



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017  
& ANSI/NCSL Z540-1-1994

AVALON TEST EQUIPMENT  
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CALIBRATION

Valid To: July 31, 2024

Certificate Number: 4859.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory at the location listed above as well as the satellite laboratory location listed below to perform the following calibrations<sup>1,5</sup>:

I. Acoustics & Vibration

Parameter/Equipment	Range	CMC <sup>2,9</sup> (±)	Comments
Sound Level – Measuring Equipment			
Fixed Points	94 dB 114 dB	0.37 dB 0.37 dB	Bruel & Kjaer 4231

II. Dimensional

Parameter/Equipment	Range	CMC <sup>2,6</sup> (±)	Comments
Calipers <sup>8</sup>	Up to 12 in	$(3.9 \mu\text{in/in} + 0.7 \mu\text{in}) + 0.6R$	Gage blocks
Indicators- Dial & Digital Indicators, LVDT's <sup>8</sup>	Up to 8 in	$(2.2 \mu\text{in/in} + 2.1 \mu\text{in}) + 0.6R$	Gage blocks
Micrometer <sup>8</sup>	Up to 12 in	$(3.9 \mu\text{in/in} + 0.7 \mu\text{in}) + 0.6R$	Gage blocks

III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Voltage – Generate			
Fixed Point	10 V	0.29 $\mu\text{V/V}$	MI 1330A
Variable DC	(0 to 0.33) V (0.33 to 3.3) V (3.3 to 33) V 33 V to 0.33 kV (0.33 to 1.02) kV	4.9 $\mu\text{V/V} + 0.5 \mu\text{V}$ 2.9 $\mu\text{V/V} + 1.4 \mu\text{V}$ 3.4 $\mu\text{V/V} + 17 \mu\text{V}$ 3.9 $\mu\text{V/V} + 15 \mu\text{V}$ 3.7 $\mu\text{V/V} + 1.2 \text{ mV}$	Fluke 5522A
	100 V to 30 kV	0.03 % + 2.1 V	Keytek DCA-2
	(1 to 60) kV	0.19 % + 36 V	CPS HVP-500
DC Voltage – Measure	0 V 10 $\mu\text{V}$ to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV*	1.3 $\mu\text{V}$ 0.5 $\mu\text{V/V} + 1.1 \mu\text{V}$ 7.8 $\mu\text{V/V} + 0.16 \mu\text{V}$ 8.4 $\mu\text{V/V} + 0.3 \mu\text{V}$ 11 $\mu\text{V/V} + 40 \mu\text{V}$ 9 $\mu\text{V/V} + 0.2 \text{ mV}$	Agilent 3458A, option 002  *Add 12 ppm x ( $V_{\text{in}}/1000$ ) <sup>2</sup> for V > 100
	100 V to 30 kV	0.03 % + 2.1 V	Keytek DCA-2
	(1 to 100) kV	0.19 % + 36 V	CPS HVP-500
DC Current – Generate	(0 to 0.33) mA (0.33 to 3.3) mA (3.3 to 33) mA 33 mA to 0.33 A (0.33 to 3) A (11 to 20.5) A	15 $\mu\text{A/A} + 2.3 \text{ nA}$ 6.5 $\mu\text{A/A} + 19 \text{ nA}$ 15 $\mu\text{A/A} + 0.18 \mu\text{A}$ 22 $\mu\text{A/A} + 1 \mu\text{A}$ 81 $\mu\text{A/A} + 8 \mu\text{A}$ 0.11 mA/A + 0.14 mA	Fluke 5522A
Current Clamp – Non-Toroidal	(16.5 to 1025) A	0.62 % + 0.16 A	Fluke 5522A w/ 5500 Coil
DC Current – Measure	(10 to 100) nA (0.1 to 1) $\mu\text{A}$ (1 to 10) $\mu\text{A}$ (10 to 100) $\mu\text{A}$ 100 $\mu\text{A}$ to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	0.13 mA/A + 0.034 nA 29 $\mu\text{A/A} + 0.043 \text{ nA}$ 56 $\mu\text{A/A} + 0.016 \text{ nA}$ 26 $\mu\text{A/A} + 0.04 \text{ nA}$ 25 $\mu\text{A/A} + 0.1 \text{ nA}$ 21 $\mu\text{A/A} + 3 \text{ nA}$ 87 $\mu\text{A/A} + 0.73 \mu\text{A}$ 87 $\mu\text{A/A} + 23 \mu\text{A}$	Agilent 3458A, option 002

