



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017  
& ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3-2006

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CALIBRATION

Valid to: June 30, 2024

Certificate Number: 2357.15

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations<sup>1,6</sup>:

I. Dimensional

Parameter/Equipment	Range	CMC <sup>2,5</sup> (±)	Comments
Micrometers <sup>3</sup> – Length Flatness Parallelism	(0.05 to 4) in (4 to 12) in Up to 1 in Up to 1 in	(30 + 0.76L) μin (24 + 2.3L) μin 8.0 μin 10 μin	Gage blocks Optical flats
Calipers <sup>3</sup>	(0.05 to 4) in (4 to 12) in (12 to 48) in	(58 + 0.51L) μin (60 + 2.9L) μin (83 + 2.4L) μin	Gage blocks
Indicators <sup>3</sup>	(0.05 to 4) in Up to 0.05 in	(30 + 1.0L) μin 36 μin	Gage blocks Calibration tester
Height Gauges & Depth Gauges <sup>3</sup>	Up to 4 in (4 to 48) in	(58 + 0.76L) μin (45 + 3.2L) μin	Gage blocks w/ surface plate
Rulers & Tape Measures <sup>3</sup>	Up to 25 ft	0.0012 in/ft	Microrule
Protractors, Inclinometers & Levels <sup>3</sup>	Up to 90°	0.012°	Sine plate, gage blocks, angle blocks

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Pins & Plugs	Up to 1 in	23 μin	Master pins w/laser micrometer
Linear Displacement <sup>3</sup>	Up to 50 in	0.032 in	TE connectivity PT1E-50-UP-250- AB-TTL-M6 position transducer w/ indicator

## II. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
DC Voltage – Generate <sup>3</sup>	0 V  Up 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	67 nV  8.7 μV/V + 0.39 μV 4.9 μV/V + 0.62 μV 3.3 μV/V + 2.3 μV 3.3 μV/V + 3.9 μV 4.9 μV/V + 39 μV 6.4 μV/V + 0.39 mV	Copper short  Fluke 5720A
DC Voltage – Measure <sup>3</sup>	0 V  Up to 200 mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1050) V  Up to 1 kV <sub>dc</sub> (1 to 10) kV <sub>dc</sub>	67 nV  6 nV/mV + 93 nV 3.6 μV/V + 0.39 μV 3.6 μV/V + 3.9 μV 5.5 μV/V + 39 μV 5.5 μV/V + 0.49 mV  0.16 mV/V 0.16 mV/V	Fluke 8508A w/ short  Fluke 8508A  Fluke 80E

Parameter/Equipment	Range	CMC <sup>2, 4</sup> (±)	Comments
DC Current – Generate <sup>3</sup>	0 A	2.2 pA	OPEN
	(0 to 2) pA (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	23 mA/A + 3.9 fA 23 mA/A + 39 fA 23 mA/A + 0.39 pA 23 mA/A + 3.9 pA 23 mA/A + 6.2 pA 23 mA/A + 39 pA 23 mA/A + 0.39 nA	Fluke 5720A w/ Keithley 5156
	(0 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 (11 to 20.5) A	40 μA/A + 5.4 nA 33 μA/A + 6.2 nA 33 μA/A + 39 nA 42 μA/A + 0.62 μA 74 μA/A + 12 μA 0.28 mA/A + 0.37 mA 0.81 mA/A + 0.58 mA	Fluke 5720A w/ 5725A  Fluke 5522A
Clamp-On Only	(16.5 to 149.999) A (150 to 1025) A	5.1 mA/A + 0.11 mA 4.7 mA/A + 0.39 mA	Fluke 5522A w/5500A/coil
DC Power – Generate <sup>3</sup>	(0.01 to 330) W (0.33 to 2.9) kW (3.0 to 20.5) kW	0.18 mW/W 0.18 mW/W 0.57 mW/W	Fluke 5522A
DC Current – Measure <sup>3</sup>	0 A	2.2 pA	OPEN
	(0 to 200) μA (0.2 to 2) mA (2 to 20) mA (20 to 200) mA (0.2 to 2) A (2 to 20) A (1 to 15) A (15 to 100) A (100 to 300) A (100 to 1000) A	13 pA/μA + 0.31 nA 13 nA/mA + 3.1 nA 14 nA/mA + 31 nA 48 nA/mA + 0.62 μA 0.18 mA/A + 12 μA 0.41 mA/A + 0.31 mA 29 μA/A + 4.7 μA 90 μA/A + 47 μA 0.20 mA/A + 0.14 mA 0.67 mA/A + 0.47 mA	Fluke 8508A  L&N 4360 shunt L&N 4361 shunt L&N 4363 shunt Empro E1500 100

