FLUKE®

5520A
Multi-Product Calibrator

Extended Specifications
2005

5520A Specifications

The following tables list the 5520A specifications. All specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5520A has been turned off. (For example, if the 5520A has been turned off for 5 minutes, the warm-up period is 10 minutes.)

All specifications apply for the temperature and time period indicated. For temperatures outside of t_{cal} ±5 °C (t_{cal} is the ambient temperature when the 5520A was calibrated), the temperature coefficient as stated in the General Specifications must be applied.

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

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

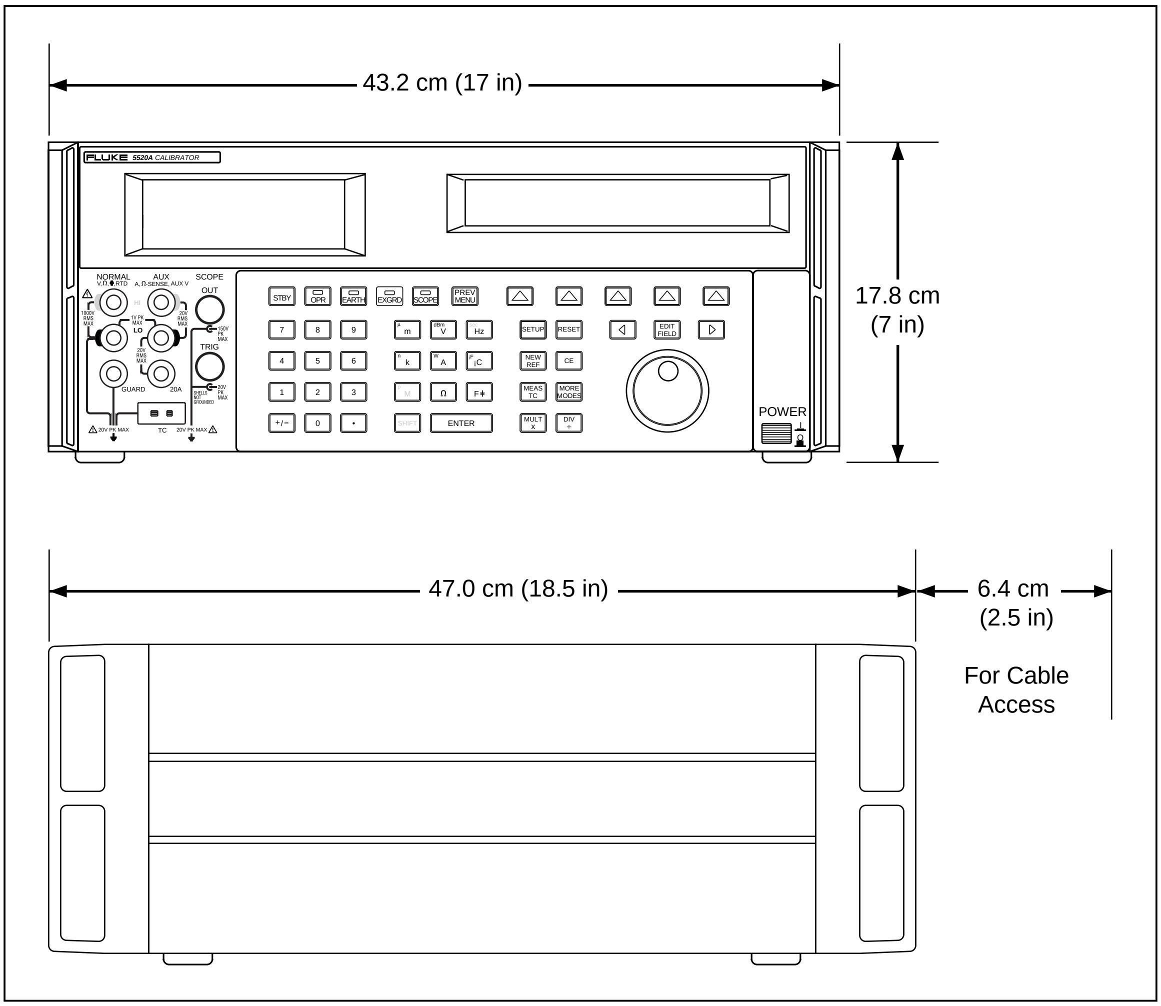

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Figure A. 5520A Calibrator Dimensional Outline

