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

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CALIBRATION

Valid To: March 31, 2023 Certificate Number: 2357.17

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 one satellite locations listed below to perform the following calibrations[1, 8]:

I. Dimensional

Parameter/Equipment	Range	CMC[2, 5] (±)	Comments
Angle Generation –Levels and Protractors[3]	Up to 360°	0.012°	Sine plate, angle blocks and surface plate
Calipers[3]	Up to 4 in (>4 to 12) in (>12 to 48) in	(58 + 0.76*L*) µin (55 + 1.6*L*) µin (35 + 3.2*L*) µin	Grade 0 gage blocks Grade 2 gage blocks
Height Gages[3]	Up to 4 in (>4 to 12) in (>12 to 48) in	110 µin 110 µin (83 + 22*L*) µin	Grade 0 gage blocks Grade 2 gage blocks and surface plate
Micrometers[3]	Up to 4 in (>4 to 12) in (>12 to 48) in	(7.6 + 2.6*L*) µin (24 + 2.6*L*) µin (13 + 3.5*L*) µin	Grade 0 gage blocks Grade 2 gage blocks
Plain Plug & Pin Gages – Outside Diameter and Length	Up to 4 in	(6.0 + 0.8*L*) µin	Labmaster™ w/ Grade 00 gage blocks

Parameter/Equipment	Range	CMC[2, 5, 9] (±)	Comments
Ring Gages –			
Inside Diameter	Up to 4 in	(9.0 + 1.3*L*) µin	Labmaster™ w/ Grade 00 gage blocks
External Thread Gages –			
Pitch Diameter	Up to 4 in	(69 + 0.3*L*) µin	Thread wires
Major Diameter	Up to 4 in	(8.8 + 1.8*L*) µin	Labmaster™ w/ Grade 00 gage blocks
Indicators[3]	Up to 4 in (>4 to 12) in (>12 to 48) in	(15 + 1.5*L*) µin (21 + 3.3*L*) µin (47 + 3.4*L*) µin	Grade 0 gage blocks Grade 2 gage blocks
Flatness[3]	Up to 1 in	5.0 µin	Optical flat
Parallelism[3]	Up to 1 in	9.8 µin	Optical parallel set

II. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Current – Generate[3]			
Up to 220 µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.69 mA/A + 25 nA 0.34 mA/A + 20 nA 0.13 mA/A + 16 nA 0.55 mA/A + 40 nA 1.4 mA/A + 80 nA	Fluke 5700A
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.67 mA/A + 40 nA 0.35 mA/A + 35 nA 0.17 mA/A + 35 nA 0.56 mA/A + 0.40 µA 1.4 mA/A + 0.80 µA	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.67 mA/A + 0.40 µA 0.33 mA/A + 0.35 µA 0.14 mA/A + 0.35 µA 0.55 mA/A + 4.0 µA 1.4 mA/A + 8.0 µA	
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.68 mA/A + 4.0 µA 0.33 mA/A + 3.5 µA 0.15 mA/A + 3.5 µA 0.55 mA/A + 40 µA 1.4 mA/A + 80 µA	
(0.22 to 2.2) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.59 mA/A + 35 µA 0.67 mA/A + 80 µA 7.8 mA/A + 0.16 mA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.41 mA/A + 0.17 mA 0.79 mA/A + 0.38 mA 3.0 mA/A + 0.75 mA	Fluke 5700A w/ 5725A
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.95 mA/A + 3.9 mA 1.2 mA/A + 3.9 mA 23 mA/A + 3.9 mA	Fluke 5520A
(0.03 to 0.33) mA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA	(10 to 30) kHz (10 to 30) kHz (10 to 30) kHz (10 to 30) kHz	12 mA/A + 0.31 µA 7.8 mA/A + 0.47 µA 3.4 mA/A + 3.1 µA 3.1 mA/A + 0.16 mA	
Clamp-On Ammeters			
(16.5 to <150) A	(45 to 65) Hz (65 to 440) Hz	0.31 % 0.81 %	Fluke 5520A w/ coil

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Current – Generate[3] (cont)			
Clamp-On Ammeters			
(150 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.33 % 0.82 %	Fluke 5520A w/ coil
AC Current – Measure[3]			
Up to 199.99 µA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.81 mA/A + 20 nA 1.9 mA/A + 20 nA 1.9 mA/A + 20 nA 4.4 mA/A + 20 nA	Fluke 8508A
(0.2 to 1.9999) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.62 mA/A + 0.20 µA 1.7 mA/A + 0.20 µA 1.8 mA/A + 0.20 µA 4.4 mA/A + 0.20 µA	
(2 to 19.999) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.6 mA/A + 2.0 µA 1.5 mA/A + 2.0 µA 1.7 mA/A + 2.0 µA 5.7 mA/A + 2.0 µA	
(20 to 199.99) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.62 mA/A + 20 µA 1.1 mA/A + 20 µA 1.4 mA/A + 20 µA	
(10 to 100) mA	(20 to 50) kHz (50 to 100) kHz	11 mA/A + 31 µA 11 mA/A + 0.12 mA	Agilent 3458A
(0.2 to 1.9999) A	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.7 mA/A + 0.20 mA 6.1 mA/A + 0.20 mA 6.8 mA/A + 0.20 mA	Fluke 8508A
100 mA to 1 A	(20 to 50) kHz	3.2 mA/A + 0.31 mA	Agilent 3458A
(2 to 20) A	(10 to 55) Hz 55 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.98 mA/A + 2.0 mA 0.12 mA/A 0.15 mA/A 4.5 mA/A + 2 mA	Fluke 8508A Fluke 8508A w/ Y5020 Fluke 8508A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Generate[3]			
Up to 2.2 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.70 mV/V + 3.9 µV 0.54 mV/V + 3.9 µV 0.51 mV/V + 3.9 µV 0.60 mV/V + 3.9 µV 0.90 mV/V + 6.2 µV 1.1 mV/V + 12 µV 1.7 mV/V + 23 µV 4.0 mV/V + 31 µV	Fluke 5700A
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.48 mV/V + 4.7 µV 0.21 mV/V + 4.7 µV 0.14 mV/V + 4.7 µV 0.33 mV/V + 4.7 µV 0.74 mV/V + 6.2 µV 1.0 mV/V + 12 µV 1.4 mV/V + 23 µV 3.7 mV/V + 31 µV	
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.55 mV/V + 12 µV 0.19 mV/V + 7.8 µV 88 µV/V + 7.8 µV 0.28 mV/V + 7.8 µV 0.70 mV/V + 23 µV 0.85 mV/V + 23 µV 1.4 mV/V + 31 µV 2.8 mV/V + 78 µV	
(0.22 to 2.2) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.63 mV/V + 78 µV 0.14 mV/V + 23 µV 67 µV/V + 5.4 µV 0.11 mV/V + 16 µV 0.23 mV/V + 62 µV 0.38 mV/V + 0.12 mV 0.93 mV/V + 0.31 mV 1.9 mV/V + 0.78 mV	
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.55 mV/V + 0.78 mV 0.14 mV/V + 0.23 mV 67 µV/V + 54 µV 0.11 mV/V + 0.16 mV 0.22 mV/V + 0.31 mV 0.47 mV/V + 1.3 mV 1.1 mV/V + 3.9 mV 2.3 mV/V + 7.0 mV	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Generate[3] (cont)			
(22 to 220) V*	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.59 mV/V + 7.8 mV 0.14 mV/V + 2.3 mV 71 µV/V + 0.78 mV 0.20 mV/V + 3.1 mV 0.47 mV/V + 7.8 mV 1.2 mV/V + 85 mV 4.2 mV/V + 85 mV 11 mV/V + 0.17 V	Fluke 5700A *Subject to 2.2 x 10^7 V-Hz limitation
(220 to 1100) V	(15 to 50) Hz 50 Hz to 1 kHz	0.36 mV/V + 16 mV 75 µV/V + 3.1 mV	
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	78 µV/V + 3.1 mV 0.13 mV/V + 4.7 mV 0.47 mV/V + 8.5 mV	Fluke 5700A w/5725A
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.47 mV/V + 8.5 mV 1.8 mV/V + 35 mV	
AC Voltage – Measure[3]			
Up to 10 mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz 100 kHz to 1 MHz	0.27 µV/V + 2.3 µV 0.18 µV/V + 0.85 µV 0.25 µV/V + 0.85 µV 0.78 µV/V + 0.85 µV 3.9 µV/V + 0.85 µV 31 µV/V + 3.9 µV	Agilent 3458A
(10 to 100) mV	(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	0.14 µV/V + 3.1 µV 72 nV/V + 1.6 µV 0.11 µV/V + 1.6 µV 0.24 µV/V + 1.6 µV 0.62 µV/V + 1.6 µV 2.3 µV/V + 7.8 µV 7.8 µV/V + 7.8 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	0.49 mV/V + 31 µV 81 µV/V + 16 µV 0.12 mV/V + 16 µV 0.33 mV/V + 16 µV 8.2 mV/V + 16 µV 8.5 mV/V + 78 µV 11 mV/V + 78 µV	