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments	
DC Resistance – Generate <sup>3</sup>	(0 to 10.9999) Ω	33 μΩ/Ω + 0.78 mΩ	Fluke 5522A	
	(11 to 32.9999) Ω	24 μΩ/Ω + 1.2 mΩ		
	(33 to 109.9999) Ω	22 μΩ/Ω + 1.1 mΩ		
	(110 to 329.9999) Ω	22 μΩ/Ω + 1.6 mΩ		
	(0.33 to 1.099 999) kΩ	22 μΩ/Ω + 1.6 mΩ		
	(1.1 to 3.299 999) kΩ	23 μΩ/Ω + 16 mΩ		
	(3.3 to 10.99 999) kΩ	23 μΩ/Ω + 16 mΩ		
	(11 to 32.99 999) kΩ	23 μΩ/Ω + 0.16 Ω		
	(33 to 109.9999) kΩ	23 μΩ/Ω + 0.16 Ω		
	(110 to 329.9999) kΩ	26 μΩ/Ω + 1.6 Ω		
	(0.33 to 1.099 999) MΩ	26 μΩ/Ω + 1.6 Ω		
	(1.1 to 3.299 999) MΩ	48 μΩ/Ω + 23 Ω		
	(3.3 to 10.99 999) MΩ	0.10 mΩ/Ω + 39 Ω		
	(11 to 32.99 999) MΩ	0.21 mΩ/Ω + 1.9 kΩ		
	(33 to 109.9999) MΩ	0.40 mΩ/Ω + 2.3 kΩ		
	(110 to 329.9999) MΩ	2.3 mΩ/Ω + 78 kΩ		
	(330 to 1100) MΩ	12 mΩ/Ω + 0.39 MΩ		PPM R3-1, 110M
(1 to 1000) MΩ	1.2 mΩ/Ω			
Fixed Values	0 Ω	20 μΩ	Copper short	
	1 kΩ	5.8 Ω	Biddle Megadek	
	10 kΩ	58 Ω		
	100 kΩ	0.58 kΩ		
	1 MΩ	5.8 kΩ		
	10 MΩ	58 kΩ		
	100 MΩ	0.58 MΩ		
	1000 MΩ	5.9 MΩ		
	10 GΩ	0.12 GΩ		
	100 GΩ	1.8 GΩ		
	0.001 Ω	0.20 mΩ/Ω		
	0.01 Ω	81 μΩ/Ω	L&N 4361	
	0.1 Ω	37 μΩ/Ω	L&N 4360	
	1 Ω	12 μΩ/Ω	L&N 4020B	
	10 Ω	15 μΩ/Ω	L&N 4025B	
	100 Ω	12 μΩ/Ω	L&N 4030B	
	1 kΩ	12 μΩ/Ω	L&N 4035B	
	10 kΩ	13 μΩ/Ω	L&N 4040B	
	100 kΩ	26 μΩ/Ω	L&N 4045B	
	1 MΩ	27 μΩ/Ω	L&N 4050B	
	1 TΩ	25 mΩ/Ω	Dr. Kamphausen	
	10 TΩ	13 mΩ/Ω	N12 and N13	

Parameter/Equipment	Range	CMC <sup>2, 4</sup> (±)	Comments
DC Resistance – Generate <sup>3</sup> (cont)  Fixed Values	1.9 Ω 19 Ω 190 Ω 1.9 kΩ 19 kΩ 190 kΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	0.18 mΩ 0.44 mΩ 2.0 mΩ 16 mΩ 0.15 Ω 2.7 Ω 60 Ω 4.0 kΩ 8.5 kΩ 26 kΩ	Fluke 5720A
DC Resistance – Measure <sup>3</sup>	(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	19 μΩ/Ω + 3.9 μΩ 9.8 μΩ/Ω + 14 μΩ 7.9 μΩ/Ω + 47 μΩ 8.1 μΩ/Ω + 0.47 mΩ 8.1 μΩ/Ω + 4.7 mΩ 8.3 μΩ/Ω + 47 mΩ 9.8 μΩ/Ω + 0.93 Ω 19 μΩ/Ω + 9.3 Ω 62 μΩ/Ω + 0.93 kΩ 0.16 mΩ/Ω + 93kΩ 0.59 mΩ/Ω + 9.3 MΩ	Fluke 8508A
Rise Time – Generate <sup>3</sup>	1 kHz to 2 MHz (200 to 300) ps  (2 to 10) MHz (200 to 350) ps	19 ps  68 ps	Fluke 5522A- SC1100
Rise Time – Measure <sup>3</sup>	400 ps to 1 μs: Positive Negative	120 ps 180 ps	Tektronix TDS684A