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
DC Current – Measure (cont)	10 $\mu$ A to 3 A 100 $\mu$ A to 10 A 1 mA to 30 A 10 mA to 100 A 100 mA to 300 A	12 $\mu$ A/A + 1.5 $\mu$ A 65 $\mu$ A/A + 9.5 $\mu$ A 4.2 $\mu$ A/A + 3.8 mA 0.16 mA/A + 0.4 mA 0.42 mA/A + 0.2 A	Ohm-Labs MCS w/ Agilent 3458A option 002
DC Resistance – Generate			
Variable	(0 to 11) $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ 330 $\Omega$ to 1.1 k $\Omega$ (1.1 to 3.3) k $\Omega$ (3.3 to 11) k $\Omega$ (11 to 33) k $\Omega$ (33 to 110) k $\Omega$ (110 to 330) k $\Omega$ 330 k $\Omega$ to 1.1 M $\Omega$ (1.1 to 3.3) M $\Omega$ (3.3 to 11) M $\Omega$ (11 to 33) M $\Omega$ (33 to 110) M $\Omega$ (110 to 330) M $\Omega$ (330 to 1100) M $\Omega$	36 $\mu\Omega/\Omega$ + 94 $\mu\Omega$ 1.7 $\mu\Omega/\Omega$ + 0.61 m $\Omega$ 5.3 $\mu\Omega/\Omega$ + 1.1 m $\Omega$ 12 $\mu\Omega/\Omega$ + 0.87 m $\Omega$ 1.3 $\mu\Omega/\Omega$ + 18 m $\Omega$ 6.6 $\mu\Omega/\Omega$ + 2.1 m $\Omega$ 9.9 $\mu\Omega/\Omega$ + 12 m $\Omega$ 11 $\mu\Omega/\Omega$ + 29 m $\Omega$ 8.4 $\mu\Omega/\Omega$ + 0.48 $\Omega$ 17 $\mu\Omega/\Omega$ + 1.7 $\Omega$ 23 $\mu\Omega/\Omega$ + 0.31 $\Omega$ 52 $\mu\Omega/\Omega$ + 14 $\Omega$ 91 $\mu\Omega/\Omega$ + 9.7 $\Omega$ 61 $\mu\Omega/\Omega$ + 2.4 k $\Omega$ 0.2 m $\Omega/\Omega$ + 3.3 k $\Omega$ 5.4 m $\Omega/\Omega$ + 27 k $\Omega$ 2.3 m $\Omega/\Omega$ + 0.78 M $\Omega$	Fluke 5522A
Fixed Points	1 $\Omega$ 10 k $\Omega$	1.4 $\mu\Omega$ 0.98 $\mu\Omega/\Omega$	MI 1330A MI 1330A
	1 $\Omega$ 10 $\Omega$ 100 $\Omega$ 1 k $\Omega$ 10 k $\Omega$ 100 k $\Omega$ 1 M $\Omega$	1.5 $\mu\Omega$ 11 $\mu\Omega$ 72 $\mu\Omega$ 1.3 m $\Omega$ 15 m $\Omega$ 52 m $\Omega$ 2.2 $\Omega$	Ohm-Labs Multiple Resistance Standard (MRS)
DC Resistance – Measure	(0.001 to 10) $\Omega$ (10 to 100) $\Omega$ 100 $\Omega$ to 1 k $\Omega$ (1 to 10) k $\Omega$ (10 to 100) k $\Omega$ 100 k $\Omega$ to 1 M $\Omega$ (1 to 10) M $\Omega$ (10 to 100) M $\Omega$ (0.1 to 1.0) G $\Omega$	24 $\mu\Omega/\Omega$ + 43 $\mu\Omega$ 4.9 $\mu\Omega/\Omega$ + 0.23 m $\Omega$ 1.1 $\mu\Omega/\Omega$ + 0.37 m $\Omega$ 1.5 $\mu\Omega/\Omega$ + 0.1 m $\Omega$ 1.7 $\mu\Omega/\Omega$ + 1 m $\Omega$ 8.1 $\mu\Omega/\Omega$ + 0.69 $\Omega$ 69 $\mu\Omega/\Omega$ + 4 $\Omega$ 0.16 m $\Omega/\Omega$ + 0.1 k $\Omega$ 1.9 m $\Omega/\Omega$ + 0.001 M $\Omega$	Agilent 3458A, option 002

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Voltage – Generate			
(1 to 33) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.018 % + 2.6 μV 0.0052 % + 2.6 μV 0.046 % + 8.2 μV 0.13 % + 13 μV 1 % + 1 μV 0.13 % + 7.1 μV	Fluke 5522A
(33 to 330) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.028 % + 7.8 μV 0.0036 % + 3.2 μV 0.0033 % + 3.1 μV 0.016 % + 4.7 μV 0.014 % + 31 μV 0.018 % + 24 μV	
(0.33 to 3.3) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.025 % + 2.5 μV 0.003 % + 20 μV 0.018 % + 71 μV 0.026 % + 34 μV 0.003 % + 0.11 mV 0.11 % + 27 μV	
(3.3 to 33) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.021 % + 0.22 mV 0.003 % + 0.2 mV 0.0026 % + 0.22 mV 0.0027 % + 0.89 mV 0.0037 % + 1.3 mV	
(33 to 330) V	45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.0046 % + 2.2 mV 0.01 % + 2.7 mV 0.0048 % + 1.5 mV 0.02 % + 3 mV 0.004 % + 23 mV	
(330 to 1020) V	45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.0049 % + 16 mV 0.017 % + 13 mV 0.036 % + 11 mV	
AC Voltage – Measure			
(10 to 100) mV	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 4) MHz	0.10 mV/V + 1 μV 38 μV/V + 1.6 μV 36 μV/V + 1.8 μV 42 μV/V + 2.3 μV 0.17 mV/V + 1 μV 7.3 mV/V + 0.47 mV 11 mV/V + 0.41 mV	Agilent 3458A, option 002

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Voltage – Measure (cont)			
100 mV to 1 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	26 µV/V + 0.4 µV 28 µV/V + 1.6 µV 22 µV/V + 4.9 µV 30 µV/V + 3.7 µV 0.15 mV/V + 3 µV 2 mV/V + 0.19 mV 14 mV/V + 0.1 mV 42 mV/V + 1.3 mV 70 mV/V + 5 mV	Agilent 3458A, option 002
(1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	0.1 mV/V + 0.49 mV 0.11 mV/V + 80 µV 0.15 mV/V + 0.2 mV 0.35 mV/V + 0.27 mV 1.1 mV/V + 0.1 mV 3.5 mV/V + 0.4 mV 13 mV/V + 1 mV 46 mV/V + 2 mV 54 mV/V + 9 mV 0.14 V/V + 60 mV	
(10 to 100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.27 mV/V + 0.1 mV 0.25 mV/V + 1.2 mV 0.29 mV/V + 0.4 mV 0.84 mV/V + 1.6 mV	
(100 to 700) V	40 Hz to 1 kHz (1 to 20) kHz	0.34 mV/V + 1 mV 0.41 mV/V + 2 mV	
AC Current – Generate			
(29 to 330) µA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.1 % + 0.1 µA 0.072 % + 0.043 µA 0.3 % + 0.011 µA 0.51 % + 0.12 µA 0.54 % + 0.12 µA	Fluke 5522A
330 µA to 3.3 mA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.11 % + 27 nA 0.039 % + 11 nA 0.039 % + 21 nA 0.071 % + 0.97 µA 0.19 % + 0.29 µA	

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Current – Generate (cont)			
(3.3 to 33) mA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.23 % + 3.4 μA 0.016 % + 32 nA 0.015 % + 0.81 μA 0.033 % + 0.11 μA 0.094 % + 1.1 μA	Fluke 5522A
(33 to 330) mA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.0084 % + 43 μA 0.019 % + 0.33 μA 0.019 % + 0.33 μA 0.079 % + 9.9 μA 0.26 % + 26 μA	
(0.33 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.035 % + 59 μA 0.033 % + 11 μA 0.033 % + 0.21 mA 0.068 % + 0.17 mA	
(3 to 20.5) A	(10 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.059 % + 0.17 mA 0.077 % + 0.66 mA 0.84 % + 1.3 mA	
Clamp-On Only (Toroidal-Type)			
(16.5 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.33 % + 28 mA 0.92 % + 28 mA	Fluke 5522A w/ 5500/coil
Clamp-On Only (Other-Type)			
(16.5 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.72 % + 0.28 A 1.3 % + 16 mA	
AC Current – Measure			
(1 to 100) μA	45 Hz to 1 kHz	0.34 mA/A + 3.4 nA	Agilent 3458A, option 002
(0.1 to 1) mA	(45 to 100) Hz (0.1 to 5) kHz (5 to 10) kHz	1.1 mA/A + 0.38 μA 0.94 mA/A + 0.16 μA 1.4 mA/A + 0.31 μA	
(1 to 10) mA	(45 to 100) Hz (0.1 to 5) kHz (5 to 10) kHz	1.9 mA/A + 1.8 μA 1.9 mA/A + 0.2 μA 1.9 mA/A + 1.8 μA	