General Specifications

Warmup Time	Twice the time since last warmed up, to a maximum of 30 minutes.
Settling Time	Less than 5 seconds for all functions and ranges except as noted.
Standard Interfaces	IEEE-488 (GPIB), RS-232
Temperature Performance	• Operating: 0 °C to 50 °C • Calibration (tcal): 15 °C to 35 °C • Storage: -20 °C to 70 °C [3]
Temperature Coefficient	Temperature Coefficient for temperatures outside tcal +5 °C is 0.1X/°C of the 90-day specification (or 1-year, as applicable) per °C.
Relative Humidity [1]	• Operating: <80 % to 30 °C, <70 % to 40 °C, <40 % to 50 °C • Storage: <95 %, non-condensing
Altitude	• Operating: 3,050 m (10,000 ft) maximum • Non-operating: 12,200 m (40,000 ft) maximum
Safety	Complies with IEC 1010-1 (1992-1); ANSI/ISA-S82.01-1994; CAN/CSA-C22.2 No. 1010.1-92
Analog Low Isolation	20 V
EMC	Designed to comply with FCC Rules Part 15; VFG 243/1991. If used in areas with Electromagnetic fields of 1 to 3 V/m, resistance outputs have a floor adder of 0.508 . Performance not specified above 3 V/m. This instrument may be susceptible to electro-static discharge (ESD) from direct contact to the binding posts. Good static aware practices should be followed when handling this and other pieces of electronic equipment.
Line Power [2]	• Line Voltage (selectable): 100 V, 120 V, 220 V, 240 V • Line Frequency: 47 to 63 Hz • Line Voltage Variation: ±10 % about line voltage setting
Power Consumption	600 VA
Dimensions	• Height: 17.8 cm (7 inches), standard rack increment, plus 1.5 cm (0.6 inch) for feet on bottom of unit; • Width: 43.2 cm (17 inches), standard rack width • Depth: 47.3 cm (18.6 inches) overall
Weight (without options)	22 kg (49 lb)
Absolute Uncertainty Definition	The 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 for the temperature range indicated.
Specification Confidence Interval	99 %

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

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

[3] The DC Current ranges 0 to 1.09999 A and 1.1 to 2.99999 A are sensitive to storage temperatures above 50 °C. If the 5520A is stored above 50 °C for greater than 30 minutes, these ranges must be re-calibrated. Otherwise, the 90 day and 1 year uncertainties of these ranges double.

Electrical Specifications

DC Voltage Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + μV)		Stability	Resolution μV	Max Burden [1]
	90 days	1 year	24 hours, ± 1 °C ± (ppm output + μV)		
0 to 329.9999 mV	15 + 1	20 + 1	3 + 1	0.1	50 Ω
0 to 3.299999 V	9 + 2	11 + 2	2 + 1.5	1	10 mA
0 to 32.99999 V	10 + 20	12 + 20	2 + 15	10	10 mA
30 to 329.9999 V	15 + 150	18 + 150	2.5 + 100	100	5 mA
100 to 1000.000 V	15 + 1500	18 + 1500	3 + 300	1000	5 mA
Auxiliary Output (dual output mode only) [2]					
0 to 329.999 mV	300 + 350	400 + 350	30 + 100	1	5 mA
0.33 to 3.29999 V	300 + 350	400 + 350	30 + 100	10	5 mA
3.3 to 7 V	300 + 350	400 + 350	30 + 100	100	5 mA
TC Simulate and Measure in Linear 10 μV/°C and 1 mV/°C modes [3]					
0 to 329.999 mV	40 + 3	50 + 3	5 + 2	0.1	10 Ω