Parameter/Range	Frequency	CMC <sup>2, 4</sup> ( $\pm$ )	Comments
AC Voltage – Generate <sup>3</sup>			
(0.2 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	0.40 mV/V + 3.9 $\mu$ V 0.81 mV/V + 3.9 $\mu$ V 0.27 mV/V + 3.9 $\mu$ V 0.33 mV/V + 3.9 $\mu$ V 0.58 mV/V + 4.7 $\mu$ V 1.3 mV/V + 9.3 $\mu$ V 2.2 mV/V + 19 $\mu$ V 3.7 mV/V + 19 $\mu$ V	Fluke 5720A
(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	0.26 mV/V + 3.9 $\mu$ V 0.13 mV/V + 3.9 $\mu$ V 0.10 mV/V + 3.9 $\mu$ V 0.20 mV/V + 3.9 $\mu$ V 0.48 mV/V + 4.7 $\mu$ V 1.0 mV/V + 9.3 $\mu$ V 1.3 mV/V + 19 $\mu$ V 3.0 mV/V + 19 $\mu$ V	
(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	0.37 mV/V + 12 $\mu$ V 0.10 mV/V + 6.2 $\mu$ V 80 $\mu$ V/V + 6.2 $\mu$ V 0.20 mV/V + 6.2 $\mu$ V 0.47 mV/V + 16 $\mu$ V 0.86 mV/V + 19 $\mu$ V 1.3 mV/V + 23 $\mu$ V 2.7 mV/V + 47 $\mu$ V	
(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	0.50 mV/V + 39 $\mu$ V 86 $\mu$ V/V + 16 $\mu$ V 42 $\mu$ V/V + 7.8 $\mu$ V 72 $\mu$ V/V + 9.3 $\mu$ V 0.13 mV/V + 31 $\mu$ V 0.41 mV/V + 78 $\mu$ V 0.94 mV/V + 0.19 mV 1.6 mV/V + 0.31 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	0.38 mV/V + 0.39 mV 93 $\mu$ V/V + 0.16 mV 42 $\mu$ V/V + 54 $\mu$ V 71 $\mu$ V/V + 93 $\mu$ V 95 $\mu$ V/V + 0.19 mV 0.27 mV/V + 0.62 mV 0.94 mV/V + 1.9 mV 1.6 mV/V + 3.1 mV	

Parameter/Range	Frequency	CMC <sup>2,4</sup> ( $\pm$ )	Comments
AC Voltage – Generate <sup>3</sup> (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	0.44 mV/V + 3.9 mV 90 $\mu$ V/V + 1.6 mV 54 $\mu$ V/V + 0.54 mV 80 $\mu$ V/V + 0.93 mV 0.15 mV/V + 2.3 mV 0.88 mV/V + 16 mV 4.2 mV/V + 39 mV 8.0 mV/V + 78 mV	Fluke 5720A
(220 to 250) V	(15 to 50) Hz	0.34 mV/V + 16 mV	
(220 to 1100) V	50 Hz to 1 kHz	70 $\mu$ V/V + 3.1 mV	
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	73 $\mu$ V/V + 3.1 mV 0.13 mV/V + 4.7 mV 0.47 mV/V + 8.5 mV	Fluke 5720 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	Fluke 5720A wideband output
Wideband – OPT 003			
Up to 1.1 mV	Absolute: 30 Hz to 500 kHz	8 mV/V + 1.6 $\mu$ V	Fluke 5720A wideband output
(1.1 to 3) mV	30 Hz to 500 kHz	6.2 mV/V + 2.3 $\mu$ V	
(3 to 11) mV	30 Hz to 500 kHz	6.1 mV/V + 6.2 $\mu$ V	
(11 to 33) mV	30 Hz to 500 kHz	5.1 mV/V + 12 $\mu$ V	
(33 to 110) mV	30 Hz to 500 kHz	5 mV/V + 31 $\mu$ V	
(110 to 330) mV	30 Hz to 500 kHz	4.1 mV/V + 78 $\mu$ V	
330 mV to 1.1 V	30 Hz to 500 kHz	4.2 mV/V + 0.31 mV	
(1.1 to 3.5) V	30 Hz to 500 kHz	3.2 mV/V + 0.39 mV	
Up to 1.1 mV	Flatness: (10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.4 mV/V 0.86 mV/V 3.9 mV/V + 2.3 $\mu$ V 5.5 mV/V + 2.3 $\mu$ V 7 mV/V + 2.3 $\mu$ V 24 mV/V + 12 $\mu$ V	

Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Voltage – Generate <sup>3</sup> (cont)			
Wideband – OPT 003			
(1.1 to 3) mV	Flatness: (10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.4 mV/V 0.81 mV/V 1.6 mV/V + 2.3 μV 3.1 mV/V + 2.3 μV 4.7 mV/V + 2.3 μV 13 mV/V + 2.3 μV	Fluke 5720A wideband output
(3 to 11) mV	(10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.3 mV/V 0.80 mV/V 1.0 mV/V + 2.3 μV 1.8 mV/V + 2.3 μV 3.5 mV/V + 2.3 μV 8.2 mV/V + 2.3 μV	
(11 to 33) mV	(10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.3 mV/V 0.80 mV/V 0.89 mV/V + 2.3 μV 1.7 mV/V + 2.3 μV 3.3 mV/V + 2.3 μV 8.0 mV/V + 2.3 μV	
(33 to 110) mV	(10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.3 mV/V 0.79 mV/V 0.84 mV/V + 2.3 μV 1.6 mV/V + 2.3 μV 3.3 mV/V + 2.3 μV 7.9 mV/V + 2.3 μV	
(110 to 330) mV	(10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.3 mV/V 0.80 mV/V 0.82 mV/V + 2.3 μV 1.6 mV/V + 2.3 μV 3.2 mV/V + 2.3 μV 7.9 mV/V + 2.3 μV	



Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments
AC Voltage – Generate <sup>3</sup> (cont)			
330 mV to 1.1 V	(10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.3 mV/V 0.79 mV/V 0.81 mV/V + 2.3 μV 1.6 mV/V + 2.3 μV 3.2 mV/V + 2.3 μV 7.9 mV/V + 2.3 μV	Fluke 5720A wideband output
(1.1 to 3.5) V	(10 to 30) Hz 30 Hz to 120 kHz (0.12 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	2.3 mV/V 0.79 mV/V 0.81 mV/V + 2.3 μV 1.6 mV/V + 2.3 μV 3.2 mV/V + 2.3 μV 7.9 mV/V + 2.3 μV	
AC Voltage – Measure <sup>3</sup>			
(0 to 200) mV	(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	0.33 mV/V + 12 μV 0.11 mV/V + 3.9 μV 0.10 mV/V + 3.9 μV 0.10 mV/V + 1.9 μV 0.10 mV/V + 3.9 μV 0.27 mV/V + 7.8 μV 0.59 mV/V + 19 μV	Fluke 8508A
(0 to 100) mV	(100 to 300) kHz (0.3 to 1) MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	3.1 mV/V + 7.8 μV 10 mV/V + 7.8 μV 41 mV/V + 54 μV 41 mV/V + 62 μV 15 % + 78 μV	HP 3458A
(0.2 to 2) 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	0.47 mV/V + 93 μV 0.10 mV/V + 19 μV 92 μV/V + 19 μV 63 μV/V + 19 μV 78 μV/V + 19 μV 0.20 mV/V + 39 μV 0.46 mV/V + 0.19 mV 2.4 mV/V + 1.9 mV 8.1 mV/V + 19 mV	Fluke 8508A