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Current – Measure (cont)			
(10 to 100) mA	(45 to 100) Hz (0.1 to 5) kHz (5 to 10) kHz	0.71 mA/A + 24 µA 0.41 mA/A + 1.8 µA 0.77 mA/A + 23 µA	Agilent 3458A, option 002  Agilent 3458A, option 002 w/ Ohm-Labs multiple current shunts (MCS)
(0.1 to 1) A	(45 to 100) Hz (0.1 to 5) kHz	1.4 mA/A + 0.18 mA 1.1 mA/A + 0.06 mA	
(0.001 to 10) A	(10 to 60) Hz (60 to 400) Hz	0.0028 % + 0.54 mA 0.0016 % + 0.67 mA	
(1 to 30) A	(10 to 60) Hz (60 to 400) Hz	0.014 % + 0.05 mA 0.013 % + 0.06 mA	
Phase – Generate  Sinewave Voltage to Voltage  Phase Range: (0 to 360)°	(10 to 65) Hz (65 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz	0.0011 % + 0.050° 0.0011 % + 0.053° 0.0011 % + 0.053° 0.21°	Fluke 5522A

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Power – Generate  33 mV to 1020 V	11 µW to 1.09 mW (1.09 to 109) mW 109 mW to 10.9 W (10.9 to 990) W (.99 to 20.5) kW	0.01 % + 0.8 nW 0.011 % + 0.07 µW 0.0071 % + 8.3 µW 0.017 % + 4.1 mW 0.019 % + 0.8 W	Fluke 5522A

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
AC Power – Generate  PF = 1, $\Phi = 0^\circ$ @ (45 to 65) Hz  33 mV to 1020 V:			
0.33 V & 0.0033 A	109 $\mu$ W to 109 mW	0.01 % + 0.037 $\mu$ W	Fluke 5522A
3.3 V & 0.33A	10.9 mW to 1.09 W	0.04 % + 4.4 $\mu$ W	
33 V & 3.0 A	(1.09 to 99) W	0.068 % + 79 $\mu$ W	
330 V & 3.0 A	(10.9 to 990) W	0.067 % + 2.6 mW	
1020 V & 3.0 A	(109 to 3060) W	0.067 % + 37 mW	
1020 V & 20.5 A	(990 to 20.5) kW	0.13 % + 0.61 W	

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
Capacitance – Generate			
(220 to 400) pF	10 Hz to 10 kHz	0.059 % + 1.8 pF	Fluke 5522A
(0.4 to 1.1) nF	10 Hz to 10 kHz	0.058 % + 2.3 pF	
(1.1 to 3.3) nF	10 Hz to 3 kHz	0.1 % + 0.8 pF	
(3.3 to 11) nF	10 Hz to 1 kHz	0.084 % + 1.8 pF	
(11 to 33) nF	10 Hz to 1 kHz	0.044 % + 7.7 pF	
(33 to 110) nF	10 Hz to 1 kHz	0.033 % + 38 pF	
(110 to 330) nF	10 Hz to 1 kHz	0.047 % + 98 pF	
(0.33 to 1.1) $\mu$ F	(10 to 600) Hz	0.036 % + 0.37 nF	
(1.1 to 3.3) $\mu$ F	(10 to 300) Hz	0.06 % + 0.30 nF	
(3.3 to 11) $\mu$ F	(10 to 150) Hz	0.082 % + 0.36 nF	
(11 to 33) $\mu$ F	(10 to 120) Hz	0.06 % + 12 nF	
(33 to 110) $\mu$ F	(10 to 80) Hz	0.12 % + 10 nF	
(110 to 330) $\mu$ F	(0 to 50) Hz	0.02 % + 0.38 mF	
(0.33 to 1.1) mF	(0 to 20) Hz	0.063 % + 0.51 $\mu$ F	
(1.1 to 3.3) mF	(0 to 6) Hz	0.022 % + 0.55 $\mu$ F	
(3.3 to 11) mF	(0 to 2) Hz	0.05 % + 0.25 $\mu$ F	
(11 to 33) mF	(0 to 0.6) Hz	0.04 % + 6 $\mu$ F	
(33 to 110) mF	(0 to 0.2) Hz	0.014 % + 16 $\mu$ F	





Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments	
Electrical Stimulation of Thermocouple				
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.22 °C 0.22 °C 0.22 °C 0.12 °C 0.12 °C	Fluke 5522A	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.22 °C 0.22 °C 0.22 °C 0.12 °C 0.12 °C		
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.22 °C 0.22 °C 0.22 °C 0.12 °C		
Oscilloscopes <sup>3</sup> –				
DC Voltage: 50 Ω 1 MΩ	(0 to ± 6.6) V (0 to ± 130) V	0.056 % + 11 μV 0.0077 % + 12 μV		Fluke 5522A/SC1100
AC Voltage (Square Wave): 50 Ω	±1 mV <sub>pk-pk</sub> to ±6.6 V <sub>pk-pk</sub> 10 Hz to 10 kHz	0.094 % + 6.3 μV		
1 MΩ	±1 mV <sub>pk-pk</sub> to ±130 V <sub>pk-pk</sub> 10 Hz to 10 kHz	0.085 % + 6.6 μV		
Leveled Sine Amplitude Reference @ 50 kHz	5 mV to 5.5 V	0.26 % + 22 μV		
Leveled Sine Amplitude (Relative to 50 kHz) 5 mV to 5.5 V	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 600 MHz to 1.1 GHz	0.83 % + 79 μV 0.87 % + 87 μV 0.93 % + 84 μV 1.1 % + 85 μV		

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Oscilloscopes <sup>3</sup> – (cont)			
Time Marker	1 ns to 20 ms 50 ms to 5s	0.000 014 % + 2.5 fs 0.0022 % + 0.2 μs	Fluke 5522A/SC1100
Frequency – Generate (Leveled Sine Wave)	50 kHz to 1.1 GHz	0.000 0074 % + 25 mHz	
Impedance – Measure	(40 to 60) Ω 500 kΩ to 1.5 MΩ	0.04 % + 2 mΩ 0.051 % + 5 Ω	

