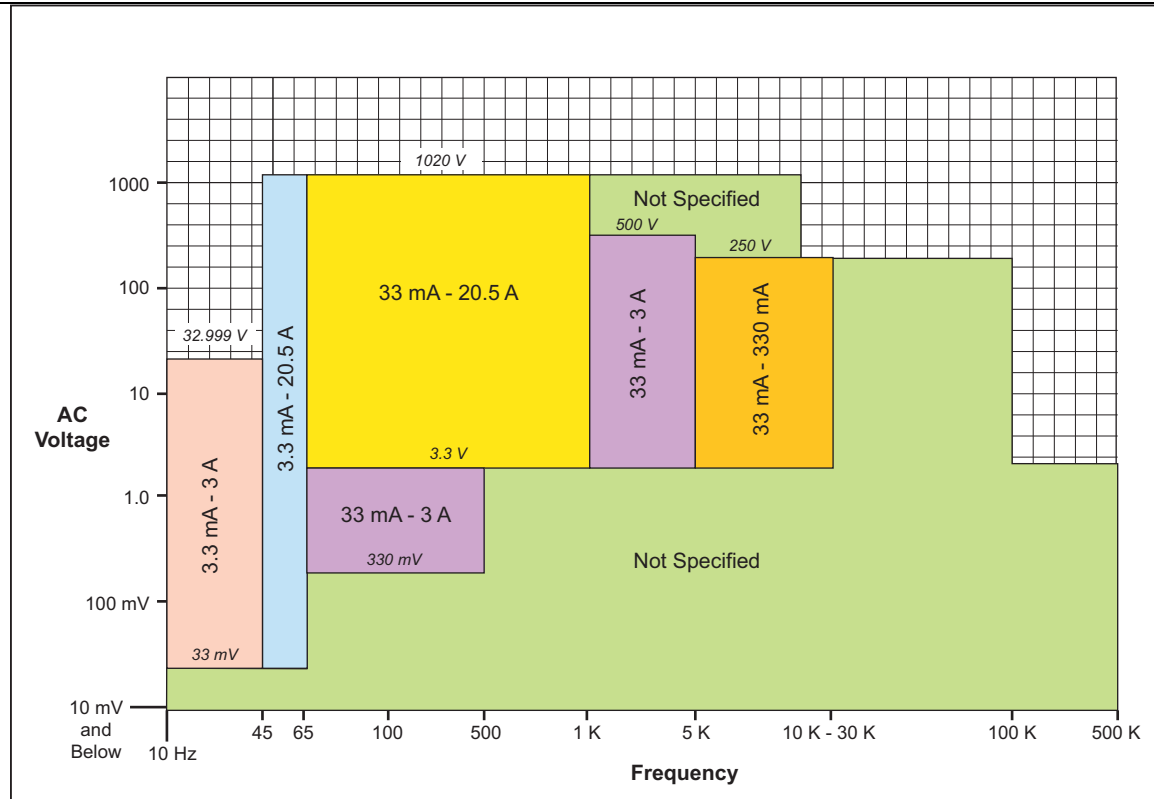


Figure 2. Permissible Combinations of AC Voltage and AC Current for Power and Dual Output

Calculate the Uncertainty Specifications of Power and Dual Output Settings

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

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

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

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

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

Examples of Specified Power Uncertainties at Various Output Settings:

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

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

Calculate Power Uncertainty

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

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

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

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

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

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.050 % + 3 mV, totaling: 100 V x .0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = 0.053 % (see "AC Voltage (Sine Wave) Specifications").

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

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

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

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

Voltage Uncertainty Uncertainty for 100 V at 400 Hz is 0.050% + 3 mV, totaling: 100 V x .00005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = 0.053 % (see "AC Voltage (Sine Wave) Specifications").

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

Phase Uncertainty (Watts) Adder for PF = 0.5 ($\Phi=60$) at 400 Hz is 2.73 % (see "Phase Specifications").

Total Power Uncertainty = $U_{\text{power}} = \sqrt{0.053^2 + 0.06^2 + 2.73^2} = 2.73\%$

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

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

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.050% + 3 mV, totaling: 100 V x .00005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = 0.053 % (see "AC Voltage (Sine Wave) Specifications").

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

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

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

Additional Specifications

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

Frequency

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

Harmonics (2nd to 50th)

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

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

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

Example of determining Amplitude Uncertainty in a Dual Output Harmonic Mode

What are the amplitude uncertainties for the following dual outputs?

NORMAL (Fundamental) Output:

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

AUX (50th Harmonic) Output:

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

AC Voltage (Sine Wave) Extended Bandwidth

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

AC Voltage (Non-Sine Wave)

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

0.93 to 9.29999 V	45 Hz to 1 kHz	0.25 + 0.25	Two digits on each range
	1 to 10 kHz	5.0 + 0.5	
	0.01 to 10 Hz	5.0 + 0.5	Six digits on each range
	10 to 45 Hz	0.25 + 0.5	
	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) ^[1]	Frequency	1-Year Absolute Uncertainty, tcal ±5 °C, ±(% of output + % of range) ^[2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 to 65.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
66 to 659.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
0.66 to 6.59999 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
6.6 to 66.0000 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
29 to 659.999 mV	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz ^[3]	5.0 + 0.5	
0.66 to 6.59999 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz ^[3]	5.0 + 0.5	
<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>			

Range ^[1] (Normal Channel)	Offset Range ^[2]	Max Peak Signal	1-Year Absolute Uncertainty, tcal $\pm 5\text{ }^\circ\text{C}$ ^[3] $\pm(\%$ 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
<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 ± 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.</p> <p>[3] For frequencies 0.01 to 10 Hz, and 500 kHz to 2 MHz, the offset uncertainty is 5 % of output, $\pm 1\%$ 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 μs	<10 μs to 1 % of final value	<2 %	1 % to 99 % <3.3 V p-p. 0.01 Hz to 100 kHz	$\pm(0.02\%$ of period + 100 ns), 50 % duty cycle $\pm(0.05\%$ 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 $\pm 5\text{ }^\circ\text{C}$ $\pm(\%$ 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 ±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	

[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 μs	40 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