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
AC Voltage – Measure <sup>3</sup> (cont)			
(0.1 to 1) V	(1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	41 mV/V + 0.54 mV 41 mV/V + 0.62 mV 15 % + 0.78 mV	Fluke 3458A
(2 to 20) 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	0.33 mV/V + 0.93 mV 0.10 mV/V + 0.19 mV 78 μV/V + 0.19 mV 63 μV/V + 0.19 mV 78 μV/V + 0.19 mV 0.19 mV/V + 0.39 mV 0.44 mV/V + 1.9 mV 2.4 mV/V + 19 mV 8.1 mV/V + 0.19 V	Fluke 8508A
(1 to 10) V	(1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	41 mV/V + 5.4 mV 41 mV/V + 6.2 mV 15 % + 7.8 mV	HP 3458A
(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	0.41 mV/V + 9.3 mV 0.10 mV/V + 1.9 mV 80 μV/V + 1.9 mV 69 μV/V + 1.9 mV 83 μV/V + 1.9 mV 0.19 mV/V + 3.9 mV 0.45 mV/V + 19 mV 2.4 mV/V + 0.19 V 8.1 mV/V + 1.9 V	Fluke 8508A
(200 to 1050) V	(1 to 10) Hz (10 to 40) Hz (0.04 to 10) kHz (10 to 20) kHz (20 to 100) kHz	0.23 mV/V + 8.1 mV 0.11 mV/V + 20 mV 89 μV/V + 20 mV 0.37 mV/V + 41 mV 0.57 mV/V + 0.20 V	
(0 to 6) kV	DC to 500 Hz	7.8 mV/V	Fluke 80K-6

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
AC Current – Generate <sup>3</sup>			
(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 (10 to 30) kHz	0.39 mA/A + 16 nA 0.17 mA/A + 9.3 nA 0.12 mA/A + 7.8 nA 0.32 mA/A + 12 nA 1.0 mA/A + 62 nA 12 mA/A + 0.31 µA	Fluke 5720A     Fluke 5522A
(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 (10 to 30) kHz	0.35 mA/A + 39 nA 0.18 mA/A + 31 nA 0.15 mA/A + 31 nA 0.22 mA/A + 0.10 µA 1.0 mA/A + 0.62 µA 7.8 mA/A + 0.47 µA	Fluke 5720A     Fluke 5522A
(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 (10 to 30) kHz	0.36 mA/A + 0.39 µA 0.16 mA/A + 0.31 µA 0.12 mA/A + 0.31 µA 0.20 mA/A + 0.54 µA 1.0 mA/A + 4.7 µA 3.2 mA/A + 3.1 µA	Fluke 5720A     Fluke 5522A
(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 (10 to 30) kHz	0.37 mA/A + 3.9 µA 0.16 mA/A + 3.1 µA 0.12 mA/A + 2.3 µA 0.20 mA/A + 3.1 µA 1.0 mA/A + 9.3 µA 3.2 mA/A + 0.16 mA	Fluke 5720A     Fluke 5522A
(0.22 to 2.2) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.26 mA/A + 31 µA 0.41 mA/A + 78 µA 6.3 mA/A + 0.16 mA	Fluke 5720A
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.39 mA/A + 0.13 mA 0.76 mA/A + 0.29 mA 2.8 mA/A + 0.58 mA	Fluke 5720A w/ 5725A
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.96 mA/A + 3.9 mA 1.2 mA/A + 3.9 mA 23 mA/A + 3.9 mA	Fluke 5522A

Parameter/Range	Frequency	CMC <sup>2, 4, 5</sup> (±)	Comments
AC Current – Generate <sup>3</sup> (cont)			
Clamp-On Only (16.5 to 149.999) A	(45 to 65) Hz	0.32 %	Fluke 5522A w/ 5500A/coil
(16.5 to 149.999) A	(65 to 440) Hz	0.66 %	
(150 to 1025) A	(45 to 65) Hz	0.32 %	
(150 to 1025) A	(65 to 440) Hz	0.66 %	
AC Current – Measure <sup>3</sup>			
Up to 200 µA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.69 mA/A + 19 nA 0.33 mA/A + 19 nA 0.63 mA/A + 19 nA 3.1 mA/A + 19 nA	Fluke 8508A
(0.2 to 2) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.59 mA/A + 0.19 µA 0.33 mA/A + 0.19 µA 0.61 mA/A + 0.19 µA 3.2 mA/A + 0.19 µA	
(2 to 20) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.57 mA/A + 1.9 µA 0.29 mA/A + 1.9 µA 0.61 mA/A + 1.9 µA 5.0 mA/A + 1.9 µA	
(20 to 200) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.58 mA/A + 19 µA 0.26 mA/A + 19 µA 0.88 mA/A + 19 µA	
(0.2 to 2) A	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.57 mA/A + 0.19 mA 0.82 mA/A + 0.19 mA 2.4 mA/A + 0.19 mA	
(2 to 20) A	10 Hz to 2 kHz (2 to 10) kHz	0.93 mA/A + 1.9 mA 2.1 mA/A + 1.9 mA	