Parameter/Range	Frequency	CMC[2,4,5] (±)	Comments
AC Voltage – Measure[3] (cont)			
(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	0.49 mV/V + 0.31 mV 80 µV/V + 0.16 mV 0.12 mV/V + 0.16 mV 0.33 mV/V + 0.16 mV 8.2 mV/V + 0.16 mV 8.5 mV/V + 0.78 mV 11 mV/V + 0.78 mV	Agilent 3458A
(10 to 100) 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	0.51 mV/V + 3.1 mV 0.17 mV/V + 1.6 mV 0.17 mV/V + 1.6 mV 0.36 mV/V + 1.6 mV 8.3 mV/V + 1.6 mV 8.8 mV/V + 7.8 mV 14 mV/V + 7.8 mV	
(20 to 200) V	(1 to 10) Hz (10 to 40) Hz (40 to 100) Hz (0.1 to 2) kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.82 mV/V + 12 mV 0.3 mV/V + 2 mV 0.11 mV/V + 2 mV 96 µV/V + 2 mV 0.13 mV/V + 2 mV 0.24 mV/V + 4.0 mV 0.6 mV/V + 20 mV 3.2 mV/V + 0.2 V 10 mV/V + 2 mV	Fluke 8508A
(200 to 1050) V	(1 to 10) Hz (10 to 40) Hz 40 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.32 mV/V + 70 mV 0.32 mV/V + 20 mV 0.13 mV/V + 20 mV 0.27 mV/V + 40 mV 0.64 mV/V + 0.2 V	
(1 to 30) kV	60 Hz	6.0 mV/V	Ross VD50 w/ 34401A
AC Resistance – Generate[3]			
0.1 Ω 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ	DC to 1 MHz DC to 1 MHz DC to 10 MHz DC to 1 MHz DC to 1 MHz DC to 1 MHz DC to 1 MHz	0.15 % 0.023 % (0.010 + 0.0085f) % 0.028 % 0.012 % (0.012 + 0.013f) % (0.037 + 2.3f) %	HP 16074A f = Frequency in MHz

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Capacitance – Generate[3], Fixed Points			
1 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.39 fF 0.40 fF 0.45 fF 0.57 fF 0.73 fF 1.5 fF 2.5 fF 4.1 fF	HP 16380A & HP 16380C
10 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	3.5 fF 3.5 fF 3.8 fF 3.8 fF 3.5 fF 3.5 fF 4.1 fF 4.3 fF	
100 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	43 fF 35 fF 36 fF 37 fF 38 fF 39 fF 52 fF 64 fF	
1 nF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.35 pF 0.35 pF 0.38 pF 0.45 pF 0.56 pF 0.72 pF 2.0 pF 2.9 pF	
10 nF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.62 pF 0.71 pF 0.71 pF 0.73 pF	
100 nF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	7.1 pF 7.1 pF 7.1 pF 9.1 pF	
1 µF	(100 to 120) Hz 120 Hz to 1 kHz	76 pF 70 pF	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Capacitance – Generate[3] (cont)			
1 µF	(1 to 10) kHz (10 to 100) kHz	70 pF 0.58 nF	Fluke 5520A
(220 to 399.9) pF (0.4 to 1.0999) nF (1.1 to 3.2999) nF (3.3 to 10.9999) nF (11 to 32.9999) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.09999) µF (1.1 to 3.29999) µF (3.3 to 10.9999) µF (11 to 32.9999) µF (33 to 109.999) µF (110 to 329.999) µF (0.33 to 1.09999) mF (1.1 to 3.29999) mF (3.3 to 10.9999) mF (11 to 32.9999) mF (33 to 110) mF	10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 3 kHz (0.01 to 1) kHz (0.01 to 1) kHz (0.01 to 1) kHz (0.01 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	5.8 mF/F + 7.8 pF 4 mF/F + 7.8 pF 4 mF/F + 7.8 pF 2.1 mF/F + 7.8 pF 2 mF/F + 78 pF 2.1 mF/F + 78 pF 2 mF/F + 0.23 nF 2.1 mF/F + 0.78 nF 2 mF/F + 2.3 nF 2.1 mF/F + 7.8 nF 3.2 mF/F + 23 nF 3.6 mF/F + 78 nF 3.5 mF/F + 0.23 µF 3.5 mF/F + 0.78 µF 3.5 mF/F + 2.3 µF 3.6 mF/F + 7.8 µF 5.9 mF/F + 23 µF 8.6 mF/F + 78 µF	
DC Current – Generate[3]	(2 to 20) pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA (0.2 to 2) µA (2 to 20) µA (20 to 200) µA (0.2 to 2) mA	4.3 fA/pA + 12 fA 2.9 fA/pA + 35 fA 0.74 pA/nA + 0.12 pA 0.74 pA/nA + 1.2 pA 0.41 pA/nA + 12 pA 0.29 nA/µA + 0.12 nA 0.29 nA/µA + 1.2 nA 0.29 nA/µA + 12 nA 0.29 µA/mA + 0.12 µA	Keithley 263
	Up to 220 µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A (2.2 to 11) A	39 µA/A + 7.8 nA 39 µA/A + 7.8 nA 39 µA/A + 78 nA 47 µA/A + 0.78 µA 64 µA/A + 23 µA 0.28 mA/A + 0.37 mA	Fluke 5700A w/ 5725A
	(11 to 20.5) A	0.78 mA/A + 0.58 mA	Fluke 5520A
	(20 to 50) A (50 to 100) A	0.68 mA/A + 0.23 mA 0.69 mA/A + 0.23 mA	Fluke 5700A w/ Valhalla 2555A monitored w/ shunts and HP 3458A opt 002

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Current – Generate[3] (cont)	(16.5 to <150) A (150 to 1025) A	3.9 mA/A + 0.11 mA 4 mA/A + 0.39 mA	Fluke 5520A w/ coil
DC Current – Measure[3]	Up to 2 nA (2 to 6.5) nA (6.5 to 100) nA (0.1 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 (1 to 2) A (2 to 20) A (1 to 20) A (20 to 100) A	4.7 pA/nA + 0.46 pA 4.7 pA/nA + 1.2 pA 66 µA/A + 31 pA 32 µA/A + 31 pA 16 µA/A + 0.078 nA 16 µA/A + 0.62 nA 16 µA/A + 3.9 nA 16 µA/A + 39 nA 27 µA/A + 390 nA 85 µA/A + 7.8 µA 0.18 mA/A + 12 µA 0.41 mA/A + 0.31 mA 38 µA/A 0.32 mA/A	Keithley 485 HP 3458A Fluke 8508A HP 3458A opt 002 w/ shunts
DC Resistance – Generate[3]	(0 to 10.9999) Ω (11 to 32.9999) Ω (33 to 109.9999) Ω (110 to 329.9999) Ω (330 to 1099.999) Ω (1.1 to 3.299 999) kΩ (3.3 to 10.999 99) kΩ (11 to 32.999 99) kΩ (33 to 109.9999) kΩ (110 to 329.9999) kΩ (330 to 1099.999) kΩ (1.1 to 3.299 999) MΩ (3.3 to 10.999 99) MΩ (11 to 32.999 99) MΩ (33 to 109.9999) MΩ (110 to 329.9999) MΩ (330 to 1099.999) MΩ (10 to 100) MΩ (100 to 1000) MΩ (1 to 10) GΩ (10 to 100) GΩ (100 to 1000) GΩ	31 µΩ/Ω + 0.78 mΩ 23 µΩ/Ω + 1.2 mΩ 22 µΩ/Ω + 1.1 mΩ 22 µΩ/Ω + 1.6 mΩ 22 µΩ/Ω + 1.6 mΩ 22 µΩ/Ω + 16 mΩ 22 µΩ/Ω + 16 mΩ 22 µΩ/Ω + 0.16 Ω 22 µΩ/Ω + 0.16 Ω 31 µΩ/Ω + 1.6 Ω 32 µΩ/Ω + 1.6 Ω 47 µΩ/Ω + 23 Ω 0.13 mΩ/Ω + 39 Ω 0.21 mΩ/Ω + 1.9 kΩ 0.42 mΩ/Ω + 2.3 kΩ 2.3 mΩ/Ω + 78 kΩ 12 mΩ/Ω + 0.39 MΩ 0.13 % 0.23 % 0.58 % 1.2 % 1.2 %	Fluke 5520A IET HRRS-B-5-100K