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

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

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

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p ± (ppm output + floor)	Bandwidth 10 Hz to 10 kHz rms
0 to 329.9999 mV	0 + 1 μV	6 μV
0 to 3.299999 V	0 + 10 μV	60 μV
0 to 32.99999 V	0 + 100 μV	600 μV
30 to 329.9999 V	10 + 1 mV	20 mV
100 to 1000.000 V	10 + 5 mV	20 mV
Auxiliary Output (dual output mode only) [1]		
0 to 329.999 mV	0 + 5 μV	20 μV
0.33 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 Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + μA)		Resolution	Max Compliance Voltage V	Max Inductive Load mH
	90 days	1 year			
0 to 329.999 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 (20 A Range)	380 + 500	500 + 500	100 μA	4	
11 to 20.5 A [1]	800 + 750 [2]	1000 + 750 [2]	100 μA	4	

[1] Duty Cycle: Currents < 11 A may be provided continuously. For currents > 11 A, see Figure B. 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 5520A 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 B is achieved only after the 5520A is outputting currents < 5 A for the "off" period first.

[2] Specifications apply within two minutes of selecting operate.

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

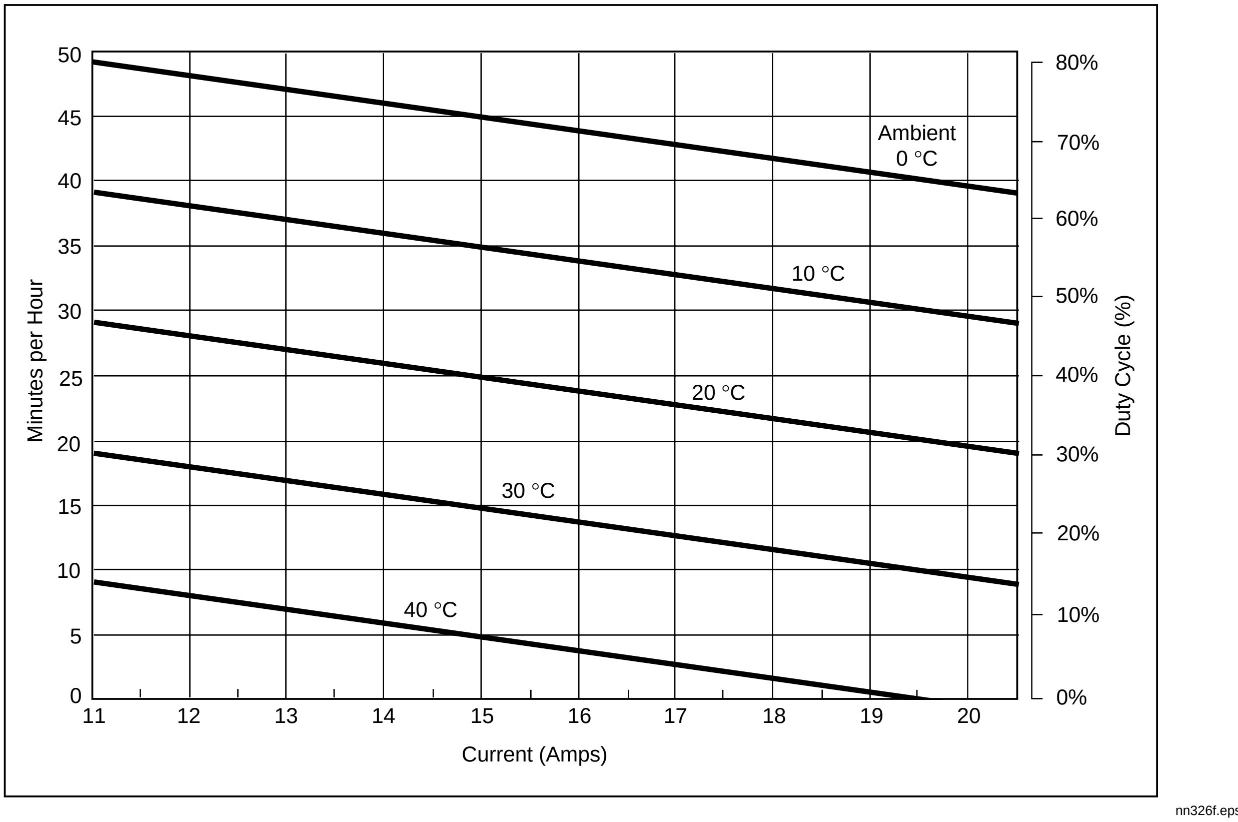

Figure B. Allowable Duration of Current > 11 A

Resistance Specifications

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

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

[2] Applies for a 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] For currents lower than shown, the floor adder increases by:
Floor (new) = Floor (old) X Imin/Iactual.
For example, a 50 μA stimulus measuring 100 Ω, has a floor specification of: 0.0014 Ω X 1 mA/50 μA = 0.028 Ω, assuming an ohms zero cal within 12 hours.