Parameter/Range	Frequency	CMC <sup>2, 4, 5</sup> (±)	Comments
AC Power – Generate <sup>3</sup>  33 mV to 1020 V	(45 to 65) Hz, PF = 1 109 μW to 1 mW (1 to 4) mW (4 to 11) mW (11 to 40) mW (40 to 396) mW 396 mW to 11 W (11 to 264) W 264 W to 3 kW (3 to 21) kW	2.3 mW/W 1.4 mW/W 1.1 mW/W 1.3 mW/W 1.0 mW/W 1.0 mW/W 0.94 mW/W 0.96 mW/W 0.81 mW/W	Fluke 5522A
AC Level Flatness – Measure <sup>3</sup> , (1, 3, 6) V	10 Hz 100 Hz 1 kHz 10 kHz 30 kHz 100 kHz 300 kHz 1 MHz 3 MHz 8 MHz 10 MHz 20 MHz 30 MHz 50 MHz 70 MHz 80 MHz 100 MHz	0.13 % 0.12 % 0.12 % 0.12 % 0.24 % 0.30 % 0.30 % 0.58 % 0.70 % 0.71 % 0.71 % 0.76 % 1.8 % 2.8 % 3.6 % 3.9 % 4.8 %	Thermal converters 1395A w/ HP 3458A & Fluke 5700A

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
AC Resistance – Generate <sup>3</sup> , Fixed Values			
10 Ω	DC 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	4.0 mΩ 5.0 mΩ 5.0 mΩ 6.0 mΩ 7.0 mΩ 20 mΩ 41 mΩ	HP 42030 resistor set
100 Ω	DC 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	41 mΩ 40 mΩ 46 mΩ 46 mΩ 43 mΩ 83 mΩ 93 mΩ	
1 kΩ	DC to 3 MHz (3 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.33 Ω 0.51 Ω 2.0 Ω 3.0 Ω	
10 kΩ	DC to 1 MHz	3.2 Ω	
100 kΩ	DC to 1 MHz	46 Ω	

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
Capacitance – Generate <sup>3</sup> , Fixed Values			
0 F		24 pF	OPEN
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	0.40 fF 0.41 fF 0.46 fF 0.57 fF 0.74 fF 0.98 fF 2.7 fF 4.0 fF	HP 16380A standard capacitor
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 3.6 fF 4.2 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 37 fF 37 fF 38 fF 40 fF 52 fF 64 fF	
1000 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	0.35 pF 0.35 pF 0.38 pF 0.45 pF 0.57 pF 0.72 pF 2.0 pF 2.9 pF	

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
Capacitance – Generate <sup>3</sup> , Fixed Values (cont)			
10 nF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.72 pF 0.72 pF 0.73 pF 0.75 pF	HP 16380C standard capacitor
100 nF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	7.2 pF 7.2 pF 7.3 pF 9.3 pF	
1 µF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	77 pF 71 pF 71 pF 0.59 nF	
(0.19 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF (0.33 to 1.1) µF (1.1 to 3.29) µF (3.3 to 11) µF (11 to 33) µF (33 to 110) µF (110 to 330) µF (0.33 to 1.1) mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	10 Hz to 10 kHz 10 Hz to 3 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 (10 to 50) Hz (10 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	1.4 pF/nF + 7.8 pF 4.1 pF/nF + 7.8 pF 2.0 pF/nF + 7.8 pF 2.0 pF/nF + 78 pF 2.1 pF/nF + 0.23 nF 2.0 nF/µF + 0.78 nF 2.0 nF/µF + 2.3 nF 2.1 nF/µF + 7.8 nF 3.2 nF/µF + 23 nF 3.7 nF/µF + 78 nF 3.7 nF/µF + 0.23 µF 3.7 µF/mF + 0.78 µF 3.5 µF/mF + 2.3 µF 3.5 µF/mF + 7.8 µF 5.8 µF/mF + 23 µF 8.5 µF/mF + 78 µF	Quadtech 1413 Fluke 5522A