#### IV. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC <sup>2,3,7,9</sup> (±)	Comments
RF Power – Measure			
Absolute:			
Power Reference 1 mW, Type-N(f) 50 Ω	50 MHz	0.27 %	Keysight N432A w/ 478A-H76, Agilent 3458A option 002
(20 to 30) dBm	9 kHz to 7 GHz (7 to 18) GHz	1.5 % + <i>M</i> 1.9 % + <i>M</i>	Agilent power Meter w/ E9304- H19 series power sensors
(10 to 20) dBm	9 kHz to 9.999 MHz 10 MHz to 3.999 999 GHz (4 to 18) GHz (18 to 26.999 999) GHz (27 to 33.999 999) GHz (34 to 38.999 999) GHz (39 to 43.999 999) GHz (44 to 50) GHz (50 to 70) GHz	1.4 % + <i>M</i> 1.5 % + <i>M</i> 2.0 % + <i>M</i> 2.1 % + <i>M</i> 2.2 % + <i>M</i> 2.5 % + <i>M</i> 2.9 % + <i>M</i> 3.4 % + <i>M</i> 4.0 % + <i>M</i>	Keysight EPM power meter w/ 8480, N8480, E9300 series power sensors
(0 to 10) dBm	9 kHz to 5.999 999 GHz (6 to 12.999 999) GHz (13 to 18) GHz	1.3 % + <i>M</i> 1.5 % + <i>M</i> 1.9 % + <i>M</i>	

Parameter/Range	Frequency	CMC <sup>2, 3, 7, 9</sup> ( $\pm$ )	Comments	
RF Power – Measure (cont)				
Absolute:				
(0 to 10) dBm	(18 to 33.999 999) GHz (34 to 38.999 999) GHz (39 to 43.999 999) GHz (44 to 50) GHz (50 to 70) GHz	2.1 % + <i>M</i> 2.5 % + <i>M</i> 2.8 % + <i>M</i> 3.3 % + <i>M</i> 4.2 % + <i>M</i>	Keysight EPM power meter w/ 8480, N8480, E9300 series power sensors	
(-10 to 0) dBm	9 kHz to 9.999 MHz 10 MHz to 9.999 999 GHz (10 to 16.999 999) GHz (17 to 18) GHz (18 to 26.5) GHz (26.5 to 33.99 9999) GHz (34 to 38.999 999) GHz (39 to 50) GHz (50 to 70) GHz	1.4 % + <i>M</i> 1.2 % + <i>M</i> 1.3 % + <i>M</i> 1.6 % + <i>M</i> 1.9 % + <i>M</i> 2.1 % + <i>M</i> 2.5 % + <i>M</i> 3.3 % + <i>M</i> 4.2 % + <i>M</i>		
(-20 to -10) dBm	9 kHz to 9.999 MHz 10 MHz to 8.999 999 GHz (9 to 16.999 999) GHz (17 to 18) GHz (18 to 26.5) GHz (26.5 to 33.999 999) GHz (34 to 38.999 999) GHz (39 to 50) GHz (50 to 70) GHz	1.5 % + <i>M</i> 1.3 % + <i>M</i> 1.4 % + <i>M</i> 1.7 % + <i>M</i> 1.9 % + <i>M</i> 2.1 % + <i>M</i> 2.5 % + <i>M</i> 3.3 % + <i>M</i> 4.1 % + <i>M</i>		
(-30 to -20) dBm	9 kHz to 6.999 999 GHz (7 to 18) GHz (18 to 33.999 999) GHz (34 to 39.999 999) GHz (40 to 50) GHz (50 to 70) GHz	3.2 % + <i>M</i> 3.5 % + <i>M</i> 3.9 % + <i>M</i> 4.2 % + <i>M</i> 4.7 % + <i>M</i> 5.4 % + <i>M</i>		E4448A w/ option 233
(-40 to -30) dBm	9 kHz to 10.999 999 GHz (11 to 16.999 999) GHz (17 to 18) GHz	3.3 % + <i>M</i> 3.4 % + <i>M</i> 3.5 % + <i>M</i>		
(-50 to -40) dBm	9 kHz to 16.999 999 GHz (17 to 18) GHz	7.0 % + <i>M</i> 7.1 % + <i>M</i>		
Relative:				
(-60 to 20) dB	100 kHz to 50 GHz	0.071 dB		
(-80 to -60) dB		0.086 dB		
(-140 to -80) dB		0.1 dB		



Parameter/Range	Frequency	CMC <sup>2,3,9</sup> (±)	Comments
RF Power – Generate  (-36 to 23.98) dBm  DUT VSWR ≤ 1.4  (10 to 18) dBm (10 to 19) dBm (10 to 17) dBm (10 to 13) dBm (0 to 10) dBm  (0 to 9) dBm (0 to 8) dBm  (-10 to 0) dBm  (-90 to -10) dBm	1 Hz to 10 MHz (10 to 80) MHz  250 kHz to 400 MHz (0.4 to 3.2) GHz (3.2 to 15) GHz (15 to 30) GHz 250 kHz to 2 GHz (2 to 20) GHz (20 to 30) GHz  (30 to 65) GHz (65 to 67) GHz  250 kHz to 2 GHz (2 to 20) GHz (20 to 67) GHz  250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz	0.15 dB 0.18 dB  0.48 dB 0.6 dB 0.5 dB 0.47 dB 0.4 dB 0.43 dB 0.43 dB  0.76 dB 0.87 dB  0.39 dB 0.43 dB 0.51 dB  0.39 dB 0.42 dB 0.44 dB 0.61 dB	Keysight 33611A  Keysight E8257D DUT: device under test
Frequency Modulation – Measure  Rate: 20 Hz to 10 kHz Dev.: (0.2 to 40) kHz Peak  Rate: 50 Hz to 200 kHz Dev.: (0.25 to 400) kHz Peak  Rate: 50 Hz to 200 kHz Dev.: (0.25 to 400) kHz Peak	250 kHz to 10 MHz  10 MHz to 6.6 GHz  (6.6 to 13.2) GHz	$\beta > 0.20$ 0.47 % $\beta > 1.2$ 0.20 %  $\beta > 0.20$ 0.65 % $\beta > 0.45$ 0.12 %  $\beta > 0.20$ 1.3 % $\beta > 8.0$ 1.3 %	Keysight E4448A w/ opt 233  $\beta = \text{deviation} \div$ rate