AC Voltage (Sine Wave) Specifications

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

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

Note

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

AC Voltage (Sine Wave) Specifications (cont.)

AUX (Auxiliary Output) [dual output mode only] [1]						
Range	Frequency	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μV)		Resolution	Max Burden	Max Distortion and Noise 10 Hz to 100 kHz Bandwidth ± (% output + floor)
		90 days	1 year			
10 to 329.999 mV	10 to 20 Hz	0.15 + 370	0.2 + 370	1 μV	5 mA	0.2 + 200 μV
	20 to 45 Hz	0.08 + 370	0.1 + 370			0.06 + 200 μV
	45 Hz to 1 kHz	0.08 + 370	0.1 + 370			0.08 + 200 μV
	1 to 5 kHz	0.15 + 450	0.2 + 450			0.3 + 200 μV
	5 to 10 kHz	0.3 + 450	0.4 + 450			0.6 + 200 μV
	10 Hz to 30 kHz	4.0 + 900	5.0 + 900			1 + 200 μV
0.33 to 3.29999 V	10 to 20 Hz	0.15 + 450	0.2 + 450	10 μV	5 mA	0.2 + 200 μV
	20 to 45 Hz	0.08 + 450	0.1 + 450			0.06 + 200 μV
	45 Hz to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 μV
	1 to 5 kHz	0.15 + 1400	0.2 + 1400			0.3 + 200 μV
	5 to 10 kHz	0.3 + 1400	0.4 + 1400			0.6 + 200 μV
	10 to 30 kHz	4.0 + 2800	5.0 + 2800			1 + 200 μV
3.3 to 5 V	10 to 20 Hz	0.15 + 450	0.2 + 450	100 μV	5 mA	0.2 + 200 μV
	20 to 45 Hz	0.08 + 450	0.1 + 450			0.06 + 200 μV
	45 Hz to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 μV
	1 to 5 kHz	0.15 + 1400	0.2 + 1400			0.3 + 200 μV
	5 to 10 kHz	0.3 +1400	0.4 + 1400			0.6 + 200 μV

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

Note

Remote sensing is not provided. 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) Specifications

LCOMP off						
Range	Frequency	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μA) 90 days	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μA) 1 year	Compliance adder ± (μA/V)	Max Distortion & Noise 10 Hz to 100 kHz BW ± (% output + floor)	Max Inductive Load μH
29.00 to 329.99 μA	10 to 20 Hz	0.16 + 0.1	0.2 + 0.1	0.05	0.15 + 0.5 μA	200
	20 to 45 Hz	0.12 + 0.1	0.15 + 0.1	0.05	0.1 + 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	
	10 to 30 kHz	1.2 + 0.4	1.6 + 0.4	10	1.2 + 0.5 μA	
0.33 to 3.2999 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	
	10 to 30 kHz	0.8 + 0.6	1.0 + 0.6	10	1.2 + 0.5 μA	
3.3 to 32.999 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	
	10 to 30 kHz	0.32 + 4	0.4 + 4	10	1.0 + 0.5 μA	
33 to 329.99 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	
	10 to 30 kHz	0.32 + 200	0.4 + 200	10	0.6 + 50 μA	
0.33 to 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 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 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 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 B. 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 5520A 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 B is achieved only after the 5520A 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) Specifications (cont.)

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

[1] Duty Cycle: Currents < 11 A may be provided continuously. For currents > 11 A, see Figure B. 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 5520A 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 B is achieved only after the 5520A is outputting currents < 5 A for the "off" period first.

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

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

[4] Subject to compliance voltages limits.

