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

ADVANCED TEST EQUIPMENT CORP.
10401 Roselle Street
San Diego, CA 92121
Gabriel Alcala Phone: 858 558 6500

CALIBRATION

Valid To: April 30, 2017 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 calibrations[1]:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
DC Voltage – Generate	(0 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	7.2 µV/V + 0.50 µV 4.7 µV/V + 1.0 µV 3.2 µV/V + 3.0 µV 3.1 µV/V + 5.5 µV 4.8 µV/V + 50 µV 11 µV/V + 420 µV	Fluke 5720A
	(1 to 2) kV (2 to 20) kV	0.12 % 0.28 %	Vitrek 4600with SRS PS350 high voltage supply and or equivalent
	(20 to 120) kV	1.2 %	Ross VMP 200A with high voltage supply
DC Voltage – Measure	(0 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
	(0 to 2) kV (2 to 20) kV	0.12 % 0.28 %	Vitrek VM4600
	(20 to 64) kV (64 to 85) kV (85 to 100) kV (100 to 140) kV	0.16 % 0.12 % 0.15 % 0.12 %	VMP200-3.8-J-U-ALFA-CK Probe/Voltmeter

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
DC Current – Generate	(1 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (1.1 to 2.99999) A (3 to 10.9999) A (11 to 20.5) 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 0.031 % + 31 µA 0.040 % + 390 µA 0.083 % + 580 µA	Fluke 5720A Fluke 5520A
DC Current – Measure	Up to 100 nA 100 nA to 1µA (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 (1.1 to 3) A (3 to 11) A (11 to 20) A (20 to 200) A	39 µA/A + 46 pA 25 µA/A + 46 pA 25 µA/A + 120 pA 23 µA/A + 930 pA 23 µA/A + 6.2 nA 23 µA/A + 58 nA 41 µA/A +1.3 µA 0.015 % + 17 µA 0.040 % 0.040 % 0.040% 0.25 %	Agilent 3458A Fluke Y5020 with Agilent 3458A L&N 4363 with Agilent 3458A
DC Power – Generate	(0.3 to 330) W (0.33 to 6.6) kW (6.6 to 20) kW	0.060 % 0.090 % 0.13 %	Fluke 5520A
DC Resistance – Generate	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.11 to 1.1) kΩ (1.3 to 3.3) kΩ (3.3to 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 (33 to 330) MΩ (330 to 1100) MΩ	0.026 % + 0.60 mΩ 0.015 % + 0.90 mΩ 77 µΩ/Ω + 0.80 mΩ 65 µΩ/Ω + 1.2 mΩ 78 µΩ/Ω + 1.2 mΩ 21 µΩ/Ω + 12 mΩ 37 µΩ/Ω + 12 mΩ 73 µΩ/Ω + 120 mΩ 55 µΩ/Ω + 120 mΩ 71 µΩ/Ω + 1.2 Ω 55 µΩ/Ω + 1.2 Ω 0.013 % + 18 Ω 0.025 % + 30 Ω 0.061 % + 1.5 kΩ 0.60 % + 6.0 kΩ 3.1 % + 310 kΩ	Fluke 5520A