Parameter/Range	Frequency	CMC <sup>2, 3, 7, 9</sup> ( $\pm$ )	Comments
Phase Modulation – Measure  Rate: 200 Hz to 20 kHz Dev.: > 0.7 Rad	100 kHz to 6.6 GHz	1.2 %	Keysight E4448A w/opt 233
Amplitude Modulation – Measure  100 kHz to 10 MHz  10 MHz to 3 GHz  (3 to 26.5) GHz  (26.5 to 31.15) GHz  (31.15 to 50) GHz	Rate: 50 Hz to 10 kHz Depth: (5 to 99) %  Rate: 50 Hz to 100 kHz Depth: (20 to 99) %  Rate: 50 Hz to 100 kHz Depth: (20 to 99) %  Rate: 50 Hz to 100 kHz Depth: (20 to 99) %  Rate: 50 Hz to 100 kHz Depth: (20 to 99) %	0.38 % + 0.006 AM  0.54 % + 0.005 AM  0.62 % + 0.005 AM  0.8 % + 0.01 AM  0.8 % + 0.01 AM	Keysight E4448A w/opt 233  AM = total amplitude modulation depth (in percent)
Phase Noise – Measure	1 MHz to 50 GHz	2 dBc/Hz	Keysight E4448A w/ option 233
RF Attenuation – Generate  1 dB 2 dB 3 dB 4 dB 5 dB 6 dB 7 dB 8 dB 9 dB 10 dB	DC to 18 GHz	0.10 dB + <i>M</i> 0.16 dB + <i>M</i> 0.14 dB + <i>M</i> 0.31 dB + <i>M</i> 0.35 dB + <i>M</i> 0.17 dB + <i>M</i> 0.22 dB + <i>M</i> 0.23 dB + <i>M</i> 0.20 dB + <i>M</i> 0.12 dB + <i>M</i>	Aeroflex 8310-202- F programmable attenuator (11 dB)

Parameter/Range	Frequency	CMC <sup>2,7,9</sup> ( $\pm$ )	Comments
RF Attenuation – Generate (cont)  11 dB 10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	DC to 18 GHz	0.13 dB + <i>M</i> 0.12 dB + <i>M</i> 0.11 dB + <i>M</i> 0.11 dB + <i>M</i> 0.12 dB + <i>M</i> 0.11 dB + <i>M</i> 0.12 dB + <i>M</i> 0.12 dB + <i>M</i> 0.11 dB + <i>M</i> 0.11 dB + <i>M</i> 0.11 dB + <i>M</i> 0.11 dB + <i>M</i> 0.20 dB + <i>M</i>	Aeroflex 8310-202-F programmable attenuator (110 dB)
Harmonics – Measure  DUT VSWR $\leq$ 1.4 (0 to 100) dBc	3 Hz to 3.05 GHz (2.85 to 6.6) GHz (6.2 to 13.2) GHz (12.8 to 19.2) GHz (18.7 to 26.8) GHz (26.4 to 31.15) GHz (31 to 50) GHz	0.37 dB 0.39 dB 0.39 dB 0.41 dB 0.45 dB 0.45 dB 0.45 dB	Keysight E4448A w/option 233
Transmission S12/S21 – Measure  50 $\Omega$ w/ Type N Connectors:  (0 to 20) dB  (20 to 40) dB  (40 to 60) dB	10 MHz to 18 GHz	Mag: (0.041 to 0.27) dB Phase: (0.18 to 1.7) $^{\circ}$  Mag: (0.048 to 0.69) dB Phase: (0.19 to 4.6) $^{\circ}$  Mag: (0.068 to 0.55) dB Phase: (0.31 to 3.7) $^{\circ}$	Keysight N5235A/85054B

Parameter/Range	Frequency	CMC <sup>2,9</sup> ( $\pm$ )	Comments
Transmission S12/S21 – Measure (cont)  50 $\Omega$ w/ 3.5 mm Connectors:  (0 to 20) dB  (20 to 40) dB  (40 to 60) dB  50 $\Omega$ w/ 2.4 mm Connectors:  (0 to 20) dB  (20 to 40) dB  50 $\Omega$ with 2.4 mm Connectors:  (40 to 60) dB	                10 MHz to 26.5 GHz                10 MHz to 50 GHz                10 MHz to 50 GHz	                Mag: (0.0068 to 0.13) dB Phase: (0.2 to 2.8) $^\circ$  Mag: (0.025 to 0.94) dB Phase: (0.23 to 11) $^\circ$  Mag: (0.32 to 5.5) dB Phase: (2.5 to 41) $^\circ$  Mag: (0.049 to 0.56) dB Phase: (0.21 to 4.47) $^\circ$  Mag: (0.10 to 0.57) dB Phase: (0.52 to 4.4) $^\circ$  Mag: (0.15 to 1.8) dB Phase: (0.93 to 12) $^\circ$	                Keysight N5235A/85052D                Keysight N5235A/85056D                Keysight N5235A/85056D
Reflection S11/S22 – Measure  50 $\Omega$ Type N:  (0.0001 to 0.25) lin  (0.25 to 0.5) lin  (0.5 to 0.75) lin  (0.75 to 1) lin	                10 MHz to 18 GHz	                Lin Mag: (0.0013 to 0.011) lin Phase: (3.3 to 180) $^\circ$  Lin Mag: (0.0025 to 0.32) lin Phase: (0.3 to 1.6) $^\circ$  Lin Mag: (0.0025 to 0.011) lin Phase: (0.3 to 1.7) $^\circ$  Lin Mag: (0.0025 to 0.016) lin Phase: (0.17 to 0.8) $^\circ$	                Keysight N5235A/85054B



Parameter/Range	Frequency	CMC <sup>2,3,9</sup> (±)	Comments
Reflection S11/S22 – Measure (cont)			
50 Ω w/ 3.5 mm Connectors:			
(0.0001 to 0.25) lin	10 MHz to 26.5 GHz	Lin Mag: (0.0003 to 0.0026) lin Phase: (0.43 to 33)°	Keysight N5235A/85052D
(0.25 to 0.5) lin		Lin Mag (0.0005 to 0.021) lin Phase: (0.21 to 6.16)°	
(0.5 to 0.75) lin		Lin Mag: (0.0005 to 0.027) lin Phase: (0.23 to 14)°	
(0.75 to 1) lin		Lin Mag: (0.0009 to 0.023) lin Phase: (0.29 to 6.6)°	
50 Ω w/ 2.4 mm Connectors:			
(0.0001 to 0.25) lin	10 MHz to 50 GHz	Lin Mag: (0.0007 to 0.019) lin Phase: (4.3 to 51)°	Keysight N5235A/85056D
(0.25 to 0.5) lin		Lin Mag: (0.0029 to 0.03) lin Phase: (0.52 to 11)°	
(0.5 to 0.75) lin		Lin Mag: (0.002 to 0.053) lin Phase: (0.28 to 37)°	
(0.75 to 1) lin		Lin Mag: (0.0089 to 0.11) lin Phase: (0.25 to 5.43)°	Keysight N5235A/85056D