Range	Resolution µA	Max Compliance Voltage V rms [1]
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 Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (% of output + floor)		Resolution	Allowed Frequency or Charge-Discharge Rate		
	90 days	1 year		Min and Max to Meet Specification	Typical Max for < 0.5 % Error	Typical Max for < 1 % Error
0.19 to 0.3999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	20 kHz	40 kHz
0.4 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 10.9999 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 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 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 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 1.09999 μF	0.19 + 1 nF	0.25 + 1 nF	10 pF	10 to 600 Hz	1.5 kHz	2 kHz
1.1 to 3.29999 μF	0.19 + 3 nF	0.25 + 3 nF	10 pF	10 to 300 Hz	800 Hz	1 kHz
3.3 to 10.9999 μF	0.19 + 10 nF	0.25 + 10 nF	100 pF	10 to 150 Hz	450 Hz	650 Hz
11 to 32.9999 μF	0.30 + 30 nF	0.40 + 30 nF	100 pF	10 to 120 Hz	250 Hz	350 Hz
33 to 109.999 μF	0.34 + 100 nF	0.45 + 100 nF	1 nF	10 to 80 Hz	150 Hz	200 Hz
110 to 329.999 μF	0.34 + 300 nF	0.45 + 300 nF	1 nF	0 to 50 Hz	80 Hz	120 Hz
0.33 μF to 1.09999 mF	0.34 + 1 μF	0.45 + 1 μF	10 nF	0 to 20 Hz	45 Hz	65 Hz
1.1 to 3.2999 mF	0.34 + 3 μF	0.45 + 3 μF	10 nF	0 to 6 Hz	30 Hz	40 Hz
3.3 to 10.9999 mF	0.34 + 10 μF	0.45 + 10 μF	100 nF	0 to 2 Hz	15 Hz	20 Hz
11 to 32.9999 mF	0.7 + 30 μF	0.75 + 30 μF	100 nF	0 to 0.6 Hz	7.5 Hz	10 Hz
33 to 110 mF	1.0 + 100 μF	1.1 + 100 μF	10 μF	0 to 0.2 Hz	3 Hz	5 Hz

[1] The output is continuously variable from 190 pF to 110 mF.

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

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

Temperature Calibration (Thermocouple) Specifications

TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]		TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]	
		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) Specifications

RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2]	
		90 days	1 year
Pt 385, 100 Ω	-200 to -80	0.04	0.05
	-80 to 0	0.05	0.05
	0 to 100	0.07	0.07
	100 to 300	0.08	0.09
	300 to 400	0.09	0.10
	400 to 630	0.10	0.12
	630 to 800	0.21	0.23
Pt 3926, 100 Ω	-200 to -80	0.04	0.05
	-80 to 0	0.05	0.05
	0 to 100	0.07	0.07
	100 to 300	0.08	0.09
	300 to 400	0.09	0.10
	400 to 630	0.10	0.12
Pt 3916, 100 Ω	-200 to -190	0.25	0.25
	-190 to -80	0.04	0.04
	-80 to 0	0.05	0.05
	0 to 100	0.06	0.06
	100 to 260	0.06	0.07
	260 to 300	0.07	0.08
	300 to 400	0.08	0.09
	400 to 600	0.08	0.10
	600 to 630	0.21	0.23
Pt 385, 200 Ω	-200 to -80	0.03	0.04
	-80 to 0	0.03	0.04
	0 to 100	0.04	0.04
	100 to 260	0.04	0.05
	260 to 300	0.11	0.12
	300 to 400	0.12	0.13
	400 to 600	0.12	0.14
	600 to 630	0.14	0.16
Pt 385, 500 Ω	-200 to -80	0.03	0.04
	-80 to 0	0.04	0.05
	0 to 100	0.05	0.05
	100 to 260	0.06	0.06
	260 to 300	0.07	0.08
	300 to 400	0.07	0.08
	400 to 600	0.08	0.09
	600 to 630	0.09	0.11
Pt 385, 1000 Ω	-200 to -80	0.03	0.03
	-80 to 0	0.03	0.03
	0 to 100	0.03	0.04
	100 to 260	0.04	0.05
	260 to 300	0.05	0.06
	300 to 400	0.05	0.07
	400 to 600	0.06	0.07
	600 to 630	0.22	0.23
PtNi 385, 120 Ω (Ni120)	-80 to 0	0.06	0.08
	0 to 100	0.07	0.08
	100 to 260	0.13	0.14
Cu 427, 10 Ω [3]	-100 to 260	0.3	0.3

[1] Resolution is 0.003 °C

[2] Applies for COMP OFF (to the 5520A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.