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
DC Resistance – Generate	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330)Ω (0.11 to 1.1) kΩ (1.3 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 (33 to 330) MΩ (330 to 1100) MΩ	0.026 % + 0.60 mΩ 0.015 % + 0.90 mΩ 77 µΩ/Ω + 0.80 mΩ 65 µΩ/Ω + 1.2 mΩ 78 µΩ/Ω + 1.2 mΩ 21 µΩ/Ω + 12 mΩ 37 µΩ/Ω + 12 mΩ 73 µΩ/Ω + 120 mΩ 55 µΩ/Ω + 120 mΩ 71 µΩ/Ω + 1.2 Ω 55 µΩ/Ω + 1.2 Ω 0.013 % + 18 Ω 0.025 % + 30 Ω 0.061 % + 1.5 kΩ 0.60 % + 6.0 k Ω 3.1 % + 310 kΩ	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	91 µΩ/Ω 91 µΩ/Ω 33 µΩ/Ω 28 µΩ/Ω 11 µΩ/Ω 9.9 µΩ/Ω 8.2 µΩ/Ω 8.2 µΩ/Ω 8.3 µΩ/Ω 8.1 µΩ/Ω 11 µΩ/Ω 12 µΩ/Ω 20 µΩ/Ω 25 µΩ/Ω 40 µΩ/Ω 55 µΩ/Ω 95 µΩ/Ω	Fluke 5720A
	1 mΩ 10 mΩ 100 mΩ 1 Ω 10 kΩ	0.47 % 0.48 % 0.10 % 0.090 % 6.1 µΩ/Ω	L&N 4363 L&N 4361 L&N 4360 L&N 4210 ESI SR104

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
DC Resistance – Generate (cont)			
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	70 μΩ/Ω 75 μΩ/Ω 75 μΩ/Ω 75 μΩ/Ω 75 μΩ/Ω 77 μΩ/Ω 82 μΩ/Ω 76 μΩ/Ω 77 μΩ/Ω 76 μΩ/Ω 76 μΩ/Ω	ESI SR1050-10/3458
Fixed Resistor	1.0 GΩ (250 V) (250 V) (750 V) (1 kV)	 0.0024 % 0.0024 % 0.0092 % 1.3 %	Ohm-Labs 109
	10 GΩ (250 V) (500 V) (1 kV)	 0.11 % 0.0050 % 0.012 %	Ohm-Labs 110
	100 GΩ (250 V) (500 V) (1 kV) (5 kV)	 0.18 % 0.21 % 0.16 % 3.6 %	Ohm-Labs 111
	1 TΩ (100 V) (200 V) (1 kV) (5 kV)	 2.6 % 2.5 % 2.7 % 2.2 %	Ohm-Labs 112
DC Resistance – Measure	(0 to 1) Ω (1 to 10) Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1to 1) MΩ (1 to 10) MΩ (10 to 100) MΩ (0.1 to 1.2) GΩ	41 μΩ/Ω + 3.7 μΩ 18 μΩ/Ω + 37 μΩ 14 μΩ/Ω + 140 μΩ 12 μΩ/Ω + 830 μΩ 12 μΩ/Ω + 8.1 mΩ 12 μΩ/Ω + 81 mΩ 20 μΩ/Ω + 1.9 Ω 0.014 % + 81 Ω 0.061 % + 1.9 kΩ 0.58 % + 170 kΩ	Agilent 3458A

Parameter/Range	Frequency	CMC[2, 4, 5] (±)	Comments
AC Voltage – Generate			
(0 to 2.2) mV	(40 to 100) Hz (100 to 500) Hz 500 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.080 % + 3.9 µV 0.080 % + 3.9 µV 0.080 % + 3.9 µV 0.14 % + 3.9 µV 0.19 % + 4.7 µV 0.71 % + 9.3 µV 0.67 % + 20 µV 0.27 % + 20 µV	Fluke 5720A
(2.2 to 22) mV	(40 to 100) Hz (100 to 500) Hz 500 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.010 % + 3.9 µV 0.010 % + 3.9 µV 0.010 % + 3.9 µV 0.030 % + 3.9 µV 0.060 % + 4.7 µV 0.12 % + 9.3 µV 0.24 % + 20 µV 0.28 % + 20 µV	
(22 to 220) mV	(40 to 100) Hz (100 to 500) Hz 500 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MH	0.0090 % + 6.2 µV 0.0090 % + 6.2 µV 0.0080 % + 6.3 µV 0.021 % + 6.6 µV 0.049 % + 17 µV 0.089 % + 21 µV 0.14 % + 26 µV 0.27 % + 52 µV	
220 mV to 2.2 V	(40 to 100) Hz (100 to 500) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.075 % + 7.8 µV 0.075 % + 7.9 µV 0.0050 % + 7.8 µV 0.0080 % + 9.6 µV 0.011 % + 32 µV 0.044 % + 80 µV 0.098 % + 200 µV 0.16 % + 330 µV	
(2.2 to 22) V	(40 to 100) Hz (100 to 500) Hz 500 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1MHz	0.010 % + 56 µV 0.010 % + 56 µV 0.010 % + 56 µV 0.010 % + 96 µV 0.010 % + 200 µV 0.030 % + 650 µV 0.10 % + 2 mV 0.15 % + 3.2 mV	
(22 to 220) V	(40 to 100) Hz (100 to 500) Hz 500 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.010 % + 0.55 mV 0.010 % + 0.55 mV 0.010 % + 0.55 mV 0.020 % + 1.5 mV 0.020 % + 2.4 mV	
(220 to 1100) V	(50 to 500) Hz 500 Hz to 1 kHz	0.010 % + 3.1 mV 0.010 % + 0.9 mV	

