



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005
& ANSI/NCSL Z540-1-1994

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CALIBRATION

Valid To: April 30, 2019

Certificate Number: 3410.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 4, 5} (±)	Comments
DC Voltage – Generate	Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	7.3 μV/V + 0.39 μV 4.7 μV/V + 0.62 μV 3.2 μV/V + 2.4 μV 3.1 μV/V + 3.9 μV 4.7 μV/V + 39 μV 6.3 μV/V + 390 μV	Fluke 5720A
	(1 to 2) kV (2 to 20) kV	0.061 % + 0.31 V 0.070 % + 3.1 V	Vitretek VM 4600
	(20 to 140) kV	0.18 %	Ross VMP 200
DC Voltage – Measure	Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	6.0 μV/V + 0.38 μV 4.8 μV/V + 0.38 μV 4.7 μV/V + 0.61 μV 7.1 μV/V + 60 μV 12 μV/V + 0.13 mV	Agilent 3458A
	Up to 2 kV (2 to 20) kV	0.061 % + 0.31 V 0.070 % + 3.1 V	Vitretek VM 4600
	(20 to 140) kV	0.18 %	Ross VMP 200A

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Current – Generate	Up to 220 µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A	41 µA/A + 5.4 nA 33 µA/A + 6.2 nA 34 µA/A + 40 nA 43 µA/A + 0.70 µA 83 µA/A + 12 µA	Fluke 5720A
	(1.1 to 3.0) A (3 to 11) A (11 to 20.5) A	0.031 % + 31 µA 0.040 % + 0.39 mA 0.083 % + 0.58 mA	Fluke 5520A
DC Current – Measure	Up to 100 nA 100 nA to 1 µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	39 µA/A + 46 pA 25 µA/A + 46 pA 25 µA/A + 0.12 nA 23 µA/A + 0.93 nA 23 µA/A + 6.2 nA 23 µA/A + 58 nA 41 µA/A + 1.3 µA 0.015 % + 17 µA	Agilent 3458A
	(1.1 to 3) A (3 to 11) A (11 to 20) A	0.049 % 0.040 % 0.040 %	Fluke Y5020 with Agilent 3458A
	(20 to 200) A	0.88 %	L&N 4363 with Agilent 3458A
DC Power – Generate	10 µW to 337 W 0.011 W to 3.1 kW 0.099 W to 20.9 kW	0.047 % 0.040 % 0.060 %	Fluke 5520A
DC Resistance – Generate	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.33 to 1.1) kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ (0.33 to 1.1) MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ	34 µΩ/Ω + 0.78 µΩ 27 µΩ/Ω + 1.2 mΩ 29 µΩ/Ω + 1.1 mΩ 28 µΩ/Ω + 1.6 mΩ 60 µΩ/Ω + 1.6 mΩ 25 µΩ/Ω + 16 mΩ 24 µΩ/Ω + 16 mΩ 42 µΩ/Ω + 0.16 Ω 24 µΩ/Ω + 0.16 Ω 26 µΩ/Ω + 1.6 Ω 27 µΩ/Ω + 1.6 Ω 49 µΩ/Ω + 24 Ω 110 µΩ/Ω + 39 Ω 200 µΩ/Ω + 2.0 kΩ	Fluke 5520A

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Resistance – Generate (cont)	(33 to 110) MΩ (110 to 330) MΩ (330 to 1100) MΩ	410 μΩ/Ω + 2.0 kΩ 0.24 % + 78 kΩ 1.2 % + 0.39 Ω	Fluke 5520A
Fixed Points	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	87 μΩ/Ω 89 μΩ/Ω 24 μΩ/Ω 26 μΩ/Ω 11 μΩ/Ω 11 μΩ/Ω 8.1 μΩ/Ω 8.1 μΩ/Ω 8.1 μΩ/Ω 8.3 μΩ/Ω 12 μΩ/Ω 11 μΩ/Ω 21 μΩ/Ω 25 μΩ/Ω 38 μΩ/Ω 46 μΩ/Ω 99 μΩ/Ω	Fluke 5720A
	1 mΩ 10 mΩ 100 mΩ 1 Ω 10 kΩ	0.47 % 0.48 % 0.046 % 41 μΩ/Ω 1.9 μΩ/Ω	L&N 4363 L&N 4361 L&N 4360 L&N 4210 ESI SR104
Decade Resistance Generate	10 MΩ 20 MΩ 30 MΩ 40 MΩ 50 MΩ 60 MΩ 70 MΩ 80 MΩ 90 MΩ 100 MΩ 110 MΩ	58 μΩ/Ω 58 μΩ/Ω 58 μΩ/Ω 58 μΩ/Ω 58 μΩ/Ω 59 μΩ/Ω 63 μΩ/Ω 59 μΩ/Ω 59 μΩ/Ω 58 μΩ/Ω 58 μΩ/Ω	ESI SR1050



Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Resistance – Generate (cont)			
Fixed Resistor	1.0 GΩ		Ohm-Labs 109
	100 V	0.0078 %	
	200 V	0.0077 %	
	1000 V	0.041 %	
	5000 V	0.035 %	
	10 GΩ		Ohm-Labs 110
	100 V	0.11 %	
	200 V	0.025 %	
	1000 V	0.061 %	
	5000 V	0.065 %	
	100 GΩ		Ohm-Labs 111
	200 V	0.63 %	
	500 V	0.64 %	
	1000 V	0.91 %	
	5000 V	0.92 %	
	1 TΩ		Ohm-Labs 112
	200 V	12 %	
	500 V	12 %	
	1000 V	14 %	
	5000 V	14 %	
DC Resistance – Measure	Up to 1 Ω	41 μΩ/Ω + 3.7 μΩ	Agilent 3458A
	(1 to 10) Ω	18 μΩ/Ω + 37 μΩ	
	(10 to 100) Ω	14 μΩ/Ω + 0.14 mΩ	
	(0.1 to 1) kΩ	12 μΩ/Ω + 0.83 mΩ	
	(1 to 10) kΩ	12 μΩ/Ω + 8.1 mΩ	
	(10 to 100) kΩ	12 μΩ/Ω + 81 mΩ	
	(0.1 to 1) MΩ	20 μΩ/Ω + 1.9 Ω	
	(1 to 10) MΩ	0.014 % + 81 Ω	
	(10 to 100) MΩ	0.061 % + 1.9 kΩ	
	(0.1 to 1.0) GΩ	0.58 % + 0.17 MΩ	

Parameter/Range	Frequency	CMC ^{2,4,5} (\pm)	Comments
AC Voltage – Generate			
(0 to 2.2) mV	(20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.032 % + 3.9 μ V 0.032 % + 3.9 μ V 0.058 % + 3.9 μ V 0.070 % + 4.7 μ V 0.64 % + 9.3 μ V 0.64 % + 20 μ V 1.1 % + 20 μ V	Fluke 5720A
(2.2 to 22) mV	(20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.016 % + 3.9 μ V 0.016 % + 3.9 μ V 0.021 % + 3.9 μ V 0.049 % + 4.7 μ V 0.14 % + 9.3 μ V 0.17 % + 20 μ V 0.38 % + 20 μ V	
(22 to 220) mV	(20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.0092 % + 6.2 μ V 0.0083 % + 6.2 μ V 0.020 % + 6.2 μ V 0.047 % + 16 μ V 0.087 % + 20 μ V 0.14 % + 24 μ V 0.28 % + 47 μ V	
(.22 to 2.2) V	(20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.0087 % + 16 μ V 0.0045 % + 7.8 μ V 0.0072 % + 9.3 μ V 0.011 % + 31 μ V 0.041 % + 78 μ V 0.094 % + 0.20 mV 0.17 % + 0.31 mV	
(2.2 to 22) V	(20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.0089 % + 0.16 mV 0.0047 % + 55 μ V 0.0072 % + 93 μ V 0.010 % + 0.20 mV 0.034 % + 0.62 mV 0.096 % + 2.0 mV 0.19 % + 3.1 mV	
(22 to 220) V	(20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.0088 % + 1.6 mV 0.0054 % + 0.55 mV 0.0079 % + 0.93 mV 0.017 % + 2.4 mV	
(220 to 1100) V	(0.05 to 1) kHz	0.0081 % + 3.1 mV	



Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage – Measure			
(0 to 10) mV	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.027 % + 1.3 μV 0.036 % + 1.3 μV 0.12 % + 1.3 μV 0.62 % + 1.3 μV 5.0 % + 2.3 μV	Agilent 3458A synchronous sub-sampled mode
(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	0.0085 % + 2.3 μV 0.017 % + 2.3 μV 0.035 % + 2.3 μV 0.10 % + 2.3 μV 0.40 % + 12 μV 1.2 % + 12 μV	
(0.1 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	0.0091 % + 23 μV 0.017 % + 23 μV 0.035 % + 23 μV 0.093 % + 23 μV 0.36 % + 120 μV 0.67 % + 120 μV	
(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	0.0092 % + 0.47 mV 0.094 % + 0.23 mV 0.018 % + 0.23 mV 0.037 % + 0.23 mV 0.11 % + 0.23 mV 0.45 % + 1.2 mV 1.2 % + 1.2 mV	
(10 to 100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.024 % + 2.3 mV 0.024 % + 2.3 mV 0.041 % + 2.3 mV 0.14 % + 2.3 mV	
(100 to 700) V	40 Hz to 1 kHz (1 to 20) kHz	0.067 % + 16 mV 0.10 % + 16 mV	
(0.5 to 2) kV (2 to 20) kV	60 Hz 60 Hz	0.22 % 0.21 %	
(10 to 100) kV	60 Hz	1.2 %	ROSS VMP 200

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Current – Generate			
Up to 220 µA	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.039 % + 7.8 nA 0.046 % + 12 nA 0.11 % + 62 nA	Fluke 5720A
(0.22 to 2.2) mA	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.012 % + 31 nA 0.020 % + 110 nA 0.11 % + 620 nA	
(2.2 to 22) mA	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.012 % + 310 nA 0.021 % + 550 nA 0.11 % + 4.7 µA	
(22 to 220) mA	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.013 % + 2.4 µA 0.021 % + 3.1 µA 0.11 % + 9.3 µA	
(0.22 to 2.2) A	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.026 % + 31 µA 0.043 % + 78 µA 0.63 % + 160 µA	
(1.1 to 3.0) A	(10 to 45) Hz (0.045 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.15 % + 78 µA 0.059 % + 78 µA 0.47 % + 780 µA 2.0 % + 3.9 mA	Fluke 5520A
(3 to 11) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.053 % + 1.6 mA 0.082 % + 1.6 mA 2.5 % + 1.6 mA	
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.10 % + 3.9 mA 0.19 % + 3.9 mA 2.4 % + 3.9 mA	
Clamp-On Only			
(16.5 to 149.99) A	(45 to 440) Hz	0.73 %	Fluke 5520A with 5500 coil
(150 to 1025) A	(45 to 440) Hz	0.61 %	

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Current – Measure			
Up to 100 µA	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.070 % + 36 nA 0.070 % + 24 nA 0.070 % + 58 nA	Agilent 3458A
(0.1 to 1) mA	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.11 % + 58 nA 0.090 % + 46 nA 0.090 % + 0.59 µA 0.11 % + 1.3 µA	
(1 to 10) mA	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.070 % + 0.60 µA 0.020 % + 0.50 µA 0.040 % + 5.8 µA 0.070 % + 12 µA	
(10 to 100) mA	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.070 % + 6.3 µA 0.040 % + 6.3 µA 0.040 % + 58 µA 0.070 % + 0.12 mA	
(0.1 to 1) A	(45 to 100) Hz 100 Hz to 5 kHz	0.10 % + 52 µA 0.12 % + 0.12 mA	
Up to 10 A	(50 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.10 % 0.67 % 0.53 %	Fluke Y5020 with Agilent 3458A
(10 to 20) A	(50 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.049 % 0.15 % 0.15 %	
AC Power – Generate			
(45 to 65) Hz (PF = 1)			
(3.3 to 30) mA	(33 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	0.041 % + 4.8 µW 0.037 % + 37 µW 0.043 % + 0.37 mW 0.040 % + 1.2 mW 0.047 % + 6.1 mW	Fluke 5520A
(33 to 330) mA	(33 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	0.037 % + 49 µW 0.037 % + 0.37 mW 0.037 % + 3.7 mW 0.038 % + 12 mW 0.046 % + 61 mW	



Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
AC Power – Generate (45 to 65) Hz (PF = 1) – (cont)			
(0.33 to 1.1) A	(33 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	0.043 % + 0.25 mW 0.043 % + 1.9 mW 0.043 % + 19 mW 0.044 % + 61 mW 0.051 % + 0.31 W	Fluke 5520A
(1.1 to 3) A	(33 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	0.057 % + 0.25 mW 0.058 % + 1.9 mW 0.057 % + 19 mW 0.058 % + 61 mW 0.064 % + 310 mW	
(3 to 11) A	(33 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	0.055 % + 4.9 mW 0.055 % + 37 mW 0.055 % + 0.37 W 0.055 % + 1.2 W 0.061 % + 6.1 W	
(11 to 20.5) A	(33 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	0.097 % + 12 mW 0.097 % + 91 mW 0.097 % + 0.91 W 0.10 % + 3.1 W 0.11 % + 16 W	
Capacitance– Generate			
(0.19 to 0.4) nF	(0.01 to 10) kHz	0.68 % + 7.8 pF	Fluke 5520A
(0.4 to 1.1) nF	(0.01 to 10) kHz	0.46 % + 7.8 pF	
(1.1 to 3.3) nF	(0.01 to 3) kHz	0.41 % + 7.8 pF	
(3.3 to 11) nF	(0.01 to 1) kHz	0.22 % + 7.8 pF	
(11 to 33) nF	(0.01 to 1) kHz	0.21 % + 78 pF	
(33 to 110) nF	(0.01 to 1) kHz	0.21 % + 78 pF	
(110 to 330) nF	(0.01 to 1) kHz	0.21 % + 0.24 nF	
(0.33 to 1.1) μF	(10 to 600) Hz	0.21 % + 0.78 nF	
(1.1 to 3.3) μF	(10 to 300) Hz	0.21 % + 2.4 nF	
(3.3 to 11) μF	(10 to 150) Hz	0.22 % + 7.8 nF	
(11 to 33) μF	(10 to 120) Hz	0.34 % + 24 nF	
(33 to 110) μF	(10 to 80) Hz	0.37 % + 78 nF	
(110 to 330) μF	(10 to 50) Hz	0.38 % + 0.24 μF	
(0.33 to 1.1) mF	(10 to 20) Hz	0.39 % + 0.78 μF	
(1.1 to 3.3) mF	(0 to 6) Hz	0.37 % + 2.4 μF	
(3.3 to 11) mF	(0 to 2) Hz	0.38 % + 7.8 μF	



Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
Capacitance– Generate (cont) (11 to 33) mF (33 to 110) mF	 (0 to 0.6) Hz (0 to 0.2) Hz	 0.60 % + 24 μF 0.87 % + 78 μF	 Fluke 5520A
Oscilloscope – Level Sine Wave– Amplitude Characteristics 50 kHz	 5 mV _{p-p} 10 mV _{p-p} 20 mV _{p-p} 50 mV _{p-p} 100 mV _{p-p} 200 mV _{p-p} 0.5 V _{p-p} 1 V _{p-p} 2 V _{p-p} 5 V _{p-p}	 1.9 % + 0.24 mV 2.0 % + 0.24 mV 1.9 % + 0.24 mV 1.9 % + 0.24 mV 2.1 % + 0.24 mV 2.0 % + 0.24 mV 2.0 % + 0.24 mV 2.0 % + 0.24 mV 2.0 % + 0.24 mV 2.0 % + 0.24 mV	 Fluke 5820A
Leveled Sine Flatness Test (50 kHz)			
5.5 V	1 MHz 10 MHz 50 MHz 100 MHz 200 MHz 300 MHz 400 MHz 500 MHz 600 MHz	3.2 % + 0.24 mV 3.3 % + 0.24 mV 3.4 % + 0.24 mV 3.9 % + 0.24 mV 4.0 % + 0.24 mV 4.3 % + 0.24 mV 5.5 % + 0.24 mV 5.5 % + 0.24 mV 5.6 % + 0.24 mV	
3.4 V	1 MHz 10 MHz 50 MHz 100 MHz 200 MHz 300 MHz 400 MHz 500 MHz 600 MHz	3.2 % + 0.24 mV 3.2 % + 0.24 mV 3.4 % + 0.24 mV 3.8 % + 0.24 mV 3.9 % + 0.24 mV 4.2 % + 0.24 mV 5.5 % + 0.24 mV 5.4 % + 0.24 mV 5.6 % + 0.24 mV	



Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
Oscilloscope (cont) – Leveled Sine Flatness Test (50 kHz)			
1.3 V	1 MHz	3.4 % + 0.24 mV	Fluke 5820A
	10 MHz	3.2 % + 0.24 mV	
	50 MHz	3.4 % + 0.24 mV	
	100 MHz	3.8 % + 0.24 mV	
	200 MHz	3.9 % + 0.24 mV	
	300 MHz	4.2 % + 0.24 mV	
	400 MHz	5.8 % + 0.24 mV	
	500 MHz	5.7 % + 0.24 mV	
	600 MHz	5.5 % + 0.24 mV	
	1.2 V	1 MHz	
10 MHz		3.2 % + 0.24 mV	
50 MHz		3.4 % + 0.24 mV	
100 MHz		3.8 % + 0.24 mV	
200 MHz		3.9 % + 0.24 mV	
300 MHz		4.2 % + 0.24 mV	
400 MHz		5.5 % + 0.24 mV	
500 MHz		5.4 % + 0.24 mV	
400 mV	1 MHz	3.1 % + 0.24 mV	
	10 MHz	3.2 % + 0.24 mV	
	50 MHz	3.4 % + 0.24 mV	
	100 MHz	3.8 % + 0.24 mV	
	200 MHz	3.9 % + 0.24 mV	
	300 MHz	4.2 % + 0.24 mV	
	400 MHz	5.8 % + 0.24 mV	
	500 MHz	6.0 % + 0.24 mV	
100 mV	1 MHz	3.2 % + 0.24 mV	
	10 MHz	3.2 % + 0.24 mV	
	50 MHz	3.3 % + 0.24 mV	
	100 MHz	3.5 % + 0.24 mV	
	200 MHz	3.9 % + 0.24 mV	
	300 MHz	4.2 % + 0.24 mV	
	400 MHz	5.8 % + 0.24 mV	
	500 MHz	5.8 % + 0.24 mV	
10 mV	1 MHz	3.2 % + 0.24 mV	
	10 MHz	2.9 % + 0.24 mV	
	50 MHz	3.3 % + 0.24 mV	
	100 MHz	3.8 % + 0.24 mV	



Parameter/Range	Frequency	CMC ^{2, 4, 5} (\pm)	Comments
Oscilloscopes (cont) – Leveled Sine Flatness Test (50 kHz)			
10 mV	200 MHz 300 MHz 400 MHz 500 MHz 600 MHz	3.8 % + 0.24 mV 4.2 % + 0.24 mV 5.5 % + 0.24 mV 5.5 % + 0.24 mV 5.6 % + 0.24 mV	Fluke 5820A

Parameter/Equipment	Range	CMC ^{2, 4, 5} (\pm)	Comments
Oscilloscope – Amplitude/Vertical Gain Characteristics- Volt Function			
Square @ 1 kHz (1 M Ω)	1.8 mV _{pk-pk} 12 mV _{pk-pk} 22 mV _{pk-pk} 56 mV _{pk-pk} 90 mV _{pk-pk} 155 mV _{pk-pk} 220 mV _{pk-pk} 560 mV _{pk-pk} 0.9 V _{pk-pk} 3.75 V _{pk-pk} 6.6 V _{pk-pk} 30.8 V _{pk-pk} 55 V _{pk-pk}	1.3 % + 32 μ V 1.6 % + 32 μ V 0.080 % + 32 μ V 0.080 % + 32 μ V 0.080 % + 32 μ V 0.090 % + 32 μ V 0.090 % + 32 μ V 0.080 % + 32 μ V 0.10 % + 32 μ V 0.090 % + 32 μ V 0.10 % + 32 μ V 0.080 % + 32 μ V 0.080 % + 32 μ V	Fluke 5820A
Square @ 1 kHz (50 Ω)	1.8 mV _{pk-pk} 6.4 mV _{pk-pk} 10.9 mV _{pk-pk} 28 mV _{pk-pk} 44.9 mV _{pk-pk} 78 mV _{pk-pk} 110 mV _{pk-pk} 280 mV _{pk-pk} 0.45 V _{pk-pk} 0.78 V _{pk-pk} 1.1 V _{pk-pk} 2.5 V _{pk-pk}	1.5 % + 32 μ V 0.65 % + 32 μ V 0.79 % + 32 μ V 0.23 % + 32 μ V 0.22 % + 32 μ V 0.72 % + 32 μ V 0.44 % + 32 μ V 0.43 % + 32 μ V 0.39 % + 32 μ V 0.38 % + 32 μ V 0.52 % + 32 μ V 0.48 % + 32 μ V	



Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of RTDs			
Pt 385, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.070 °C 0.070 °C 0.080 °C 0.090 °C 0.090 °C 0.11 °C 0.19 °C	Fluke 5520A
Pt 3926, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.060 °C 0.060 °C 0.070 °C 0.090 °C 0.090 °C 0.11 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.040 °C 0.040 °C 0.040 °C 0.050 °C 0.060 °C 0.060 °C 0.060 °C 0.070 °C 0.11 °C	
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.030 °C 0.030 °C 0.040 °C 0.060 °C 0.060 °C 0.060 °C 0.070 °C 0.090 °C	
Pt 385, 1 kΩ	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.020 °C 0.020 °C 0.040 °C 0.060 °C 0.060 °C 0.060 °C 0.060 °C 0.18 °C	