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Resistance –Generate, Fixed Points[3]	1 mΩ 10 mΩ 100 mΩ 1 Ω 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	2.4 mΩ/Ω 12 µΩ/Ω 25 µΩ/Ω 12 µΩ/Ω 0.13 mΩ 0.18 mΩ 0.27 mΩ 0.48 mΩ 1.6 mΩ 3.1 mΩ 12 mΩ 23 mΩ 0.11 Ω 0.21 Ω 1.4 Ω 3.2 Ω 50 Ω 62 Ω 0.37 kΩ 0.84 kΩ 12 kΩ	L&N 4223B JG Biddle 601230 JG Biddle 601230 Rubicon 1 Ω Fluke 5700A

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Resistance – Measure[3]	(0 to 2) Ω (2 to 20) Ω (20 to 200) Ω (0.2 to 2) kΩ (2 to 20) kΩ (20 to 200) kΩ (0.2 to 2) MΩ (2 to 20) MΩ (20 to 200) MΩ (0.2 to 2) GΩ (2 to 20) GΩ	22 μΩ/Ω + 4.0 μΩ 15 μΩ/Ω + 14 μΩ 12 μΩ/Ω + 50 μΩ 11 μΩ/Ω + 0.50 mΩ 9.2 μΩ/Ω + 5.0 mΩ 11 μΩ/Ω + 50 mΩ 17 μΩ/Ω + 1.0 Ω 20 μΩ/Ω + 10 Ω 77 μΩ/Ω + 1.00 kΩ 0.22 mΩ/Ω + 100 kΩ 1.5 mΩ/Ω + 10 MΩ	Fluke 8508A
DC Voltage – Generate[3]	0 V (0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	7.6 nV 8.3 μV/V + 0.62 μV 6.7 μV/V + 0.93 μV 6.7 μV/V + 3.1 μV 6.7 μV/V + 6.2 μV 7.4 μV/V + 78 μV 8.9 μV/V + 0.47 mV	Copper short Fluke 5700A
DC Voltage – Measure[3]	0 V (0 to 200) mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1050) V (1 to 30) kV	7.6 nV 6.4 μV/V + 100 nV 3.6 μV/V + 0.40 μV 3.5 μV/V + 4.0 μV 5.9 μV/V + 40 μV 7.5 μV/V + 0.53 mV 1.6 mV/V	Copper short Fluke 8508A Ross VD50 w/ HP 34401A

Parameter/Equipment	Range	CMC[2] (±)	Comments
Distortion – Measure Fundamental Frequency[3] –			
(0 to 99.9) dB (0 to 99.9) dB	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.3 dB	HP 8903B
Inductance – Generate[3]			
100 µH 1 mH 10 mH 100 mH 1 H 10 H	100 Hz to 1 kHz 100 Hz to 1 kHz 100 Hz to 1 kHz 100 Hz to 1 kHz 100 Hz to 1 kHz 100 Hz to 1 kHz	0.45 µH 1.3 µH 13 µH 0.12 mH 1.5 mH 7.6 mH	GenRad 1482-B GenRad 1482-E GenRad 1482-H GenRad 1482-L GenRad 1482-P GenRad 1482-T
Electrical Simulation of Thermocouple Indicators and Indicating Systems[3] – Generate[3] –			
Type J	(-210.0 to 1000.0) °C (> 1000 to 1200.0) °C	0.098 °C 0.15 °C	Millivolt sourcing using ice point reference and PRT
Type K	(-270.0 to 1372.0) °C	0.11 °C	
Type T	(-270.0 to 400.0) °C	0.14 °C	
Electrical Simulation of Thermocouple Indicators and Indicating Systems[3] - Measure[3] –			
Type J	(-210.0 to 1200.0) °C	0.079 °C	Millivolt measuring using ice point, reference and PRT
Type K	(-270.0 to 1372.0) °C	0.11 °C	
Type T	(-270.0 to 400.0) °C	0.074 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Simulation of Thermocouple Indicators and Indicating Systems[3] – Generate & Measure[3]			
Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1820) °C	0.40 °C 0.29 °C 0.25 °C 0.27 °C	Fluke 5520A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.25 °C 0.21 °C 0.25 °C 0.39 °C 0.66 °C	
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.39 °C 0.13 °C 0.11 °C 0.13 °C 0.16 °C	
Type L	(-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.29 °C 0.21 °C 0.15 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.32 °C 0.18 °C 0.15 °C 0.14 °C 0.21 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.47 °C 0.29 °C 0.27 °C 0.32 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.42 °C 0.29 °C 0.30 °C 0.37 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Simulation of RTD Indicators and Indicating Systems [3] –			
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	0.085 ºC 0.12 ºC 0.12 ºC 0.11 ºC 0.097 ºC 0.11 ºC 0.20 ºC	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	0.064 °C 0.076 °C 0.075 °C 0.089 °C 0.095 °C 0.17 ºC	
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	0.21 ºC 0.060 ºC 0.068 °C 0.070 °C 0.077 °C 0.084 °C 0.090 °C 0.13 ºC 0.19 ºC	
Pt 385, 200 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	0.041 °C 0.043 °C 0.044 °C 0.051 °C 0.098 °C 0.11 ºC 0.11 ºC 0.13 ºC	
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	0.036 °C 0.043 °C 0.044 °C 0.051 °C 0.066 °C 0.066 °C 0.073 °C 0.088 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Simulation of RTD Indicators and Indicating Systems – (cont)			
Pt 385, 1000 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	0.029 °C 0.029 °C 0.036 °C 0.042 °C 0.050 °C 0.18 °C 0.057 °C 0.18 °C	Fluke 5520A
PtNi 385, 120 Ω (Ni120)	(-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.081 °C 0.11 °C 0.11 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.69 °C	
Oscilloscopes[3] –			
Amplitude – DC Signal Into 50 Ω Load Into 1 MΩ Load	 (0 to 6.0) V (0 to 200) V	 0.20 mV/V + 19 µV 0.20 mV/V + 19 µV	Fluke 9500B w/ 9530 active heads
Amplitude – Square Wave 50 Ω Load	 ±1 mV to 6 V_{p-p}, 10 Hz to 100 kHz	 0.88 mV/V + 7.8 µV	
1 MΩ Load	±1 mV to 200 V_{p-p}, 10 Hz to 100 kHz	0.92 mV/V + 7.8 µV	
Bandwidth (5 mV to 3 V) $_{p-p}$	 0.1 Hz to 300 MHz (300 to 550) MHz (0.55 to 1.1) GHz (1.1 to 3.2) GHz	 2.1 % 2.4 % 4.1 % 5.4 %	Fluke 9500B w/ 9530 active heads
(5 mV to 1 V) $_{p-p}$	(3.2 to 18) GHz (18 to 26.5) GHz	3.1 % 3.8 %	Signal generator, splitter, power sensor, and power meter
Resistance	(40 to 90) Ω (0.8 to 1.2) MΩ	0.78 mΩ/Ω 0.78 mΩ/Ω	Fluke 9500B w/ 9530 active heads
Time Markers	450.5 ps to 55 s	0.30 µs/s	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Power Supplies[3] –			
Volts	Up to 1000 V	72 µV/V	Tektronix DMM4050
Current	Up to 30 A	0.23 mA/A	PCS-1000 digital shunt
Ripple / Noise RMS - CV Ripple / Noise RMS - CC	Up to 1000 V Up to 30 A	0.27 mV 0.63 mA	Tektronix MDO3014 w/ load
Transient Response			
Time Voltage	Up to 5 ms Up to 1 V	22 ms/s 0.30 mV/V	Tektronix MDO3014 w/ load

III. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Level Flatness – Measure[3]	(0.1 to 10) kHz (>10 to 30) kHz (>30 to 300) kHz (>0.3 to 1) MHz (>1 to 10) MHz (>10 to 20) MHz (> 20 to 30) MHz (>30 to 50) MHz (>50 to 70) MHz (>70 to 80) MHz (>80 to 100) MHz	0.12 % 0.23 % 0.29 % 0.58 % 0.71 % 0.76 % 1.8 % 2.8 % 3.6 % 3.9 % 4.8 %	Thermal voltage converters
RF Power – Measure[3]			HP EPM-442A (E4419A) w/ E9304A-H18
(-60 to + 20) dBm	9 kHz to 500 MHz (0.5 to 6) GHz (6 to 12) GHz (12 to18) GHz	1.5 % 1.7 % 1.9 % 2.5 %	
(-30 to +20) dBm	(100 to 500) kHz 500 kHz to 1 MHz (1 to 50) MHz (0.05 to 2) GHz (2 to 4.2) GHz	1.7 % 1.7 % 1.5 % 1.6 % 2.0 %	w/ HP 8482A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
RF Power – Measure[3] (cont)			
(-30 to +20) dBm	10 MHz to 2 GHz (2 to 8) GHz (8 to 12) GHz (12 to 14) GHz (14 to 18) GHz	1.5 % 1.7 % 1.7 % 2.0 % 2.0 %	w/ HP 8481A
	50 MHz to 12 GHz (12 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	2.0 % 2.2 % 2.5 % 2.7 % 3.4 %	w/ HP 8487A
(-70 to -20) dBm	(10 to 50) MHz (50 to 100) MHz (0.1 to 2) GHz (2 to 12.4) GHz (12.4 to 18) GHz (18 to 34) GHz (34 to 40) GHz (40 to 50) GHz	2.3 % 1.5 % 1.4 % 1.9 % 2.2 % 3.0 % 3.9 % 5.6 %	w/ HP 8481D w/ HP 8487D
(-35 to 20) dBm	DC to 100 MHz (> 0.10 to 2.4) GHz (> 2.4 to 8) GHz (> 8 to 12.4) GHz (>12.4 to 18) GHz (> 18 to 26.5) GHz (> 26.5 to 33) GHz (> 33 to 40) GHz (> 40 to 44) GHz (>44 to 50) GHz	0.016 dB 0.042 dB 0.064 dB 0.080 dB 0.097 dB 0.097 dB 0.12 dB 0.12 dB 0.14 dB 0.14 dB	R&S NRP50T w/ Power Meter
1.0 mW	@ 50 MHz	0.30 %	HP 432A w/ HP 478A-H76, HP 3458A
RF Power[3] – Generate			
(16 to 24) dBm	(0.2 to 100) kHz (0.1 to 125) MHz	0.023 dB 0.049 dB	Fluke 96270A – leveling head output

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
RF Power[3] – Generate (cont)			
(3 to 16) dBm	(0.2 to 100) kHz (0.1 to 150) MHz (0.15 to 1.4) GHz	0.023 dB 0.050 dB 0.20 dB	Fluke 96270A – leveling head output
(-7 to 3) dBm	(0.2 to 100) kHz (0.1 to 300) MHz (0.3 to 1.4) GHz (1.4 to 4.0) GHz	0.024 dB 0.050 dB 0.17 dB 0.26 dB	
(-47 to -17) dBm	(0.2 to 100) kHz (0.1 to 300) MHz (0.3 to 1.4) GHz (1.4 to 3.5) GHz (3.5 to 4.0) GHz	0.024 dB 0.052 dB 0.17 dB 0.26 dB 0.41 dB	
(-66 to -47) dBm	(0.1 to 10) MHz (10 to 300) MHz (0.3 to 1.4) GHz (1.4 to 4) GHz	0.16 dB 0.089 dB 0.33 dB 0.44 dB	R&S NRP50T w/ Power Meter
(-85 to -66) dBm	(0.1 to 10) MHz (10 to 150) MHz	0.40 dB 0.12 dB	
(-124 to -85) dBm	(0.15 to 1.5) GHz (1.5 to 4) GHz	0.42 dB 0.80 dB	
(10 to -10) dBm[6]	(10 to 100) MHz (0.1to 1.4) GHz	0.71 dB 1.5 dB	
(0 to -10) dBm[6]	10 MHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz	0.62 dB 0.73 dB 1.1 dB 2.5 dB	
(-10 to -60) dBm[6]	10 MHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz	0.92 dB 1.0 dB 1.3 dB 2.2 dB	
(-60 to -90) dBm[6]	10 MHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz	1.4 dB 1.5 dB 1.8 dB 2.6 dB	

Parameter/Range	Frequency	CMC[2,4] (±)	Comments
RF Power[3] – Generate (cont)			
(-35 to 20) dBm	DC to 100 MHz (> 0.10 to 2.4) GHz (> 2.4 to 8) GHz (> 8 to 12.4) GHz (>12.4 to 18) GHz (> 18 to 26.5) GHz (> 26.5 to 33) GHz (> 33 to 40) GHz (> 40 to 44) GHz (>44 to 50) GHz	0.016 dB 0.042 dB 0.064 dB 0.080 dB 0.097 dB 0.097 dB 0.12 dB 0.12 dB 0.14 dB 0.14 dB	R&S NRP50T w/ Power Meter
RF Attenuation – Tuned RF Power Measure[3]			
(0 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB (-70 to -80) dB (-80 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB (-110 to -115) dB (-115 to -120) dB	100 kHz to 10 MHz	0.024 dB 0.029 dB 0.035 dB 0.041 dB 0.047 dB 0.052 dB 0.058 dB 0.064 dB 0.070 dB 0.073 dB 0.085 dB 0.092 dB 0.13 dB 0.21 dB 0.27 dB	Rohde and Schwarz FSMR 50

Parameter/Range	Frequency	CMC[2,4] (±)	Comments
RF Attenuation – Tuned RF Power Measure[3] (cont)			
(0 to -5) dB	10 MHz to 22 GHz	0.019 dB	Rohde and Schwarz FSMR 50
(-5 to -10) dB		0.024 dB	
(-10 to -20) dB		0.029 dB	
(-20 to -30) dB		0.035 dB	
(-30 to -40) dB		0.041 dB	
(-40 to -50) dB		0.047 dB	
(-50 to -60) dB		0.053 dB	
(-60 to -70) dB		0.059 dB	
(-70 to -80) dB		0.065 dB	
(-80 to -85) dB		0.067 dB	
(-85 to -90) dB		0.073 dB	
(-90 to -100) dB		0.082 dB	
(-100 to -105) dB		0.091 dB	
(-105 to -110) dB		0.093 dB	
(-110 to -115) dB		0.22 dB	
(-115 to -120) dB		0.47 dB	
(-120 to -130) dB		1.3 dB	
(0 to -5) dB	(22 to 26.5) GHz	0.28 dB	
(-5 to -10) dB		0.35 dB	
(-10 to -15) dB		0.34 dB	
(-15 to -20) dB		0.30 dB	
(-20 to -25) dB		0.21 dB	
(-25 to -30) dB		0.31 dB	
(-30 to -35) dB		0.26 dB	
(-35 to -40) dB		0.35 dB	
(-40 to -45) dB		0.41 dB	
(-45 to -50) dB		0.35 dB	
(-50 to -55) dB		0.32 dB	
(-55 to -60) dB		0.51 dB	
(-60 to -65) dB		0.38 dB	
(-65 to -70) dB		0.23 dB	
(-70 to -75) dB		0.27 dB	
(-75 to -80) dB		0.34 dB	
(-80 to -85) dB		0.31 dB	
(-85 to -90) dB		0.30 dB	
(-90 to -95) dB		0.27 dB	
(-95 to -100) dB		0.27 dB	
(-100 to -105) dB		0.31 dB	
(-105 to -110) dB		0.45 dB	
(-110 to -115) dB		0.31 dB	
(-115 to -120) dB		2.9 dB	
(-120 to -130) dB		1.3 dB	

Parameter/Range	Frequency	CMC[2,4] (±)	Comments
RF Attenuation – Tuned RF Power Measure[3] (cont)			
(0 to -5) dB	(26.5 to 40) GHz	0.26 dB	Rohde and Schwarz FSMR 50
(-5 to -20) dB		0.39 dB	
(-20 to -25) dB		0.29 dB	
(-25 to -30) dB		0.22 dB	
(-30 to -35) dB		0.44 dB	
(-35 to -40) dB		0.31 dB	
(-40 to -45) dB		0.45 dB	
(-45 to -50) dB		0.61 dB	
(-50 to -55) dB		0.41 dB	
(-55 to -60) dB		0.51 dB	
(-60 to -65) dB		0.41 dB	
(-65 to -70) dB		0.29 dB	
(-70 to -75) dB		0.41 dB	
(-75 to -80) dB		0.42 dB	
(-80 to -85) dB		0.41 dB	
(-85 to -90) dB		0.42 dB	
(-90 to -95) dB		0.40 dB	
(-95 to -100) dB		0.38 dB	
(-100 to -105) dB		0.47 dB	
(-105 to -110) dB		0.55 dB	
(-110 to -115) dB		0.18 dB	
(-115 to -120) dB		0.26 dB	
(0 to -5) dB	(40 to 50) GHz	0.36 dB	
(-5 to -10) dB		0.45 dB	
(-10 to -15) dB		0.44 dB	
(-15 to -20) dB		0.50 dB	
(-20 to -25) dB		0.52 dB	
(-25 to -30) dB		0.51 dB	
(-30 to -35) dB		0.55 dB	
(-35 to -40) dB		0.43 dB	
(-40 to -45) dB		0.49 dB	
(-45 to -50) dB		0.30 dB	
(-50 to -55) dB		0.36 dB	
(-55 to -65) dB		0.44 dB	
(-65 to -70) dB		0.35 dB	
(-70 to -75) dB		0.42 dB	
(-75 to -80) dB		0.36 dB	
(-80 to -85) dB		0.41 dB	
(-85 to -90) dB		0.37 dB	
(-90 to -95) dB		0.38 dB	
(-95 to -100) dB		0.39 dB	
(-100 to -105) dB		0.37 dB	
(-105 to -110) dB		0.35 dB	