Parameter/Range	Frequency	CMC[2, 4, 5] (±)	Comments
AC Voltage – Measure			
(0 to 10) mV	(1 to 100) Hz 100 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	0.040 % + 5.3 µV 0.060 % + 5.3 µV 0.050 % + 5.3 µV 0.050 % + 5.5 µV 0.41 % + 8.4 µV 5.3 % + 15 µV 1.6 % + 15 µV	Agilent 3458A synchronous sub-sampled mode
(10 to 100) mV	(1 to 100) Hz 100 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 2) MHz	0.010 % + 5.9 µV 1.2 % + 5.9 µV 0.020 % + 5.9 µV 0.020 % + 6.1 µV 0.98 % + 8.4 µV 0.42 % + 15 µV 1.4 % + 30 µV 1.9 % + 30 µV	
(0.1 to 1) 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 2) MHz	0.030 % + 93 µV 0.030 % + 29 µV 0.030 % + 7.0 µV 0.050 % + 19 µV 0.11 % + 81 µV 0.45 % + 150 µV 1.3 % + 410 µV 1.7 % + 990 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 (1 to 2) MHz	0.040 % + 930 µV 0.040 % + 71 µV 0.050 % + 71 µV 0.060 % + 190 µV 0.11 % + 410 µV 0.41 % + 1.7 mV 1.2 % + 5.0 mV 1.5 % + 10 mV	
(10 to 100) V	(1 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.040 % + 9.3 mV 0.040 % + 4.2 mV 0.050 % + 9.3 mV 0.15 % + 110 mV	
(100 to 700) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.060 % + 19 mV 0.060 % + 19 mV 0.070 % + 4.2 mV 0.14 % + 4.2 mV 0.32 % + 4.2 mV	VMP200-3.8-J-U-ALFA-CK probe/voltmeter
(0.7 to 2) kV (2 to 20) kV (20 to 85) kV	60 Hz 60 Hz 60 Hz	0.42 % 0.41 % 1.2 %	ROSS VMP 200