Parameter/Equipment	Range	CMC <sup>2,3,9</sup> (±)	Comments
ESD Simulators –			
Contact Voltage	0.2 to 30 kV	0.03 % + 2.1 V	IEC/EN 61000-4-2, ISO 10605 Keytek DCA-2, Agilent 34401A, Teseq MD-103, Agilent DSO80604B
Rise Time	(0.6 to 1) ns	6.8 %	
Peak Current	(1 to 60) A	1 % + 0.13 A	
30 ns Current	(1 to 30) A	1.5 % + 0.15 A	
60 ns Current	(0.5 to 16) A	2.6 % + 0.15 A	



Parameter/Equipment	Range	CMC <sup>2,3,9</sup> (±)	Comments
EFT/Burst Generators – Peak Voltage Rise Time Impulse Duration Burst Duration Burst Period Repetition Rate	10 V to 8 kV (3.5 to 7) ns (30 to 200) ns (0.5 to 30) ms 100 to 300 ms 1 kHz to 1 MHz	5.7 % + 0.08 V 0.29 % + 0.23 ns 0.059 % + 0.29 ns 0.027 % + 0.003 ms 0.013 % + 0.002 ms 0.0029 % + 0.02 kHz	IEC 61000-4-4 w/500 MHz oscilloscope, and Haefely PAT 50/1000
Transient Generators – Rise Time – Open Circuit Short Circuit Duration/Pulse Width – Open Circuit Short Circuit Peak Voltage Peak Current Phase Angle Frequency	(0.05 to 50) µs (0.05 to 50) µs 1 µs to 1 s (1 to 1000) µs 10 V to 7 kV 5 A to 3 kA (0 to 360) ° 5 kHz to 1 MHz	0.07 % + 0.019 µs 0.078 % + 0.014 µs 0.000 36 % + 0.52 µs 0.013 % + 0.24 µs 3.9 % + 0.08 V 6.3 % + 0.53 A 0.013 % + 0.031° 0.0029 % + 0.02 kHz	IEC 61000-4-5, IEC 61000-4-12, IEC 61000-4-18 w/ 500 MHz oscilloscope, high voltage differential probe, Pearson 110
PQT – Output Voltage Voltage Pulse Rise/Fall Time Phase Angle	(0 to 480) V AC or DC (1 to 5) µs (0 to 360)°	2.0 % + 1.6 V 3.1 % + 0.006 µs 0.013 % + 0.031°	IEC 61000-4-11, w/ 500 MHz oscilloscope, high voltage differential probe

V. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2,9</sup> (±)	Comments
Frequency – Measuring Equipment	1 mHz to 80 MHz	0.14 nHz/Hz + 0.11 mHz	Keysight 33611A phase locked to pendulum GPS-89
	250 kHz to 67 GHz	1.3 pHz/Hz + 0.87 mHz	Keysight E8257D phase locked to pendulum GPS-89
Fixed Points	10 MHz	1.1 pHz	pendulum GPS-89

Parameter/Equipment	Range	CMC <sup>2,3,9</sup> (±)	Comments
Frequency – Measure	1 μHz to 6 GHz	0.87 nHz/Hz + 0.0011 Hz	Keysight 53220A phase locked to pendulum GPS-89
	100 kHz to 50 GHz	0.2 pHz/Hz + 0.12 Hz	Keysight E4448A w/ opt 233 phase locked to pendulum GPS-89

SATELLITE LABORATORY

Avalon Test Equipment  
 2928 Skyway Cir. N  
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I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Voltage – Generate  Variable DC	(0 to 0.33) V (0.33 to 3.3) V (3.3 to 33) V (33 V to 0.33 kV (0.33 to 1.02) kV	10 µV/V + 0.65 µV 5.9 µV/V + 2.5 µV 7.0 µV/V + 9.0 µV 7.7 µV/V + 75 µV 4.5 µV/V + 1.5 mV	Fluke 5522A
DC Voltage – Measure	0 V 10 µV to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV*	6.6 µV 7 µV/V + 3.2 µV 6.9 µV/V + 0.03 µV 4.7 µV/V + 2.2 µV 6.1 µV/V + 2.0 µV 8.3 µV/V + 0.13 mV	Agilent 3458A, option 002  *Add 12 ppm x Vin/1000 <sup>2</sup> for V > 100
DC Current – Generate  Current Clamp (Non-Toroidal)	(0 to 0.33) mA (0.33 to 3.3) mA (3.3 to 33) mA 33 mA to 0.33 A (.33 to 3) A (3 to 20.5) A  (16.5 to 1025) A	54 µA/A + 3.2 nA 58 µA/A + 9.8 nA 94 µA/A + 0.81 µA 65 µA/A + 4.7 µA 0.39 mA/A + 0.12 mA 1.3 mA/A + 2.7 mA  6.2 mA/A + 0.16 A	Fluke 5522A  Fluke 5522A w/5500 coil