[3] Based on MINCO Application Aid No. 18

DC Power Specification Summary

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

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

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

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

	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 ± 5 °C, ± (% of watts output) [1]			
90 days	33 to 329.999 mV	0.13	0.09	0.13	0.09
	330 mV to 1020 V	0.11	0.07	0.11	0.07
1 year	33 to 329.999 mV	0.14	0.10	0.14	0.10
	330 mV to 1020 V	0.12	0.08	0.12	0.08
	Voltage Range	**Current Range [2]**			
		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 ± 5 °C, ± (% of watts output) [1]			
90 days	33 to 329.999 mV	0.12	0.10	0.12	0.10
	330 mV to 1020 V	0.10	0.08	0.11	0.09
1 year	33 to 329.999 mV	0.13	0.11	0.13	0.11
	330 mV to 1020 V	0.11	0.09	0.12	0.10

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

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

Power and Dual Output Limit Specifications

Frequency	Voltages (NORMAL)	Currents	Voltages (AUX)	Power Factor (PF)
dc	0 to ± 1020 V	0 to ± 20.5 A	0 to ± 7 V	—
10 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 1000 V	3.3 mA to 20.5 A	10 mV to 5 V	0 to 1
65 to 500 Hz	330 mV to 1000 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
65 to 500 Hz	3.3 to 1000 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
500 Hz to 1 kHz	330 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	1
1 to 5 kHz	3.3 to 1000 V	33 mA to 2.99999 A	100 mV to 5 V	1
5 to 10 kHz	3.3 to 1000 V	33 to 329.99 mA	1 to 5 V	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). However, only those limits shown in this table are specified. See "Calculating Power Uncertainty" to determine the uncertainty at these points.
- The phase adjustment range for dual ac outputs is 0 ° to ± 179.99 °. The phase resolution for dual ac outputs is 0.01 degree.

Phase Specifications

1-Year Absolute Uncertainty, tcal ± 5 °C, (Δ Φ °)					
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 °

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 °	1.000	0.00 %	0.00 %	0.00 %	0.10 %	0.38 %	1.52 %
10 °	80 °	0.985	0.03 %	0.08 %	0.16 %	0.86 %	1.92 %	4.58 %
20 °	70 °	0.940	0.06 %	0.16 %	0.32 %	1.68 %	3.55 %	7.84 %
30 °	60 °	0.866	0.10 %	0.25 %	0.51 %	2.61 %	5.41 %	11.54 %
40 °	50 °	0.766	0.15 %	0.37 %	0.74 %	3.76 %	7.69 %	16.09 %
50 °	40 °	0.643	0.21 %	0.52 %	1.04 %	5.29 %	10.77 %	22.21 %
60 °	30 °	0.500	0.30 %	0.76 %	1.52 %	7.65 %	15.48 %	31.60 %
70 °	20 °	0.342	0.48 %	1.20 %	2.40 %	12.08 %	24.33 %	49.23 %
80 °	10 °	0.174	0.99 %	2.48 %	4.95 %	24.83 %	49.81 %	100.00 %
90 °	0 °	0.000	—	—	—	—	—	—

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

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

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

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

Calculating Power Uncertainty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Additional Specifications

The following paragraphs provide additional specifications for the 5520A Calibrator ac voltage and ac current functions. These specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5520A has been turned off. All extended range specifications are based on performing the internal zero-cal function at weekly intervals, or when the ambient temperature changes by more than 5 °C.

Frequency Specifications

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 [1]	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 5520A is the uncertainty of the external 10 MHz clock ± 5 μHz. The amplitude of the 10 MHz external reference clock signal should be between 1 V and 5 V p-p.