Parameter/Range	Frequency	CMC <sup>2,4</sup> (±)	Comments	
Dissipation Factor <sup>3</sup> , Fixed Values	1 pF, (0 to 0.01) D	100 Hz to 1 kHz	0.000 021 D	HP 16380A standard capacitor, D = Dissipation factor
		1 kHz to 1 MHz	0.000 031 D	
		(1 to 2) MHz	0.000 06 D	
		(2 to 3) MHz	0.000 091 D	
		(3 to 4) MHz	0.000 14 D	
		(4 to 5) MHz	0.0002 D	
		(5 to 10) MHz	0.000 57 D	
	10 pF, (0 to 0.01) D	100 Hz to 1 kHz	0.000 021 D	
		1 kHz to 1 MHz	0.000 021 D	
		(1 to 2) MHz	0.000 024 D	
		(2 to 3) MHz	0.000 023 D	
		(3 to 4) MHz	0.000 024 D	
		(4 to 5) MHz	0.000 032 D	
		(5 to 10) MHz	0.000 079 D	
	100 pF, (0 to 0.01) D	100 Hz to 1 kHz	0.000 021 D	
		1 kHz to 1 MHz	0.000 021 D	
		(1 to 2) MHz	0.000 021 D	
		(2 to 3) MHz	0.000 031 D	
		(3 to 4) MHz	0.000 05 D	
		(4 to 5) MHz	0.000 06 D	
		(5 to 10) MHz	0.000 16 D	
	1000 pF, (0 to 0.01) D	100 Hz to 1 kHz	0.000 021 D	
		1 kHz to 1 MHz	0.000 032 D	
		(1 to 2) MHz	0.000 065 D	
		(2 to 3) MHz	0.000 11 D	
		(3 to 4) MHz	0.000 17 D	
		(4 to 5) MHz	0.000 23 D	
		(5 to 10) MHz	0.000 64 D	
(10 to 13) MHz	0.000 94 D			

Parameter/Range	Frequency	CMC <sup>2, 4</sup> (±)	Comments
Dissipation Factor <sup>3</sup> , Fixed Values (cont)			
10 nF (0 to 0.01) D	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.000 023 D 0.000 021 D 0.000 021 D 0.000 024 D	HP 16380A standard capacitor, D = Dissipation factor
100 nF (0 to 0.01) D	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.000 031 D 0.000 021 D 0.000 021 D 0.000 076 D	
1 μF (0 to 0.01) D	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.000 044 D 0.000 021 D 0.000 04 D 0.000 13 D	
Inductance – Generate <sup>3</sup> , Fixed Values			
1 mH	100 Hz, 1 kHz	0.68 μH	GenRad 1482E
10 mH	100 Hz, 1 kHz	6.3 μH	GenRad 1482H
100 mH	100 Hz, 1 kHz	45 μH	GenRad 1482L
1 H	100 Hz, 1 kHz	0.91 mH	GenRad 1482P
10 H	100 Hz 1 kHz	9.2 mH 74 mH	GenRad 1482T
Distortion – Measure <sup>3</sup>			
(-99.9 to 0) dBm	20 Hz to 20 kHz (20 to 100) kHz	1.3 dB 2.3 dB	HP 8903B

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouple Indicators <sup>3</sup> –			
Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1820) °C	0.34 °C 0.27 °C 0.24 °C 0.26 °C	Fluke 5522A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.24 °C 0.21 °C 0.25 °C 0.39 °C 0.65 °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 0.17 °C	
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.25 °C 0.13 °C 0.12 °C 0.14 °C 0.18 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.26 °C 0.14 °C 0.13 °C 0.20 °C 0.31 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.31 °C 0.17 °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	0.45 °C 0.28 °C 0.26 °C 0.32 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.38 °C 0.28 °C 0.29 °C 0.36 °C	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouple Indicators <sup>3</sup> – (cont)			
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.50 °C 0.19 °C 0.13 °C 0.11 °C	Fluke 5522A
Type U	(-200 to 0) °C (0 to 600) °C	0.44 °C 0.21 °C	
Electrical Calibration of RTDs <sup>3</sup> –			
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 °C 0.12 °C 0.12 °C 0.11 °C 0.097 °C 0.11 °C 0.20 °C	Fluke 5522A
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 °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	0.21 °C 0.060 °C 0.068 °C 0.070 °C 0.077 °C 0.084 °C 0.090 °C 0.13 °C 0.19 °C	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of RTDs <sup>3</sup> (cont) –			
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 °C 0.11 °C 0.13 °C	Fluke 5522A
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	
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	
PtNi 385, 120 Ω	(-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	

Parameter/Equipment	Frequency	CMC <sup>2,4</sup> (±)	Comments
Phase – Generate <sup>3</sup> , (0 to 180)°	(10 to 65) Hz (65 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.093° 0.20° 0.39° 2.0° 3.9° 7.8°	Fluke 5522A