Parameter/Range	Frequency	CMC[2, 4, 5] (±)	Comments
AC Current – Generate			
(0 to 220) µA	(40 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.010 % + 7.8 nA 0.010 % + 7.8 nA 0.030 % + 12 nA 0.12 % + 130 nA	Fluke 5720A
(0.22 to 2.2) mA	(40 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.010 % + 32 nA 0.010 % + 32 nA 0.02 0% + 160 nA 0.11 % + 780 nA	
(2.2 to 22) mA	(40 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.010 % + 310 nA 0.010 % + 310 nA 0.020 % + 720 nA 0.11 % + 4.8 µA	`
(22to 220) mA	(40 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.010 % + 2.3 µA 0.010 % + 2.3 µA 0.020 % + 3.9 µA 0.11 % + 11 µA	
(0.22 to 2.2) A	(40 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.030 % + 32 µA 0.030 % + 32 µA 0.040 % + 78 µA 0.64 % + 160 µA	
(1.1 to 2.99999) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.14 % + 78 µA 0.050 % + 78 µA 0.48 % + 780 µA 2.1 % + 3.9 mA	Fluke 5520A
(3 to 10.9999) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.060 % + 1.6 mA 0.090 % + 1.6 mA 2.2 % + 1.6 mA	
(11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.12 % + 3.9 mA 0.15 % + 3.9 mA 2.5 % + 3.9 mA	
Clamp-On Only			
(16.5 to 149.99) A	(45 to 440) Hz	0.76 %	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			
(5 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 % + 590 nA 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 % + 6.3µA 0.040 % + 58 µA 0.070 % + 120 µA	
(0.1 to 1) A	(45 to 100) Hz 100 Hz to 5 kHz	0.10 % + 52 µA 0.12 % + 120 µA	
(0 to 10) A	(50 to 100) Hz 100 Hz to 1 kHz 1 kHz 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	0.16 % 0.16 % 0.16 %	
AC Power – Generation			
(0.01 to 0.1) W (0.1 to 36) W (0.89 to 3) kW (3 to 20) kW	(45 to 65) Hz, PF = 1	0.040 % 0.060 % 0.060 % 0.12 %	Fluke 5520A
Capacitance– Generate			
Up to 220 pF (220 to 390) pF (0.390 to 0.6) nF (0.6 to 1.0) nF (1.0 to 3.0) nF (3.0 to 3.3) nF (3.3 to 30) nF (30 to 300) nF (300 to 330) nF (0.3 to 1.2) µF (1.2 to 3.3) µF (3.3 to 10.9) µF	1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 100 Hz 100 Hz 100 Hz 100 Hz	3.7 % + 10 pF 2.1 % + 10 pF 1.6 % + 10 pF 1.3 % + 10 pF 1.3 % + 10 pF 1.2 % + 10 pF 0.23 % + 100 pF 0.23 % + 300 pF 0.23 % + 1.0 nF 0.55 % + 3.0 nF 0.38 % + 10 nF 1.8 % + 10 nF	Fluke 5520A

Parameter/Range	Frequency	CMC[2, 4, 5] (±)	Comments
Oscilloscope –			
Level Sine Wave – Amplitude Characteristics 50 kHz	5 mV	1.9 % + 240 µV	Fluke 5820A
	10 mV	2.0 % + 240 µV	
	20 mV	1.9 % + 240 µV	
	50 mV	1.9 % + 240 µV	
	100 mV	2.1 % + 240 µV	
	200 mV	2.0 % + 240 µV	
	0.5 V	2.0 % + 240 µV	
	1 V	2.0 % + 240 µV	
	2V	2.0 % + 240 µV	
	5V	2.0 % + 240 µV	
Leveled Sine Flatness Test (50 kHz)			
5.5 V	1 MHz	3.2 % + 240 µV	
	10 MHz	3.3 % + 240 µV	
	50 MHz	3.4 % + 240 µV	
	100 MHz	3.9 % + 240 µV	
	200 MHz	4.0 % + 240 µV	
	300 MHz	4.3 % + 240 µV	
	400 MHz	5.5 % + 240 µV	
	500 MHz	5.5 % + 240 µV	
	600 MHz	5.6 % + 240 µV	
3.4 V	1 MHz	3.2 % + 240 µV	
	10 MHz	3.2 % + 240 µV	
	50 MHz	3.4 % + 240 µV	
	100 MHz	3.8 % + 240 µV	
	200 MHz	3.9 % + 240 µV	
	300 MHz	4.2 % + 240 µV	
	400 MHz	5.5 % + 240 µV	
	500 MHz	5.4 % + 240 µV	
	600 MHz	5.6 % + 240 µV	
1.3 V	1 MHz	3.4 % + 240 µV	
	10 MHz	3.2 % + 240 µV	
	50 MHz	3.4 % + 240 µV	
	100 MHz	3.8 % + 240 µV	
	200 MHz	3.9 % + 240 µV	
	300 MHz	4.2 % + 240 µV	
	400 MHz	5.8 % + 240 µV	
	500 MHz	5.7 % + 240 µV	
	600 MHz	5.5 % + 240 µV	