Parameter/Range	Frequency	CMC ^{2,3} (±)	Comments
RF Power – Measure Power Reference 1 mW, Type-N(f) 50 Ω (-20 to 30) dBm	100 kHz to 1.3 GHz (50 to 1300) MHz (1.3 to 18) GHz (18 to 26.5) GHz	0.15 dB 0.15 dB 0.16 dB 0.17 dB	Agilent 8902A with 1722A Agilent 8902A with 1792A and 11793A
Amplitude Modulation – Measure Rate: 50 Hz to 10 kHz, Depth: (5 to 99) % 50 Hz to 10 kHz, Depth: Up to 99 % 50 Hz to 50 kHz, Depth: (5 to 99) % 50 Hz to 100 kHz, Depth: Up to 99 %	(0.15 to 10) MHz (0.15 to 10) MHz (10 to 1300) MHz (10 to 1300) MHz	2.5 % + 1 digit 3.6 % + 1 digit 1.4 % + 1 digit 3.6 % + 1 digit	Agilent 8902A with 11722A



Parameter/Frequency	Range	CMC ² (±)	Comments
Frequency Modulation – Measure Rate: 20 Hz to 10 kHz Deviation: ≤ 40 kHz _{peak} 50 Hz to 100 kHz Deviation: ≤ 400 kHz _{peak} Rate: 20 Hz to 200 kHz Deviation: ≤ 400 kHz _{peak} Rate: 50 Hz to 100 kHz, Deviation: ≤ 400 kHz _{peak} Rate: 20 Hz to 200 kHz, Deviation: ≤ 400 kHz _{peak}	(0.25 to 10) MHz (10 to 1300) MHz (10 to 1300) MHz (0.01 to 26.5) GHz (0.01 to 26.5) GHz	2.3 % + 1 digit 1.2 % + 1 digit 5.8 % + 1 digit 1.2 % + 1 digit 5.8 % + 1 digit	Agilent 8902A with 11722A Agilent 8902A with 11722A and 11792A
Phase Modulation – Measure Rate: (0.2 to 10) kHz (0.2 to 20) kHz (0.2 to 20) kHz	150 kHz to 10 MHz 10 MHz to 1.3 GHz (0.01 to 26.5) GHz	4.6 % + 1 digit 3.5 % + 1 digit 3.5 % + 1 digit	Agilent 8902A with 11722A and 11792A
Reflection S11/S22 Measure – (0.1 to 100) kHz	(0 to 0.25) lin (0.25 to 0.5) lin (0.5 to 0.75) lin (0.75 to 1) lin	(0.0037 to 0.0065) lin (1.5 to 180) deg (0.0065 to 0.0093) lin (1.1 to 1.5) deg (0.0093 to 0.013) lin (0.94 to 1.1) deg (0.013 to 0.016) lin (0.90 to 0.94) deg	Agilent E5061B and 85032B Type N precision cal kit



Parameter/Frequency	Range	CMC ² (±)	Comments
Reflection S11/S22 Measure – (cont)			
(0.1 to 10) MHz	(0 to 0.25) lin	(0.0037 to 0.0069) lin (1.6 to 180) deg	Agilent E5061B and 85032B Type N precision cal kit
	(0.25 to 0.5) lin	(0.0069 to 0.011) lin (1.3 to 1.6) deg	
	(0.5 to 0.75) lin	(0.011 to 0.016) lin (1.2 to 1.3) deg	
	(0.75 to 1) lin	(0.016 to 0.021) lin (1.2) deg	
(0.01 to 1) GHz	(0 to 0.25) lin	(0.0037 to 0.0069) lin (1.6 to 180) deg	
	(0.25 to 0.5) lin	(0.0069 to 0.011) lin (1.3 to 1.6) deg	
	(0.5 to 0.75) lin	(0.011 to 0.016) lin (1.2 to 1.3) deg	
(1 to 3) GHz	(0.75 to 1) lin	(0.016 to 0.021) lin (1.2) deg	
	(0 to 0.25) lin	(0.0050 to 0.0090) lin (2.1 to 180) deg	
	(0.25 to 0.5) lin	(0.0090 to 0.015) lin (1.7 to 2.1) deg	
	(0.5 to 0.75) lin	(0.015 to 0.022) lin (1.7) deg	
	(0.75 to 1) lin	(0.022 to 0.030) lin (1.7 to 1.8) deg	