Parameter/Range	Frequency	CMC[2,4] (±)	Comments
Modulation – Generate[3]			
AM			
(0 to 99) %	50 Hz to 50 kHz Rate	0.22 %	HP 11715A
(11 to 13.5) MHz	20 Hz to 100 kHz Rate	0.27 %	
FM			
(11 to 108) MHz	<100 kHz Rate	0.43 %	
	<200 kHz Rate	0.42 %	
(352 to 432) MHz	<100 kHz Rate	0.42 %	
	<200 kHz Rate	0.56 %	
Phase Modulation – Measure[3]			
Rate: 50 Hz to 10 kHz	200 kHz to 10 MHz	1.0 %	Rohde and Schwarz FSMR 50
Rate: 50 Hz to 100 kHz	10 MHz to 50 GHz	1.0 %	
Amplitude Modulation – Measure[3]			
Rate: 10 Hz to 10 kHz Depth: (5 to 99) %	(0.1 to 10) MHz	1.5 %	HP 83650B monitored by Rohde and Schwarz FSMR 50
Rate: 10 Hz to 50 kHz Depth: (5 to 99) %	(0.01 to 50) GHz	1.0 %	
Rate: 50 kHz to 100 kHz Depth: (5 to 99) %	(0.01 to 50) GHz	1.5 %	
Rate: 90 Hz to 150 Hz Depth: (5 to 99) %	(0.01 to 50) GHz	0.42 %	
Frequency Modulation – Measure[3]			
Rate: 10 Hz to 10 kHz Dev: ≤ 50 kHz peak	(0.1 to 10) MHz	1.2 %	Rohde and Schwarz FSMR 50
Rate: 10 Hz to 100 kHz Dev: ≤ 500 kHz peak	(0.01 to 50) GHz	1.2 %	
Rate: (100 to 200) kHz Dev: ≤ 500 kHz peak	(0.01 to 50) GHz	3.5 %	

Parameter/Range	Frequency	CMC[2,4] (±)	Comments
Power Sensor and Thermistor Calibration Factor[7]	(100 to <300) kHz (0.3 to <1) MHz (1 to <3000) MHz (3 to 4.2) GHz (>4.2 to <7) GHz (7 to 18) GHz	0.89 % 0.85 % 0.92 % 0.94 % 1.0 % 1.1 %	Weinschel (Tegam) F1116, 1806, 1805B, 1807A, power meter, HP 3458A, and 30 dB attenuator
Digital Modulation – Measure[3] Carrier: 2 MHz to 50 GHz Error Vector Magnitude for Modulation Phase Error for Modulation	 Symbol Rate ≤ 1 MHz ≤ 10 MHz ≤ 15 MHz Symbol Rate ≤ 100 kHz ≤ 1 MHz ≤ 10 MHz < 10 MHz	 0.53 % 1.1 % 2.1 % 0.32° 0.42° 0.64° 1.3°	Rohde and Schwarz FSMR50 Types: 2FSK & 4FSK (include GFSK), BPSK, QPSK (3GPP WCDMA, CDMA2000®), OQPSK, DQPSK, π/4 DQPSK, 8PSK, D8PSK, 3 π/8 8PSK (EDGE), 16QAM, 32QAM, 64QAM, 128QAM, 256 QAM, D16QAM, D32QAM, D64QAM, D128QAM, D256QAM, 8VSB, GSM, NADC, PDC, PHS, Bluetooth®, DECT, TETRA
Reflection Coefficient – Magnitude Into 50 Ω (S_{11}, S_{22})[3] – $0 < \Gamma \leq 0.2$	 30 kHz to 1.3 GHz (1.3 to 3) GHz (3 to 6) GHz (6 to 8) GHz (8 to 20) GHz (20 to 40) GHz	 0.0019 ρ 0.0028 ρ 0.0053 ρ 0.0083 ρ 0.0083 ρ 0.013 ρ	 Agilent 8753ES Agilent 8722ES

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Reflection Coefficient – Magnitude Into 50 Ω (S_{11}, S_{22})[3] – (cont)			
0.2 < Γ < 0.4	30 kHz to 1.3 GHz (1.3 to 3) GHz (3 to 6) GHz (6 to 8) GHz (8 to 20) GHz (20 to 40) GHz	0.0022 ρ 0.0031 ρ 0.0056 ρ 0.0086 ρ 0.0086 ρ 0.013 ρ	Agilent 8753ES Agilent 8722ES
0.4 < Γ ≤ 0.6	30 kHz to 1.3 GHz (1.3 to 3) GHz (3 to 6) GHz (6 to 8) GHz (8 to 20) GHz (20 to 40) GHz	0.0027 ρ 0.0035 ρ 0.0062 ρ 0.0096 ρ 0.0096 ρ 0.015 ρ	Agilent 8753ES Agilent 8722ES
0.6 < Γ ≤ 0.8	30 kHz to 1.3 GHz (1.3 to 3) GHz (3 to 6) GHz (6 to 8) GHz (8 to 20) GHz (20 to 40) GHz	0.0033 ρ 0.0042 ρ 0.0078 ρ 0.012 ρ 0.012 ρ 0.019 ρ	Agilent 8753ES Agilent 8722ES
0.8 < Γ < 1	30 kHz to 1.3 GHz (1,3 to 3) GHz (3 to 6) GHz (6 to 8) GHz (8 to 20) GHz (20 to 40) GHz	0.0040 ρ 0.0050 ρ 0.0091 ρ 0.015 ρ 0.015 ρ 0.026 ρ	Agilent 8753ES Agilent 8722ES
Transmission Coefficient – Magnitude Into 50 Ω (S_{12}, S_{21})[3]			
(-15 to 10) dBm (-25 to 0) dBm (-35 to -10) dBm (-45 to -20) dBm (-55 to -30) dBm (-65 to -40) dBm (-75 to -50) dBm (-85 to -60) dBm	30 kHz to 3 GHz	0.056 dB 0.023 dB 0.034 dB 0.043 dB 0.054 dB 0.066 dB 0.12 dB 0.18 dB	Agilent 8753ES

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Transmission Coefficient Magnitude Into 50 Ω (S12, S21)[3] (cont)			
(-15 to 10) dBm	(3 to 6) GHz	0.08 dB	Agilent 8722ES
(-25 to 0) dBm		0.03 dB	
(-35 to -10) dBm		0.052 dB	
(-45 to -20) dBm		0.076 dB	
(-55 to -30) dBm		0.064 dB	
(-65 to -40) dBm		0.077 dB	
(-75 to -50) dBm		0.161 dB	
(-85 to -60) dBm		0.283 dB	
(10 to 0) dB	50 MHz to 2 GHz	0.041 dB	
(0 to -10) dB		0.044 dB	
(-10 to -20) dB		0.072 dB	
(-20 to -30) dB		0.15 dB	
(-30 to -40) dB		0.37 dB	
(10 to 0) dB	(2 to 8) GHz	0.055 dB	
(0 to -10) dB		0.060 dB	
(-10 to -20) dB		0.074 dB	
(-20 to -30) dB		0.077 dB	
(-30 to -40) dB		0.094 dB	
(10 to 0) dB	(8 to 20) GHz	0.064 dB	
(0 to -10) dB		0.063 dB	
(-10 to -20) dB		0.088 dB	
(-20 to -30) dB		0.084 dB	
(-30 to -40) dB		0.10 dB	
(10 to 0) dB	(20 to 40) GHz	0.12 dB	
(0 to -10) dB		0.12 dB	
(-10 to -20) dB		0.14 dB	
(-20 to -30) dB		0.14 dB	
(-30 to -40) dB		0.19 dB	
Reflection Coefficient Phase Into 50 Ω (S11, S22)[3] – 0 º to 360 º			
0.0 < Γ < 1	30 kHz to 1.2 GHz (1.3 to 3) GHz (3 to 6) GHz	1.2° 1.3° 1.5°	Agilent 8753ES
0.4 < Γ ≤ 1	50 MHz to 20 GHz (20 to 40) GHz	0.91° 1.5°	Agilent 8722ES