Parameter/Range	Frequency	CMC[2, 4, 5] (±)	Comments
Oscilloscopes (cont) –			
Leveled Sine Flatness Test (50 kHz)			
1.2 V	1 MHz	3.4 % + 240 µV	Fluke 5820A
	10 MHz	3.2 % + 240 µV	
	50 MHz	3.4 % + 240 µV	
	100 MHz	3.8 % + 240 µV	
	200 MHz	3.9 % + 240 µV	
	300 MHz	4.2 % + 240 µV	
	400 MHz	5.5 % + 240 µV	
	500 MHz	5.4 % + 240 µV	
	600 MHz	5.7 % + 240 µV	
400 mV	1 MHz	3.1 % + 240 µV	
	10 MHz	3.2 % + 240 µV	
	50 MHz	3.4 % + 240 µV	
	100 MHz	3.8 % + 240 µV	
	200 MHz	3.9 % + 240 µV	
	300 MHz	4.2 % + 240 µV	
	400 MHz	5.8 % + 240 µV	
	500 MHz	6.0 % + 240 µV	
	600 MHz	5.7 % + 240 µV	
100 mV	1 MHz	3.2 % + 240 µV	
	10 MHz	3.2 % + 240 µV	
	50 MHz	3.3 % + 240 µV	
	100 MHz	3.5 % + 240 µV	
	200 MHz	3.9 % + 240 µV	
	300 MHz	4.2 % + 240 µV	
	400 MHz	5.8 % + 240 µV	
	500 MHz	5.8 % + 240 µV	
	600 MHz	5.5 % + 240 µV	
10 mV	1 MHz	3.2 % + 240 µV	
	10 MHz	2.9 % + 240 µV	
	50 MHz	3.3 % + 240 µV	
	100 MHz	3.8 % + 240 µV	
	200 MHz	3.8 % + 240 µV	
	300 MHz	4.2 % + 240 µV	
	400 MHz	5.5 % + 240 µV	
	500 MHz	5.5 % + 240 µV	
	600 MHz	5.6 % + 240 µV	

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
Oscilloscope (cont) –			
Amplitude/Vertical Gain Characteristics-Volt Function			
Square @ 1 kHz (1 MΩ)	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 µV 1.6 % + 32 µV 0.080 % + 32 µV 0.080 % + 32µV 0.080 % + 32 µV 0.090 % + 32 µV 0.090 % + 32 µV 0.080 % + 32 µV 0.10 % + 32 µV 0.090 % + 32 µV 0.10 % + 32 µV 0.080 % + 32 µV 0.080 % + 32 µV	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 µV 0.65 % + 32 µV 0.79 % + 32 µV 0.23 % + 32 µV 0.22 % + 32 µV 0.72 % + 32 µV 0.44 % + 32 µV 0.43 % + 32 µV 0.39 % + 32 µV 0.38 % + 32 µV 0.52 % + 32 µV 0.48 % + 32 µV	
Leveled Sine Frequency Source	50 kHz 500 kHz 5 MHz 50 MHz 500 MHz	13 µHz/Hz 2.9 µHz/Hz 2.4 µHz/Hz 2.3 µHz/Hz 2.0 µHz/Hz	
Time Marker	2.0 ns 5.0 ns 10.0 ns 20.0 ns 50.0 ns 100.0 ns 10.0 ms 20.0 ms 50.0 ms 100 ms 2.0 s 5.0 s	2.3 ms/s 1.6 ms/s 0.90 ms/s 0.60 ms/s 0.60 ms/s 68 ms/s 0.20 ms/s 3.5 ms/s 58 ms/s 0.20 ms/s 1.7 ms/s 4.0 ms/s	
Rise Time: 4mV to 2.5 V_{pk-pk} 1 kHz to 10 MHz	≤ 300 ps	250 ps	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Calibration of Thermocouple Indicators –			Fluke 5520A
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.24 °C 0.16 °C 0.56 °C 0.17 °C 0.21 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.28 °C 0.18 °C 0.21 °C 0.23 °C 0.33 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.50 °C 0.22 °C 0.16 °C 0.17 °C	
Electrical Calibration of RTDs –			Fluke 5520A
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	
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	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Calibration of RTDs (cont) –			
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	Fluke 5520A
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	
Ni 120, 120 Ω	(-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.080 °C 0.050 °C 0.040 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.090 °C	

II. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2, 3] (±)	Comments
RF Power – Measure			
Power Reference 1 mW, Type-N(f) 50 Ω	50 MHz	0.33 %	Agilent 432A with 478A-H75
(-30 to +20) dBm	50 MHz to 1 GHz (1 to 2) GHz (2 to 4) GHz (4 to 6) GHz (6 to 8) GHz	4.2 % + *M* 4.2 % + *M* 4.2 % + *M* 4.6 % + *M* 4.4 % + *M*	Agilent 8487A with E4419A

Parameter/Range	Frequency	CMC[2, 3] (±)	Comments
RF Power – Measure (cont)			
Power Reference 1 mW, Type-N(f) 50 Ω			
(-30 to +20) dBm	(8 to 10) GHz (10 to 12) GHz (12 to 14) GHz (14 to 16) GHz (16 to 18) GHz (18 to 22) GHz (22 to 26.5) GHz (26.5 to 28) GHz (28 to 30) GHz (30 to 33) GHz (33 to 34.5) GHz (34.5 to 37) GHz (37 to 40) GHz (40 to 42) GHz (42 to 44) GHz (44 to 46) GHz (46 to 48) GHz (48 to 50) GHz	4.4 % + *M* 4.4 % + *M* 4.4 % + *M* 4.4 % + *M* 4.4 % + *M* 4.6 % + *M* 4.7 % + *M* 4.8 % + *M* 4.9 % + *M* 4.7 % + *M* 4.8 % + *M* 5.0 % + *M* 5.5 % + *M* 5.3 % + *M* 5.9 % + *M* 5.2 % + *M* 5.3 % + *M* 5.7 % + *M*	Agilent 8487A with E4419A
(-20 to +30) dBm	100 kHz to 1.3 GHz (50 to 1300) MHz (1.3 to 18) GHz (18 to 26.5) GHz	0.16 dB 0.16 dB 0.17 dB 0.20 dB	Agilent 8902A with 11722A Agilent 8902A with 11792A and 11793A
Amplitude Modulation – Measure			
Rate: 50 Hz to 10 kHz, Depth: (5 to 99) %	(0.15 to 10) MHz	2.5 % + 1 digit	Agilent 8902A w/ 11722A
20 Hz to 10 kHz, Depth: Up to 99 %	(0.15 to 10) MHz	3.6 % + 1 digit	
50 Hz to 50 kHz, Depth: (5 to 99) %	(10 to 1300) MHz	1.4 % + 1 digit	
20 Hz to 100 kHz, Depth: Up to 99 %	(10 to 1300) MHz	3.6 % + 1 digit	

Parameter/Frequency	Range	CMC[2] (±)	Comments
Frequency Modulation – Measure			
Rate: 20 Hz to 10 kHz Deviation: ≤ 40 kHz peak	(0.25 to 10) MHz	3.2 % + 1 digit	Agilent 8902A w/ 11722A
	(10 to 1300) MHz	1.2 % + 1 digit	
50 Hz to 100 kHz Deviation: ≤ 400 kHz peak	(10 to 1300) MHz	5.8 % + 1 digit	
Rate: 20 Hz to 200 kHz Deviation: ≤ 400 kHz peak	(0.01 to 26.5) GHz	1.2 % + 1 digit	plus 11792A
	(0.01 to 26.5) GHz	5.8 % + 1 digit	
Rate: 50 Hz to 100 kHz, Deviation: ≤ 400 kHz peak			
Rate: 20 Hz to 200 kHz, Deviation: ≤ 400 kHz peak			
Phase Modulation – Measure			
Rate: (0.2 to 10) kHz	150 kHz to 10 MHz	4.6 % + 1 digit	Agilent 8902A w/ 11722A
	10 MHz to 1.3 GHz	3.5 % + 1 digit	
(0.2 to 20) kHz	(0.01 to 26.5) GHz	3.5 % + 1 digit	Plus 11792A
(0.2 to 20) kHz			