Harmonics (2nd to 50th) Specifications

Fundamental Frequency [1]	Voltages NORMAL Terminals	Currents	Voltages AUX Terminals	Amplitude Uncertainty
10 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 1000 V	3.3 mA to 20.5 A	10 mV to 5 V	
65 to 500 Hz	33 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	
500 Hz to 5 kHz	330 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	
5 to 10 kHz	3.3 to 1000 V	33 to 329.9999 mA	100 mV to 5 V	
10 to 30 kHz	3.3 to 1000 V	33 to 329.9999 mA	100 mV to 3.29999 V	

Phase uncertainty for harmonic outputs is 1 degree or the phase uncertainty shown in "Phase Specifications" for the particular output, whichever is greater. For example, the phase uncertainty of a 400 Hz fundamental output and 10 kHz harmonic output is 10 ° (from "Phase Specifications"). Another example, the phase uncertainty of a 60 Hz fundamental output and a 400 Hz harmonic output is 1 degree.

[1] The maximum frequency of the harmonic output is 30 kHz (10 kHz for 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 to 5 V on the Aux terminals).

Example of determining Amplitude Uncertainty in a Dual Output Harmonic Mode

What are the amplitude uncertainties for the following dual outputs?

NORMAL (Fundamental) Output:

100V, 100 Hz..From "AC Voltage (Sine Wave) Specifications" the single output specification for 100V, 100 Hz, is 0.015 % + 2 mV. For the dual output in this example, the specification is <u>0.015 % + 4 mV</u> as the 0.015 % is the same, and the floor is twice the value (2 x 2 mV).

AUX (50th Harmonic) Output:

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

AC Voltage (Sine Wave) Extended Bandwidth Specifications

Range	Frequency	1-Year Absolute Uncertainty tcal ± 5 °C	Max Voltage Resolution
Normal Channel (Single Output Mode)			
1.0 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) Specifications

Triangle Wave & Truncated Sine Range, p-p [1]	Frequency	1-Year Absolute Uncertainty, tcal ± 5 °C, ± (% of output + % of range) [2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 mV to 93 V	0.01 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)			
93 mV to 14 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	5.0 + 0.5	

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

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

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

Square Wave Range (p-p) [1]	Frequency	1-Year Absolute Uncertainty, tcal ± 5 °C ± (% of output + % of range) [2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 mV to 66 V	0.01 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)			
66 mV to 14 V	0.01 to 10 Hz	5.0 + 0.5	Two digits on each range
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz [3]	5.0 + 0.5	

[1] To convert p-p to rms for square wave, multiply the p-p value by 0.5.

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

[3] Limited to 1 kHz for Auxiliary outputs ≥ 6.6 V p-p.

AC Voltage, DC Offset Specifications

Range [1] (Normal Channel)	Offset Range [2]	Max Peak Signal	1-Year Absolute Offset Uncertainty, tcal ± 5 °C [3] ± (% dc output + floor)
Sine Waves (rms)			
3.3 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 mV 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 mV to 9.29999 V	0 to 5 V	8 V	0.1 + 9300 μV
9.3 mV to 92.9999 V	0 to 50 V	55 V	0.1 + 93 mV
Square Waves (p-p)			
6.6 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 mV to 6.59999 V	0 to 5 V	8 V	0.1 + 6600 μV
6.6 mV to 65.9999 V	0 to 50 V	55 V	0.1 + 66 mV

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

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

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

AC Voltage, Square Wave Characteristics

Risetime @ 1 kHz Typical	Settling Time @ 1 kHz Typical	Overshoot @ 1 kHz Typical	Duty Cycle Range	Duty Cycle Uncertainty
< 1 μs	< 10 μs to 1 % of final value	< 2 %	1 % to 99 %, < 3.3 V p-p, 0.01 Hz to 100 kHz	± (0.02 % of period + 100 ns), 50 % duty cycle ± (0.05 % of period + 100 ns), other duty cycles from 10 % to 90 %

AC Voltage, Triangle Wave Characteristics (typical)

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

AC Current (Non-Sine Wave) Specifications

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

[1] Frequency limited to 1 kHz with LCOMP on.

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

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

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

[1] Frequency limited to 1 kHz with LCOMP on.

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

AC Current, Square Wave Characteristics (typical)

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

AC Current, Triangle Wave Characteristics (typical)

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

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