Parameter/Frequency	Range	CMC ² (±)	Comments
RF Attenuation – Measure			
100 kHz to 1.3 GHz	(0 to 3) dB (3 to 10) dB (10 to 40) dB (40 to 50) dB (50 to 80) dB (80 to 90) dB (90 to 110) dB	0.077 dB + 0.010 dB 0.065 dB + 0.010 dB 0.065 dB + 0.010 dB 0.065 dB + 0.010 dB 0.077 dB + 0.010 dB 0.22 dB + 0.010 dB 0.23 dB + 0.010 dB	Agilent 8902A with 11722A, 11792A, 11793A, and source
50 MHz to 26.5 GHz	(0 to 3) dB (3 to 10) dB (10 to 40) dB (40 to 50) dB (50 to 80) dB (80 to 90) dB (90 to 100) dB	0.13 dB + 0.010 dB 0.12 dB + 0.010 dB 0.13 dB + 0.010 dB 0.12 dB + 0.010 dB 0.15 dB + 0.010 dB 0.24 dB + 0.010 dB 0.68 dB + 0.010 dB	
Transmission Measurements – S21 Magnitude and Phase			
Type N			
(0.1 to 100) kHz	(10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB	(0.073 to 0.11) dB (0.49 to 0.71) deg (0.11 to 0.12) dB (0.70 to 0.81) deg (0.12 to 0.15) dB (0.81 to 0.99) deg (0.15 to 0.21) dB (1.0 to 1.4) deg (0.21 to 0.38) dB (1.4 to 2.6) deg (0.38 to 0.91) dB (2.6 to 6.4) deg	Agilent E5061B and 85032B Type N precision cal kit



Parameter/Frequency	Range	CMC ^{2,4} (±)	Comments
Transmission Measurements – S21 Magnitude and Phase (cont)			
Type N			
100 kHz to 1 GHz	(10 to -20) dB	(0.081 to 0.12) dB (0.55 to 0.77) deg	Agilent E5061B and 85032B Type N precision cal kit
	(-20 to -30) dB	(0.14 to 0.15) dB (0.75 to 0.85) deg	
	(-30 to -40) dB	(0.13 to 0.15) dB (0.85 to 0.98) deg	
	(-40 to -50) dB	(0.15 to 0.19) dB (0.98 to 1.2) deg	
	(-50 to -60) dB	(0.18 to 0.26) dB (1.2 to 1.7) deg	
	(-60 to -70) dB	(0.26 to 0.46) dB (1.7 to 3.1) deg	
(1 to 3) GHz	(10 to -20) dB	(0.11 to 0.14) dB (0.78 to 0.98) deg	
(0.1 to 100) kHz	(-20 to -30) dB	(0.14 to 0.16) dB (0.93 to 1.1) deg	
	(-30 to -40) dB	(0.16 to 0.18) dB (1.1 to 1.2) deg	
	(-40 to -50) dB	(0.18 to 0.21) dB (1.0 to 1.2) deg	
	(-50 to -60) dB	(0.21 to 0.28) dB (1.2 to 1.9) deg	
	(-60 to -70) dB	(0.28 to 0.47) dB (1.9 to 3.2) deg	

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
ESD Simulators –			
Contact Voltage	200 V to 30 kV	0.28 %	Calibration method based on IEC/EN 61000-4-2, IEC 801-2 Brandenburg 149-03 attenuator Tek TDS7404 with schaffner MD103 target
Rise Time	(0.7 to 1) ns	4.0 %	
Peak Current	(7.5 to 112.5) A	5.7 %	
30 ns Current	(4 to 60) A	5.7 %	
60 ns Current	(2 to 30) A	5.8 %	
EFT/Burst Generators –			
Voltage	20 V to 8 kV	3.1 %	IEC/EN 61000-4-4, ANSI/IEEE C37.90, ISO 7637-2 Tektronix TDS5104 with schaffner CAS-3025 attenuator set
Rise/Fall Time	5 ns	7.2 %	
Pulse Width	(35 to 200) ns	1.2 %	
Burst Duration	(0.5 to 20) ms	1.9 %	
Burst Period	(100 to 300) ms	1.4 %	
Repetition Rate	1 kHz to 1 MHz	1.1 %	
Transient Generators –			
Front/Rise Time – Open Circuit Short Circuit	1 µs to 10 ms (1 to 100) µs	2.8 % 2.5 %	IEC/EN 61000-4-5, IEC 61000-4-9, IEC 61000-4-10, IEC 61000-4-12, IEC 61000-4-18, ANSI C37.90, ANSI C62.41, ISO 7637-2 Tektronix TDS5104 with sapphire SI-9010A and Pearson 110 differential probe
Fall time Open Circuit Short Circuit	1 µs to 10 ms (1 to 100) ms	2.2 % 2.5 %	
Pulse Width– Open Circuit	1 µs to 1000 ms	2.1 %	
Pulse Width- Short Circuit	1 µs to 1 ms	1.1 %	
Open Circuit Voltage	10 V to 20 kV	2.9 %	
Short Circuit Current	1 A to 4 kA	2.3 %	