Parameter/Frequency	Range	CMC[2] (±)	Comments
Reflection S11/S22 Measure –			
300 kHz to 1.5 GHz	(0.56 to 1) lin	(± 0.010 to ± 0.024) lin (± 1.6) deg	Agilent E5061B and 85032B Type N precision cal kit
	(0.32 to 0.56) lin	(± 0.0060 to ± 0.010) lin (± 1.8 to ± 1.4) deg	
	(0.1 to 0.32) lin	(± 0.006 to ± 0.010) lin (± 4.0 to ± 1.8) deg	
	(0.032 to 0.1) lin	(± 0.0060 to ± 0.0080) lin (± 180 to ± 4.0) deg	
	(0.001 to 0.032) lin	(± 0.0080 to ± 0.0080) lin (± 180) deg	
	(0 to 0.001) lin	(± 0.0080) lin (± 180) deg	
(1.5 to 3) GHz	(0.56 to 1) lin	(± 0.014 to ± 0.032) lin (± 2.0 to ± 1.8) deg	
	(0.32 to 0.56) lin	(± 0.010 to ± 0.014) lin (± 1.8 to ± 2.2) deg	
	(0.1 to 0.32) lin	(± 0.0090 to ± 0.010) lin (± 5 to ± 2.2) deg	
	(0.032 to 0.1) lin	(± 0.0090) lin (± 180) deg	
	(0.001 to 0.032) lin	(± 0.0090) lin (± 180) deg	
	(0 to 0.001) lin	(± 0.0090) lin (± 180) deg	
RF Attenuation – Measure			
100 kHz to 1.3 GHz	(0.0 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	0.095 dB + 0.010 dB 0.065 dB + 0.010 dB 0.065 dB + 0.010 dB 0.065 dB + 0.010 dB 0.088 dB + 0.010 dB 0.22 dB + 0.010 dB 0.23 dB + 0.010 dB	Agilent 8902A with 11722A, 11792A, 11793A, and source