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Transmission Coefficient Phase Into 50 Ω (S12, S21) [3] – 0 º to 360 º			
(-15 to 10) dBm (-25 to 0) dBm (-35 to -10) dBm (-45 to -20) dBm (-55 to -30) dBm (-65 to -40) dBm (-75 to -50) dBm (-85 to -60) dBm	30 kHz to 3 GHz	0.66° 0.15° 0.25° 0.32° 0.39° 0.47° 0.63° 1.19°	Agilent 8753ES
(-15 to 10) dBm (-25 to 0) dBm (-35 to -10) dBm (-45 to -20) dBm (-55 to -30) dBm (-65 to -40) dBm (-75 to -50) dBm (-85 to -60) dBm	(3 to 6) GHz	0.75° 0.20° 0.29° 0.35° 0.42° 0.52° 0.78° 1.77°	Agilent 8753ES
(10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB	50 MHz to 2 GHz	0.27° 0.29° 0.47° 0.97°	Agilent 8722ES
(10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB	(2 to 8) GHz	0.36° 0.41° 0.47° 0.52°	
(10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB	(8 to 20) GHz	0.43° 0.45° 0.50° 0.56°	
(10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB	(20 to 40) GHz	0.81° 0.86° 0.90° 0.96°	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Phase Noise – Measure[3]			
(1 to 10) MHz Carrier	1 Hz Offset	2.7 dB	Rohde and Schwarz FSWP50
	10 Hz Offset	2.5 dB	
	100 Hz Offset	1.6 dB	
	1 kHz Offset	1.6 dB	
	10 kHz Offset	1.6 dB	
	100 kHz Offset	1.6 dB	
	1 MHz Offset	4.0 dB	
(10 to 100) MHz	1 Hz Offset	3.7 dB	
	10 Hz Offset	2.8 dB	
	100 Hz Offset	1.6 dB	
	1 kHz Offset	1.6 dB	
	10 kHz Offset	1.6 dB	
	100 kHz Offset	1.6 dB	
	1 MHz Offset	2.7 dB	
	10 MHz Offset	3.3 dB	
	>30 MHz Offset	4.0 dB	
100 MHz to 1 GHz	1 Hz Offset	3.2 dB	
	10 Hz Offset	2.4 dB	
	100 Hz Offset	1.7 dB	
	1 kHz Offset	1.6 dB	
	10 kHz Offset	1.6 dB	
	100 kHz Offset	1.6 dB	
	1 MHz Offset	3.9 dB	
	10 MHz Offset	4.0 dB	
	>30 MHz Offset	4.0 dB	
(1 to 3) GHz	1 Hz Offset	4.2 dB	
	10 Hz Offset	2.0 dB	
	100 Hz Offset	1.6 dB	
	1 kHz Offset	1.6 dB	
	10 kHz Offset	1.6 dB	
	100 kHz Offset	1.6 dB	
	1 MHz Offset	3.8 dB	
	10 MHz Offset	4.4 dB	
	>30 MHz Offset	4.1 dB	
(3 to 7) GHz	1 Hz Offset	4.4 dB	
	10 Hz Offset	2.6 dB	
	100 Hz Offset	1.7 dB	
	1 kHz Offset	1.6 dB	
	10 kHz Offset	1.6 dB	
	100 kHz Offset	1.6 dB	
	1 MHz Offset	3.3 dB	
	10 MHz Offset	3.9 dB	
	>30 MHz Offset	4.6 dB	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Phase Noise – Measure[3] (cont)			
(7 to 10) GHz	1 Hz Offset 10 Hz Offset 100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset >30 MHz Offset	4.4 dB 2.7 dB 1.8 dB 1.6 dB 1.6 dB 1.6 dB 3.5 dB 3.3 dB 4.6 dB	Rohde and Schwarz FSWP50
(10 to 16) GHz	1 Hz Offset 10 Hz Offset 100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset >30 MHz Offset	3.2 dB 2.7 dB 1.7 dB 1.6 dB 1.6 dB 1.6 dB 3.3 dB 4.1 dB 4.0 dB	
(16 to 26.5) GHz	1 Hz Offset 10 Hz Offset 100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset >30 MHz Offset	4.1 dB 2.7 dB 1.7 dB 1.6 dB 1.6 dB 1.6 dB 3.6 dB 4.2 dB 4.0 dB	
(26.5 to 50) GHz	1 Hz Offset 10 Hz Offset 100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset >30 MHz Offset	4.1 dB 2.0 dB 1.8 dB 1.6 dB 1.6 dB 1.6 dB 3.7 dB 3.6 dB 4.4 dB	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Noise Source –			
5 dB and 27 dB Excess Noise Ratio (ENR)	(0.010 to 4) GHz (4 to 5) GHz (5 to 6) GHz (6 to 7) GHz (7 to 8) GHz (8 to 9) GHz (9 to 11) GHz (11 to 14) GHz (14 to 18) GHz (18 to 20) GHz (20 to 21) GHz (21 to 22) GHz (22 to 23) GHz (23 to 24) GHz (24 to 25) GHz (25 to 26.5) GHz	0.23 dB 0.23 dB 0.23 dB 0.23 dB 0.22 dB 0.25 dB 0.25 dB 0.25 dB 0.25 dB 0.25 dB 0.24 dB 0.26 dB 0.29 dB 0.24 dB 0.25 dB 0.25 dB	HP 346C w/ HP 8970B

IV. Mechanical

Parameter/Equipment	Range	CMC[2, 4, 9] (±)	Comments
Force – Compression/Tension[3]	Up to 4 lbf (4 to 40) lbf (40 to 220) lbf	0.017 % 0.028 % 0.031 %	Class F weights
Pressure[3] –			
Hydraulic	(100 to 1000) psig (1000 to 10 000) psig	0.051 % 0.052 %	Deadweight tester
Pneumatic	(0 to 50) psia (0 to 150) psia	0.015 psia 0.047 psia	Heise HQS-2
Pneumatic	(-14.6 to 15) psig (-14.6 to 200) psig (0 to 500) psig (0 to 1500) psig (0 to 3000) psig (0 to 10 000) psig	0.062 % of Span 0.090 % of Span 0.058 % of Span 0.065 % of Span 0.093 % of Span 0.094 % of Span	Fluke Pressure Module: Fluke 700P24EX Fluke 700PD7 Fluke 700P07 Fluke 700P09 Fluke 700P29 Fluke 700P31
Pneumatic	(0 to 10) in·H2O	0.035 % of Span	Fluke 700P01

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Pressure – Pneumatic	(0 to 45) psia (8 to 17) psia (0 to 115) psia (0 to 300) psi (0 to 1000) psi (0 to 3000) psi	0.0026 psia 0.00096 psia 0.0067 psia 0.017 psi 0.058 psi 0.18 psi	Mensor CPC6050
Scales & Balances[3]	(1 to 500) mg 1 g 2 g 3 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 3 kg 5 kg 10-kg 20 kg Up to 50 lb (50 to 100) lb (100 to 250) lb (250 to 500) lb	6.3 µg 21 µg 20 µg 29 µg 40 µg 16 µg 32 µg 58 µg 0.11 mg 0.14 mg 71 µg 87 µg 0.20 mg 1.2 mg 3.0 mg 9.9 mg 18 mg 2.7 g 4.0 g 6.1 g 8.5 g	Ultra-Class weights Class 0 weights Class 1 weights Class F weights
Torque Tools[3]	(1 to 10) in·ozf (10 to 100) in·ozf (5 to 50) in·lbf (40 to 400) in·lbf (100 to 1000) in·lbf (20 to 250) ft·lbf	0.12 % of rdg 0.58 % of rdg 0.30 % of rdg 0.31 % of rdg 0.46 % of rdg 0.43 % of rdg	AWS MTMDP-2S CDI 2000-400-02

V. Thermodynamics

Parameter/Equipment	Range	CMC[2, 4, 9] (±)	Comments
Relative Humidity – Generate	(10 to 14.7) % RH (14.7 to 49) % RH (49 to 73.5) % RH (73.5 to 95) % RH	0.51 % RH 0.54 % RH 0.55 % RH 0.59 % RH	Thunder Scientific 2500ST-LT
Relative Humidity – Measure[3]	(5 to 90) % RH (90 to 97.5) % RH	1.3 % 2.4 %	Vaisala HMI-41 RH meter w/ HMP 46 probe
Temperature – Measure[3]	(-195 to -38) ºC (> -38 to <0) ºC (0 to 100) ºC (> 100 to 200) ºC (> 200 to 420) ºC	0.065 ºC 0.060 ºC 0.014 ºC 0.075 ºC 0.087 ºC	PRT w/ readout Thermistor w/ readout PRT w/ readout
Temperature – Generate[3]	(-95 to 0) ºC (> 0 to 100) ºC (> 100 to 200) ºC (> 200 to 420) ºC (> 420 to 650) ºC	0.060 ºC 0.015 ºC 0.075 ºC 0.087 ºC 1.3 ºC	PRT or thermistor w/ readout and dry well / bath Dry well