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Current – Measure	(10 to 100) $\mu$ A 100 $\mu$ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	1.0 mA/A + 24 nA 11 $\mu$ A/A + 1.2 nA 11 $\mu$ A/A + 7.3 $\mu$ A 41 $\mu$ A/A + 5.2 $\mu$ A 70 $\mu$ A/A + 26 $\mu$ A	Agilent 3458A, option 002
	10 $\mu$ A to 3 A 100 $\mu$ A to 10 A 1 mA to 30 A 10 mA to 100 A 100 mA to 300 A	48 $\mu$ A/A + 1.8 $\mu$ A 26 $\mu$ A/A + 23 $\mu$ A 0.2 mA/A + 2.8 mA 3.4 mA/A + 2.0 mA 10 mA/A + 10 mA	Ohm-Labs MCS w/ Agilent 3458A option 002
DC Resistance – Generate			
Variable	(0 to 11) $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ 330 $\Omega$ to 1.1 k $\Omega$ (1.1 to 3.3) k $\Omega$ (3.3 to 11) k $\Omega$ (11 to 33) k $\Omega$ (33 to 110) k $\Omega$ (110 to 330) k $\Omega$ 330 k $\Omega$ to 1.1 M $\Omega$ (1.1 to 3.3) M $\Omega$ (3.3 to 11) M $\Omega$ (11 to 33) M $\Omega$ (33 to 110) M $\Omega$ (110 to 330) M $\Omega$ (330 to 1100) M $\Omega$	40 $\mu\Omega/\Omega$ + 0.14 m $\Omega$ 47 $\mu\Omega/\Omega$ + 91 $\mu\Omega$ 20 $\mu\Omega/\Omega$ + 10 $\mu\Omega$ 12 $\mu\Omega/\Omega$ + 2 m $\Omega$ 19 $\mu\Omega/\Omega$ + 30 $\mu\Omega$ 3.3 $\mu\Omega/\Omega$ + 32 m $\Omega$ 11 $\mu\Omega/\Omega$ + 0.7 m $\Omega$ 5.5 $\mu\Omega/\Omega$ + 0.11 $\Omega$ 13 $\mu\Omega/\Omega$ + 0.42 $\Omega$ 0.11 m $\Omega/\Omega$ + 0.64 $\Omega$ 36 $\mu\Omega/\Omega$ + 0.12 $\Omega$ 0.14 m $\Omega/\Omega$ + 3.4 $\Omega$ 86 $\mu\Omega/\Omega$ + 66 $\Omega$ 2 m $\Omega/\Omega$ + 9.2 k $\Omega$ 0.42 m $\Omega/\Omega$ + 22 k $\Omega$ 2 m $\Omega/\Omega$ + 0.62 M $\Omega$ 0.58 m $\Omega/\Omega$ + 0.59 M $\Omega$	Fluke 5522A
Fixed Points	1 $\Omega$ 10 $\Omega$ 100 $\Omega$ 1 k $\Omega$ 10 k $\Omega$ 100 k $\Omega$ 1 M $\Omega$	1.5 $\mu\Omega$ 11 $\mu\Omega$ 72 $\mu\Omega$ 1.3 m $\Omega$ 15 m $\Omega$ 52 m $\Omega$ 2.2 $\Omega$	Ohm-Labs multiple resistance standard (MRS)

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Resistance – Measure	(0.001 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ (.1 to 1.0) GΩ	37 μΩ/Ω + 60 μΩ 22 μΩ/Ω + 0.21 mΩ 17 μΩ/Ω + 0.7 mΩ 2.2 μΩ/Ω + 0.16Ω 8.2 μΩ/Ω + 98 mΩ 21 μΩ/Ω + 0.10 Ω 0.14 mΩ/Ω + 30 Ω 0.24 mΩ/Ω + 0.2 kΩ 0.41 mΩ/Ω + 0.59 MΩ	Agilent 3458A, option 002

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Voltage – Generate			
(1 to 33) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	1.1 mV/V + 0.2 μV 67 μV/V + 3.0 μV 81 μV/V + 2.8 μV 1.6 mV/V + 2.8 μV 1.1 mV/V + 5.3 μV 3.6 mV/V + 1.2 μV	Fluke 5522A
(33 to 330) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.36 mV/V + 21 μV 65 μV/V + 5.6 μV 60 μV/V + 5.9 μV 0.13 mV/V + 18 μV 0.18 mV/V + 26 μV 0.43 μV/V + 32 μV	
(0.33 to 3.3) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.34 mV/V + 68 μV 28 μV/V + 77 μV 7.5 μV/V + 0.16 mV 3.7 μV/V + 0.19 mV 45 μV/V + 0.19 mV 1 mV/V + 0.14 mV	
(3.3 to 33) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.23 mV/V + 0.44 mV 19 μV/V + 1.1 mV 33 μV/V + 0.8 mV 37 μV/V + 1.6 mV 0.11 mV/V + 2.2 mV	





Parameter/Range	Frequency	CMC <sup>2,4</sup> ( $\pm$ )	Comments
AC Voltage – Measure (cont)			
(10 to 100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	97 $\mu$ V/V + 0.33 mV 0.19 mV/V + 0.10 mV 0.28 mV/V + 0.60 mV 0.56 mV/V + 27 mV	Agilent 3458A, option 002
(100 to 700) V	40 Hz to 1 kHz (1 to 20) kHz	0.21 mV/V + 15 mV 0.41 mV/V + 3.0 mV	
AC Current – Generate			
(29 to 330) $\mu$ A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	1.2 mA/A + 62 nA 0.14 mA/A + 0.15 $\mu$ A 0.30 mA/A + 0.10 $\mu$ A 4.9 mA/A + 0.18 $\mu$ A 2.8 mA/A + 0.88 $\mu$ A	Fluke 5522A
330 $\mu$ A to 3.3 mA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.61 mA/A + 1.6 $\mu$ A 0.66 mA/A + 22 nA 0.59 mA/A + 55 nA 4.3 mA/A + 3.8 $\mu$ A 1.2 mA/A + 1.5 $\mu$ A	
(3.3 to 33) mA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.64 mA/A + 16 $\mu$ A 0.54 mA/A + 0.22 $\mu$ A 0.51 mA/A + 5.1 $\mu$ A 0.57 mA/A + 0.12 $\mu$ A 0.86 mA/A + 3.7 $\mu$ A	
(33 to 330) mA	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.17 mA/A + 0.11 mA 0.16 mA/A + 24 $\mu$ A 0.11 mA/A + 25 $\mu$ A 0.37 mA/A + 18 $\mu$ A 2.4 mA/A + 0.13 mA	
(0.33 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.62 mA/A + 44 $\mu$ A 0.58 mA/A + 0.18 mA 0.38 mA/A + 0.22 mA 0.96 mA/A + 0.25 mA	
(3 to 20.5) A	(10 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.88 mA/A + 1.4 mA 1.1 mA/A + 0.57 mA 7.8 mA/A + 3.3 mA	

Parameter/Range	Frequency	CMC <sup>2,4</sup> ( $\pm$ )	Comments
AC Current – Generate (cont)			
Clamp-On Only (Toroidal-Type)  (16.5 to 1025) A	(45 to 65) Hz (65 to 440) Hz	3.3 mA/A + 28 mA 9.2 mA/A + 28 mA	Fluke 5522A w/ 5500/coil
Clamp-On Only (Other-Type)  (16.5 to 1025) A	(45 to 65) Hz (65 to 440) Hz	7.2 mA/A + 0.28 A 13 mA/A + 16 mA	
AC Current – Measure			
(10 to 100) $\mu$ A	45 Hz to 1 kHz	0.29 mA/A + 6.8 nA	Agilent 3458A, option 002
(0.1 to 1) mA	(45 to 100) Hz 100 Hz to 5 kHz (5 to 10) kHz	0.47 mA/A + 0.20 $\mu$ A 0.16 mA/A + 12 nA 0.74 mA/A + 0.18 $\mu$ A	
(1 to 10) mA	(45 to 100) Hz 100 Hz to 5 kHz (5 to 10) kHz	0.41 mA/A + 1.3 $\mu$ A 0.48 mA/A + 1.2 $\mu$ A 0.41 mA/A + 1.3 $\mu$ A	
(10 to 100) mA	(45 to 100) Hz 100 Hz to 5 kHz (5 to 10) kHz	0.20 mA/A + 3.9 $\mu$ A 78 $\mu$ A/A + 5.2 $\mu$ A 0.41 mA/A + 1.8 $\mu$ A	
(0.1 to 1) A	(45 to 100) Hz 100 Hz to 5 kHz	0.79 mA/A + 0.41 mA 22 $\mu$ A/A + 0.17 mA	
Phase – Generate			
Sinewave Voltage to Voltage (0 to 360) $^\circ$	(10 to 65) Hz (65 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz	0.057 $^\circ$ 0.059 $^\circ$ 0.059 $^\circ$ 0.26 $^\circ$	Fluke 5522A



Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
Capacitance – Generate  (220 to 400) pF (0.4 to 1.1) nF (1.1 to 11) nF (11 to 110) nF (110 to 330) nF (0.33 to 1.1) μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 0.33μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 3 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz (10 to 120) Hz (10 to 80) Hz (0 to 50) Hz (0 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	0.59 mF/F + 7.6 pF 29 mF/F + 4.1 pF 0.34 mF/F + 32 pF 1.0 mF/F + 19 pF 0.9 mF/F + 0.02 pF 0.26 mF/F + 3.2 pF 1.1 mF/F + 0.4 pF 0.82 mF/F + 1.1 pF 4.0 mF/F + 0.25 μF 2.6 mF/F + 0.16 μF 1.0 mF/F + 0.22 μF 0.74 mF/F + 0.5 μF 0.16 mF/F + 3.3 μF 0.62 mF/F + 2.0 μF 1.2 mF/F + 41 μF 0.19 mF/F + 33 μF	Fluke 5522A

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
AC Power – Generate  (PF = 1, Φ = 0° at 45 Hz to 65 Hz)  33 mV to 1020 V:  0.33 V & 0.0033 A 3.3 V & 0.33A 33 V & 3.0 A 330 V & 3.0 A 1020 V & 3.0 A 1020 V & 20.5 A	109 μW to 109 mW 10.9 mW to 1.09 W (1.09 to 99) W (99 to 990) W (109 to 3060) W (990 to 20.5) kW	0.15 mW/W + 0.12 μW 0.47 mW/W + 19 μW 1.3 mW/W + 1.2 mW 1.3 mW/W + 12 mW 1.3 mW/W + 0.12 W 1.9 mW/W + 1 W	Fluke 5522A w/ 5500/coil
DC Power – Generate  33 mV to 1020 V	11 μW to 1.09 mW (1.09 to 109) mW 109 mW to 10.9 W (10.9 to 990) W (.99 to 20.5) kW	0.16 mW/W + 0.54 nW 0.25 mW/W + 0.47 μW 0.16 mW/W + 29 μW 0.86 mW/W + 7.6 mW 2.7 mW/W + 1.8 W	Fluke 5522A

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Electrical Stimulation of Thermocouple			
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.01 % + 0.36 °C 0.086 % + 0.43 °C 0.05 % + 0.36 °C 0.0016 % + 0.12 °C 0.0023 % + 0.1 °C	Fluke 5522A
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.02 % + 0.38 °C 0.13 % + 0.35 °C 0.034 % + 0.35 °C 0.0011 % + 0.12 °C 0.0027 % + 0.093 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.04 % + 0.45 °C 0.0067 % + 0.35 °C 0.017 % + 0.34 °C 0.0036 % + 0.12 °C	
Oscilloscopes <sup>3</sup> –			
DC Voltage: 50 Ω 1 MΩ	(0 to ± 6.6) V (0 to ± 130) V	0.54 mV/V + 13 μV 77 μV/V + 49 μV	Fluke 5522A/SC1100
AC Voltage (Square Wave): 50 Ω	±1 mV <sub>pk-pk</sub> to ±6.6 V <sub>pk-pk</sub> 10 Hz to 10 kHz	0.92 mV/V + 7.8 μV	
1 MΩ	±1 mV <sub>pk-pk</sub> to ±130 V <sub>pk-pk</sub> 10 Hz to 10 kHz	1.2 mV/V + 13 μV	
Leveled Sine Amplitude Reference @ 50 kHz	5 mV to 5.5 V	3.8 mV/V + 23 μV	
Leveled Sine Amplitude (Relative to 50 kHz) 5 mV to 5.5 V	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 600 MHz to 1.1 GHz	1.5 % + 45 μV 0.98 % + 81 μV 2.2 % + 20 μV 2.9 % + 15 μV	
Time Marker	1 ns to 20 ms 50 ms to 5s	0.000 041 % + 6.1 fs 0.0019 % + 0.35 μs	
Frequency – Generate	50 kHz to 1.1 GHz	0.000 024 % + 0.53 Hz	

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Oscilloscopes <sup>3</sup> – (cont)  Impedance – Measure	(40 to 60) $\Omega$ 500 k $\Omega$ to 1.5 M $\Omega$	0.4 m $\Omega/\Omega$ + 20 m $\Omega$ 0.76 % + 0.16 $\Omega$	Fluke 5522A/SC1100

<sup>1</sup> This laboratory offers commercial calibration.

<sup>2</sup> Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal Generate. Calibration and Measurement Capabilities represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of  $k = 2$ . The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

<sup>3</sup> In the statement of CMC, percentages are percentages of reading, unless otherwise indicated.

<sup>4</sup> The stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMC are expressed as either a specific value that covers the full range or as a percent or fraction of the reading plus a fixed floor specification.

<sup>5</sup> This scope meets A2LA's *P112 Flexible Scope Policy*.

<sup>6</sup> In the statement of CMC,  $R$  is the numerical value of the resolution of the device in microinches.

<sup>7</sup> In the statement of CMC,  $M$  is the source of mismatch uncertainty.

<sup>8</sup> Repeatability of the Unit under Test has not been utilized in the calculation of the CMC value for this parameter.

<sup>9</sup> The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.



# Accredited Laboratory

A2LA has accredited

## AVALON TEST EQUIPMENT

Carlsbad, CA

for technical competence in the field of

### Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and R205 – Specific Requirements: Calibration Laboratory Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 27<sup>th</sup> day of October 2022.

A handwritten signature in blue ink, appearing to be "A. ...".

Vice President, Accreditation Services  
For the Accreditation Council  
Certificate Number 4859.01  
Valid to July 31, 2024

*For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.*