Parameter/Frequency	Range	CMC[2] (±)	Comments
RF Attenuation – Measure			
50 MHz to 26.5 GHz	(0.0 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	0.15 dB + 0.010 dB 0.15 dB + 0.010 dB 0.15 dB + 0.010 dB 0.20 dB + 0.010 dB 0.17 dB + 0.010 dB 0.25 dB + 0.010 dB 0.68 dB + 0.010 dB	Agilent 8902A with 11722A, 11792A, 11793A, and source
Transmission Measurements – S21 Magnitude & Phase			
Type N			
300 kHz to 1.5 GHz	(0 to 12) dB	(± 0.12 to ± 0.16) dB (± 0.80 to ± 1.0) deg	Agilent E5061B and 85032B Type N precision cal kit
	(12 to 20) dB	(± 0.16 to ± 0.18) dB (± 1.0 to ± 1.2) deg	
	(20 to 30) dB	(± 0.18 to ± 0.26) dB (± 1.2 to ± 1.6) deg	
	(30 to 40) dB	(± 0.26 to ± 0.50) dB (± 1.6 to ± 3.6) deg	
	(40 to 50) dB	(± 0.50 to ± 1.4) dB (± 3.6 to ± 9.6) deg	
(1.5 to 3) GHz	(0 to 12) dB	(± 0.14 to ± 0.18) dB (± 0.96 to ± 1.1) deg	
	(12 to 20) dB	(± 0.18 to ± 0.20) dB (± 1.1 to ± 1.3) deg	
	(20 to 30) dB	(± 0.20 to ± 0.24) dB (± 1.3 to ± 1.6) deg	
	(30 to 40) dB	(± 0.24 to ± 0.36) dB (± 1.6 to ± 2.6) deg	
	(40 to 50) dB	(± 0.36 to ± 0.8) dB (± 2.6 to ± 5.6) deg	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
ESD Simulators –			
Contact Voltage	200 V to 30 kV	3.8 %	Calibration method based on IEC/EN 61000-4-2, IEC 801-2
Rise Time	(0.7 to 1) ns	3.5 %	Brandenburg 149-03 attenuator Tek TDS7404 with schaffner
Peak Current	(7.5 to 112.5) A	5.0 %	MD103 target
30 ns Current	(4 to 60) A	4.4 %	
60 ns Current	(2 to 30) A	4.4 %	
RC Time Constant	600 ns ± 130 ns 300 ns ± 60 ns	3.5 % 3.5 %	
EFT/Burst Generators –			
Voltage	20 V to 8 kV 1000:1 divider 2000:1 divider	 4.2 % 3.8 %	IEC/EN 61000-4-4, ANSI/IEEE C37.90, ISO 7637-2 Tektronix TDS5104 with schaffner CAS-3025 attenuator set
Rise Time Fall Time	5 ns 5 ns	5.4 % 5.4 %	
Pulse Width	(35 to 200) ns	2.8 %	
Burst Duration	(0.5 to 20) ms	2.9 %	
Burst Period	(100 to 300) ms	1.1 %	
Repetition Rate	1 kHz to 1 MHz	1.0 %	
Transient Generators –			
Front/Rise Time – Open Circuit Short Circuit	 1 µs to 10 ms (1 to 100) µs	 7.7 % 3.9 %	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
Fall time Open Circuit Short Circuit	 1 µs to 10 ms (1 to 100) ms	 4.5 % 3.9 %	
Pulse Width– Open Circuit	 1 µs to 1000 ms	 2.1 %	Tektronix TDS5104 with sapphire SI-9010A and pearson 110 differential probe
Pulse Width- Short Circuit	1 µs to 1 ms	1.1 %	
Open Circuit Voltage	10 V to 20 kV	3.7 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Transient Generators (cont) –			
Short Circuit Current	1 A to 4 kA	2.4 %	
Repetition Rate	(0.1 to 100) s	1.6 %	
Ring/Oscillatory Wave – Rise Time	75 ns (0.5 to 1.5) µs	4.4 %	
Fall Time	75 ns (0.5 to 1.5) µs	4.5 %	
Frequency	5 kHz to 1 MHz	2.4 %	
Current	1 A to 4 kA	2.4 %	
PQT – Voltage Dips and Interruptions –			
Output Voltage	Up to 260 V AC or DC	2.1 %	IEC/EN 61000-4-11
Phase Angle	(0 to 359)°	2.3 %	Tektronix TDS5104
Pulse Rise/Fall Time	(1 to 5) ns	1.5 %	
RF Bulk Injection Probe –			
Insertion Loss	10 Hz to 3 GHz	3.1 dB	Agilent VNA E5061B

III. Thermodynamics

Parameter/Equipment	Range	CMC[2] (±)	Comments
Temperature – Measure	(-196 to 420) °C	0.59 °C	PRT with thermometer
Relative Humidity – Measuring Equipment			
Fixed Points	11 % RH 33 % RH 75 % RH	2.7 % RH 3.9 % 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	(1 to 225) MHz	8.3 nHz/Hz	Agilent 53132A referenced to GPS receiver
	50 MHz to 40 GHz	8.6 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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Presented this 26th day of May 2015.

President & CEO
For the Accreditation Council
Certificate Number 3410.01
Valid to April 30, 2017

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