VI. Time & Frequency

Parameter/Equipment	Range	CMC[2,4,5,9] (±)	Comments
Frequency – Generate[3]	10 MHz 0.001 Hz to 1 kHz 1 kHz to 20 MHz (0.01 to 50) GHz	0.12 mHz + 0.6*R* 9.9 pHz/Hz 29 pHz/Hz 30 pHz/Hz	Fluke GPS Fluke GPS w/ Tektronix AFG3252C Fluke GPS w/ HP 83650B

Parameter/Equipment	Range	CMC[2,4,5,9] (±)	Comments
Frequency – Measure[3]	0.001 Hz to 1 kHz (1 to 1000) kHz 1 MHz to 12.4 GHz (100 to 500) MHz (0.5 to 45) GHz	0.12 nHz/Hz 0.30 nHz/Hz 0.12 nHz/Hz 2.9 nHz/Hz 63 pHz/Hz + 0.6*R*	Fluke GPS w/ HP 53132A Fluke GPS w/ HP 5352B
RPM – Measuring Equipment[3, 6]	Up to 100 000 RPM	0.0023 RPM + 0.6*R*	Function generator w/ GPS w/ 53132A
Stopwatch and Timers[3]	1 s to 24 hr	0.040 s/day	Timometer 4500, NIST SOP 960-12 7.B.1
Rise/Fall Time[3] – Measure Positive Negative	 17.5 ps to 35 µs 17.5 ps to 35 µs	 13 ps 16 ps	 Agilent 86100A w/ 20 GHz vertical plug-in
Rise/Fall Time[3] – Generate Rep Rate ≥ 2 MHz Rep Rate (2 to 10) MHz	 (200 to 300) ps (250 to 350) ps (125 to 175) ps	 20 ps 20 ps 38 ps	 Fluke 5520A Fluke 9500 w/ 9530 head

VII. Fiber Optics

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Relative Power – Generate and Measure[3] (Attenuation) (750 to 1700) nm	 (0 to -10) dBm (-10 to -20) dBm (-20 to -30) dBm (-30 to -40 dBm (-40 to -50) dBm	 0.010 dB 0.012 dB 0.013 dB 0.013 dB 0.017 dB	 Exfo IQ-1502 w/ FC interface, optical attenuator

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Absolute Power – Measure[3]			Exfo IQ-1502 w/ FC interface
850 nm	100 µW	1.2 %	w/ 62.5/125, 2 m multimode jumper, FC/PC connector
1310 nm	100 µW	1.1 %	w/ 9/125, 2 m single mode jumper, FC/PC connector
1550 nm	100 µW	1.1 %	
(750 to 1000) nm	-10 dBm	0.11 dB	Exfo IQ-1502 w/ FC interface
(1000 to 1700) nm	-10 dBm	0.11 dB	
Wavelength – Generate[3, 6]	(1530 to 1565) nm	0.70 pm	NIST SRM 2519A
	(700 to 1650) nm	3.6 pm	HP 86120C w/ NIST SRM 2519A
Wavelength – Measure[3]	(600 to 1270) nm	0.12 nm	Optical spectrum analyzer
	(1270 to 1650) nm	3.6 pm	HP 86120C

Satellite Facility located at a customer's site:
3135 Quarry Road – Building 3
Telford, PA 18969
Ilamcheran Alvapillai Phone: 215 660 2476