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Transient Generators – (cont) Ring/Oscillatory Wave – Rise Time Fall Time Frequency	 75 ns (0.5 to 1.5) µs 75 ns (0.5 to 1.5) µs 5 kHz to 1 MHz	 2.2 % 2.3 % 0.81 %	IEC/EN 61000-4-5, IEC 61000-4-9, IEC 61000- 4-10, IEC 61000-4-12, IEC 61000-4-18, ANSI C37.90, ANSI C62.41, ISO 7637-2 Tektronix TDS5104 with sapphire SI-9010A and Pearson 110 differential probe
Flicker & Harmonics Measure Voltage Fluctuations (Flicker) Mains Harmonic Emissions	 (100 to 280) V (0.1 to 20) A (0.5 to 179.5)°	 0.61 % 0.053 % + 5.3 mV 0.21 % + 2.2 µA 0.11°	IEC/EN 61000-3-3; IEC/EN 61000-3-12; IEC 61000-4-15; IEC 61000-3-2; IEC 61000-3-11; IEC 61000-4-7; CNS-HFC-III Agilent 3458A-001 Tektronix TDS5104B
PQT – Voltage Dips and Interruptions – Output Voltage Phase Angle Pulse Rise/Fall Time	 Up to 260 V AC or DC (0 to 359) ° (1 to 5) ns	 2.4 % 0.49 % 2.1 %	IEC/EN 61000-4-11 Tektronix TDS5104
RF Bulk Injection Probe – Insertion Loss	 10 Hz to 3 GHz	 4.1 dB	Agilent VNA E5061B

III. Thermodynamics

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measure	(-196 to 420) °C	0.59 °C	PRT with precision thermometer readout
Relative Humidity – Measuring Equipment			
Fixed Points	11 % RH 33 % RH 75 % RH	2.3 % RH 2.3 % RH 3.0 % RH	Vaisala HMK-15

IV. Time & Frequency

Parameter/Equipment	Range	CMC ² (±)	Comments
Frequency – Measuring Equipment			
Fixed Point	10 MHz	1.2 nHz/Hz	GPS receiver
	Up to 1 kHz (1 to 100) kHz 100 kHz to 1 MHz (1 to 80) MHz	2.1 MHz/Hz 14 nHz/Hz 10 nHz/Hz 7.1 nHz/Hz	Agilent 33250A referenced to GPS receiver
	50 MHz to 40 GHz	11 nHz/Hz	Anritsu 68369B
Frequency – Measure	0.1 Hz to 225 MHz	3.0 nHz/Hz	Agilent 53132A referenced to GPS receiver
	(10 to 525) MHz (0.5 to 40) GHz	9.9 nHz/Hz 8.2 nHz/Hz	Agilent 5352A

¹ This laboratory offers commercial calibration service.

² 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 measuring equipment. CMCs 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.

³ M is the Mismatch error. Uncertainty does not include mismatch error due to connections of the device to other devices in actual use. Mismatch uncertainties, due to the reflection coefficient of the device to be calibrated, are to be included in the overall measurement uncertainty. The approach of determining expanded uncertainties at approximately the 95% level of confidence, (using a coverage factor of $k = 2$) is to be applied for this calculation as well.

⁴ In the statement of CMC, percentages are percentage of reading, unless otherwise indicated.

⁵ 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.



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This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCCL 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 8 January 2009*).



Presented this 5th day of September 2017.

A handwritten signature in black ink, written over a horizontal line.

President and CEO
For the Accreditation Council
Certificate Number 3410.01
Valid to April 30, 2019

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