CALIBRATION

I. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Current – Generate			
(1 to 220) µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.70 mA/A + 25 nA 0.33 mA/A + 20 nA 0.13 mA/A + 16 nA 0.55 mA/A + 40 nA 1.4 mA/A + 80 nA	Fluke 5700A
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.67 mA/A + 40 nA 0.34 mA/A + 35 nA 0.16 mA/A + 35 nA 0.55 mA/A + 0.40 µA 1.4 mA/A + 0.80 µA	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.66 mA/A + 0.40 µA 0.33 mA/A + 0.35 µA 0.13 mA/A + 0.35 µA 0.55 mA/A + 4.0 µA 1.4 mA/A + 8.0 µA	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Current – Generate (cont)			
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.67 mA/A + 4.0 µA 0.33 mA/A + 3.5 µA 0.14 mA/A + 3.5 µA 0.55 mA/A + 40 µA 1.4 mA/A + 80 µA	Fluke 5700A
(0.22 to 2.2) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.59 mA/A + 35 µA 0.67 mA/A + 80 µA 7.8 mA/A + 0.16 mA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.41 mA/A + 0.17 mA 0.79 mA/A + 0.38 mA 3.0 mA/A + 0.75 mA	Fluke 5700A w/ 5725A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Current – Generate (cont)			
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.95 mA/A + 3.9 mA 1.2 mA/A + 3.9 mA 23 mA/A + 3.9 mA	Fluke 5520A
(29.0 to 329.99) µA (0.33 to 3.2999) mA (3.3 to 32.999) mA (33 to 329.99) mA	(10 to 30) kHz (10 to 30) kHz (10 to 30) kHz (10 to 30) kHz	12 mA/A + 0.31 µA 7.8 mA/A + 0.47 µA 3.4 mA/A + 3.1 µA 3.1 mA/A + 0.16 mA	
AC Current – Measure			
Up to 100 µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 5 kHz	3.6 mA/A + 23 nA 1.3 mA/A + 23 nA 0.54 mA/A + 23 nA	Agilent 3458A
100 µA to 1 mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	3.3 mA/A + 0.16 µA 1.3 mA/A + 0.16 µA 0.52 mA/A + 0.16 µA 0.25 mA/A + 0.16 µA	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	3.6 mA/A + 1.6 µA 1.3 mA/A + 1.6 µA 0.54 mA/A + 1.6 µA 0.27 mA/A + 1.6 µA	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	17 mA/A + 16 µA 17 mA/A + 16 µA 17 mA/A + 16 µA 10 mA/A + 16 µA	
100 mA to 1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	3.5 mA/A + 0.16 mA 1.3 mA/A + 0.16 mA 0.64 mA/A + 0.16 mA 0.79 mA/A + 0.16 mA	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Generate			
Up to 2.2 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.60 mV/V + 3.9 µV 0.36 mV/V + 3.9 µV 0.32 mV/V + 3.9 µV 0.4 mV/V + 3.9 µV 0.9 mV/V + 6.2 µV 1.2 mV/V + 12 µV 1.5 mV/V + 23 µV 4.5 mV/V + 31 µV	Fluke 5700A
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.47 mV/V + 4.7 µV 0.20 mV/V + 4.7 µV 0.11 mV/V + 4.7 µV 0.32 mV/V + 4.7 µV 0.75 mV/V + 6.2 µV 1.0 mV/V + 12 µV 1.4 mV/V + 23 µV 3.8 mV/V + 31 µV	
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.54 mV/V + 12 µV 0.19 mV/V + 7.8 µV 88 µV/V + 7.8 µV 0.28 mV/V + 7.8 µV 0.70 mV/V + 23 µV 0.86 mV/V + 23 µV 1.4 mV/V + 31 µV 2.8 mV/V + 78 µV	
(0.22 to 2.2) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.63 mV/V + 78 µV 0.14 mV/V + 23 µV 67 µV/V + 5.4 µV 0.11 mV/V + 16 µV 0.23 mV/V + 62 µV 0.38 mV/V + 0.12 mV 0.93 mV/V + 0.31 mV 1.9 mV/V + 0.78 mV	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Generate (cont)			
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.55 mV/V + 0.78 mV 0.14 mV/V + 0.23 mV 67 µV/V + 54 µV 0.11 mV/V + 0.16 mV 0.22 mV/V + 0.31 mV 0.47 mV/V + 1.3 mV 1.1 mV/V + 3.9 mV 2.3 mV/V + 7 mV	Fluke 5700A
(22 to 220) V*	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.59 mV/V + 7.8 mV 0.14 mV/V + 2.3 mV 71 µV/V + 0.78 mV 0.20 mV/V + 3.1 mV 0.47 mV/V + 7.8 mV 1.3 mV/V + 85 mV 4.2 mV/V + 85 mV 11 mV/V + 0.18 V	*Subject to 2.2 x 10^7 V-Hz limitation
(220 to 1100) V	(15 to 50) Hz 50 Hz to 1 kHz	0.36 mV/V + 16 mV 75 µV/V + 3.1 mV	Fluke 5700A
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	78 µV/V + 3.1 mV 0.13 mV/V + 4.7 mV 0.47 mV/V + 8.5 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.47 mV/V + 8.5 mV 1.8 mV/V + 35 mV	
AC Voltage – Measure			
Up to 10 mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz 100 kHz to 1 MHz	0.27 µV/V + 2.3 µV 0.18 µV/V + 0.85 µV 0.25 µV/V + 0.85 µV 0.78 µV/V + 0.85 µV 3.9 µV/V + 0.85 µV 9.3 µV/V + 3.9 µV	HP 3458A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Measure (cont)			
(10 to 100) mV	(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	0.14 µV/V + 3.1 µV 72 nV/V + 1.6 µV 0.12 µV/V + 1.6 µV 0.24 µV/V + 1.6 µV 0.63 µV/V + 1.6 µV 2.3 µV/V + 7.8 µV 7.8 µV/V + 7.8 µV	HP 3458A
(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 (0.2 to 1) MHz	64 µV/V + 31 µV 57 µV/V + 16 µV 0.11 mV/V + 16 µV 0.24 mV/V + 16 µV 0.63 mV/V + 16 µV 2.3 mV/V + 78 µV 7.8 mV/V + 78 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	62 µV/V + 0.31 mV 56 µV/V + 0.16 mV 0.11 mV/V + 0.16 mV 0.24 mV/V + 0.16 mV 0.63 mV/V + 0.16 mV 2.3 mV/V + 0.78 mV 7.8 mV/V + 0.78 mV	
(10 to 100) 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	0.16 mV/V + 3.1 mV 0.16 mV/V + 1.6 mV 0.16 mV/V + 1.6 mV 0.28 mV/V + 1.6 mV 0.93 mV/V + 1.6 mV 3.1 mV/V + 7.8 mV 12 mV/V + 7.8 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	0.32 mV/V + 31 mV 0.31 mV/V + 16 mV 0.47 mV/V + 16 mV 0.93 mV/V + 16 mV 2.3 mV/V + 16 mV	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Capacitance – Generate			
(220 to 399.9) pF	10 Hz to 10 kHz	5.2 mF/F + 7.8 pF	Fluke 5520A
(0.4 to 1.0999) nF	10 Hz to 10 kHz	4.0 mF/F + 7.8 pF	
(1.1 to 3.2999) nF	10 Hz to 3 kHz	4.0 mF/F + 7.8 pF	
(3.3 to 10.9999) nF	10 Hz to 1 kHz	2.1 mF/F + 7.8 pF	
(11 to 32.9999) nF	10 Hz to 1 kHz	2.1 mF/F + 78 pF	
(33 to 109.999) nF	10 Hz to 1 kHz	2.1 mF/F + 78 pF	
(110 to 329.999) nF	10 Hz to 1 kHz	2.1 mF/F + 0.23 nF	
(0.33 to 1.099 99) µF	(10 to 600) Hz	2.1 mF/F + 0.78 nF	
(1.1 to 3.299 99) µF	(10 to 300) Hz	2.1 mF/F + 2.3 nF	
(3.3 to 10.9999) µF	(10 to 150) Hz	2.1 mF/F + 7.8 nF	
(11 to 32.9999) µF	(10 to 120) Hz	3.2 mF/F + 23 nF	
(33 to 109.999) µF	(10 to 80) Hz	3.6 mF/F + 78 nF	
(110 to 329.999) µF	(10 to 50) Hz	3.5 mF/F + 0.23 µF	
(0.33 to 1.099 99) mF	(10 to 20) Hz	3.5 mF/F + 0.78 µF	
(1.1 to 3.299 99) mF	(DC to 6) Hz	3.5 mF/F + 2.3 µF	
(3.3 to 10.9999) mF	(DC to 2) Hz	3.5 mF/F + 7.8 µF	
(11 to 32.9999) mF	(DC to 0.6) Hz	5.8 mF/F + 23 µF	
(33 to 110) mF	(DC to 0.2) Hz	8.5 mF/F + 78 µF	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Current – Generate	Up to 220 µA	39 µA/A + 7.8 nA	Fluke 5700A
	(0.22 to 2.2) mA	39 µA/A + 7.8 nA	
	(2.2 to 22) mA	39 µA/A + 78 nA	
	(22 to 220) mA	47 µA/A + 0.78 µA	
	(0.22 to 2.2) A	64 µA/A + 23 µA	
	(2.2 to 11) A	0.27 mA/A + 0.37 mA	Fluke 5700A w/5725A
	(11 to 20.5) A	0.78 mA/A + 0.58 mA	Fluke 5520A
DC Current – Measure	(0 to 100) nA	66 µA/A + 31 pA	HP 3458A
	(0.1 to 1) µA	32 µA/A + 31 pA	
	(1 to 10) µA	16 µA/A + 78 pA	
	(10 to 100) µA	16 µA/A + 0.62 nA	
	(0.1 to 1) mA	16 µA/A + 3.9 nA	
	(1 to 10) mA	17 µA/A + 39 nA	
	(10 to 100) mA	28 µA/A + 0.39 µA	
	(0.1 to 1) A	87 µA/A + 7.8 µA	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Resistance – Measure	Up to 10 Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ (10 to 100) MΩ (0.1 to 1.2) GΩ	14 μΩ/Ω + 39 μΩ 12 μΩ/Ω + 0.39 mΩ 10 μΩ/Ω + 0.39 mΩ 10 μΩ/Ω + 3.9 mΩ 11 μΩ/Ω + 39 mΩ 16 μΩ/Ω + 1.6 Ω 43 μΩ/Ω + 78 Ω 0.40 mΩ/Ω + 0.78 kΩ 4.8 mΩ/Ω + 7.8 kΩ	HP 3458A
DC Resistance – Generate	(0 to 10.9999) Ω (11 to 32.9999) Ω (33 to 109.9999) Ω (110 to 329.9999) Ω (330 to 1099.999) Ω (1.1 to 3.299 999) kΩ (3.3 to 10.999 99) kΩ (11 to 32.999 99) kΩ (33 to 109.9999) kΩ (110 to 329.9999) kΩ (330 to 1099.999) kΩ (1.1 to 3.299 999) MΩ (3.3 to 10.999 99) MΩ (11 to 32.999 99) MΩ (33 to 109.9999) MΩ (110 to 329.9999) MΩ (330 to 1099.999) MΩ	31 μΩ/Ω + 0.78 mΩ 39 μΩ/Ω + 1.2 mΩ 22 μΩ/Ω + 1.1 mΩ 22 μΩ/Ω + 1.6 mΩ 22 μΩ/Ω + 1.6 mΩ 22 μΩ/Ω + 16 mΩ 22 μΩ/Ω + 16 mΩ 22 μΩ/Ω + 0.16 Ω 22 μΩ/Ω + 0.16 Ω 25 μΩ/Ω + 1.6 Ω 27 μΩ/Ω + 1.6 Ω 59 μΩ/Ω + 23 Ω 0.10 mΩ/Ω + 39 Ω 0.20 mΩ/Ω + 1.9 kΩ 0.39 mΩ/Ω + 2.3 kΩ 2.3 mΩ/Ω + 78 kΩ 12 mΩ/Ω + 0.39 MΩ	Fluke 5520A
DC Resistance – Generate, 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	0.13 mΩ 0.18 mΩ 0.26 mΩ 0.48 mΩ 1.6 mΩ 3.0 mΩ 12 mΩ 23 mΩ 0.11 Ω 0.21 Ω 1.3 Ω 3.0 Ω 50 Ω 60 Ω 0.36 kΩ 0.85 kΩ 10 kΩ	Fluke 5700A

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Voltage – Measure	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1100) V	8.0 µV/V + 0.23 µV 3.2 µV/V + 0.23 µV 3.2 µV/V +0.39 µV 4.7 µV/V + 23 µV 4.8 µV/V + 78 µV	HP 3458A
DC Voltage – Generate	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	7.6 µV/V + 0.62 µV 6.3 µV/V + 0.93 µV 6.2 µV/V + 3.1 µV 6.2 µV/V + 6.2 µV 7.0 µV/V + 78 µV 8.6 µV/V + 0.47 mV	Fluke 5700A
Electrical Calibration of Thermocouple Indicators – Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.27 °C 0.14 °C 0.13 °C 0.20 °C 0.31 °C	Fluke 5520A

[1] This laboratory offers commercial and field calibration service at the main laboratory and the satellite facility listed.

[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. CMC's 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] Field calibration service is available for this calibration. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

[4] 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's 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.

[5] In the statement of CMC, *L* is the numerical value of the nominal length of the device measured in inches. *T* is the numerical value of the nominal temperature of the device measured in degrees Celsius. *R* is the Least Significant Digit of the resolution of the device. In the statement of CMC, percentages are percentage of reading, unless otherwise indicated.

[6] The contributions from the "best existing device" are not included in the CMC claim.

[7] In the statement of CMC, percent is expressed as linear error of reported Cal Factor, where the ideal Cal Factor is 100 %. Number given is the CMC of the highest uncertainty test in the frequency range.

[8] This scope meets A2LA's *P112 Flexible Scope Policy*.

[9] 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

TEKTRONIX, INC.

Sayreville, NJ

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 12th day of February 2021.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2357.17
Valid to March 31, 2023

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