Parameter/Range	Frequency	CMC <sup>2, 4, 5</sup> ( $\pm$ )	Comments
Phase – Measure <sup>3</sup> (-180 to +360) <sup>o</sup>	Up to 225 MHz	0.025 <sup>o</sup>	HP 53131A
Oscilloscope – Amplitude – DC <sup>3</sup> 50 $\Omega$ 1 M $\Omega$	(-6.6 to 6.6) V (-130 to 130) V	2.0 mV/V + 31 $\mu$ V 0.40 mV/V + 31 $\mu$ V	Fluke 5522A/SC1100
Amplitude – Square Wave <sup>3</sup> 50 $\Omega$	$\pm 1$ mV to $\pm 6.6$ V <sub>(p-p)</sub> 10 Hz to 10 kHz	2.0 mV/V + 31 $\mu$ V	
Amplitude – Square Wave <sup>3</sup> 1 M $\Omega$	$\pm 1$ mV to $\pm 6.6$ V <sub>(p-p)</sub> 10 Hz to 1 kHz	0.78 mV/V + 31 $\mu$ V	
Time Marker <sup>3</sup>	5 s to 50 ms 20 ms to 1 ns	(19 + 39 <i>t</i> ) $\mu$ s/s 2.0 $\mu$ s/s	<i>t</i> is time in seconds
Non-Cardinal Points	< 20 ms	39 $\mu$ s/s	
Rise Time <sup>3</sup>	1 kHz to 2 MHz (200 to 300) ps	19 ps	
	(2 to 10) MHz (200 to 350) ps	68 ps	
Bandwidth <sup>3</sup> 50 kHz Reference	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	3.0 % 3.1 % 4.1 % 4.8 %	
Bandwidth w/ Power Sensor, 10 MHz Reference	(1.1 to 18) GHz	9.1 %	Keysight E4419B, 8481A, 11667B, 83630B

III. Electrical – RF/Microwave

Parameter/Equipment	Frequency	CMC <sup>2,7</sup> ( $\pm$ )	Comments
LISN –			
Insertion Loss	100 kHz to 100 MHz (100 to 400) MHz	0.12 dB 0.12 dB	CISPR 25, CISPR 16-1-2, HP 4195A
Impedance – Magnitude	(100 to 700) kHz 700 kHz to 100 MHz (100 to 400) MHz	0.47 $\Omega$ 1.0 $\Omega$ 1.9 $\Omega$	
Impedance – Phase	100 kHz to 200 MHz (200 to 400) MHz	6.2° 8.9°	
Decoupling Isolation	100 kHz to 200 MHz (200 to 400) MHz	0.27 dB 0.27 dB	
VSWR – Measure			
50 Ohms SWR < -3.5 dBm	(5 to 500) MHz (0.5 to 2) GHz	0.016 $\Gamma$ 0.017 $\Gamma$	Wiltron 60A50 w/ Agilent 8663A, HP8563E
SWR > -3.5 dBm	(5 to 500) MHz (0.5 to 2) GHz	0.042 $\Gamma$ 0.043 $\Gamma$	
$0 < \rho \leq 0.0476$	(50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0040 $\rho$ 0.0043 $\rho$ 0.0065 $\rho$ 0.0065 $\rho$	HP 8720C w/ 85052B
$0.0476 < \rho \leq 0.1111$	(50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0041 $\rho$ 0.0043 $\rho$ 0.0066 $\rho$ 0.0066 $\rho$	
$0.1111 < \rho \leq 0.200$	(50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0042 $\rho$ 0.0045 $\rho$ 0.0067 $\rho$ 0.0067 $\rho$	
$0.200 < \rho \leq 0.3333$	(50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0046 $\rho$ 0.0048 $\rho$ 0.0072 $\rho$ 0.0075 $\rho$	

Parameter/Equipment	Frequency	CMC <sup>2,7</sup> ( $\pm$ )	Comments
VSWR – Measure (cont)			
$0.3333 < \rho \leq 0.500$	(50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0056 $\rho$ 0.0058 $\rho$ 0.0091 $\rho$ 0.010 $\rho$	HP 8720C w/ 85052B
Reflection Magnitude – (Into 50 $\Omega$ )			
$0 < \Gamma \leq 0.2$	9 kHz to 50 MHz (50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0052 $\Gamma$ 0.0042 $\Gamma$ 0.0045 $\Gamma$ 0.0067 $\Gamma$ 0.0067 $\Gamma$	HP 4195A HP 8720C
$0.2 < \Gamma \leq 0.4$	9 kHz to 50 MHz (50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0052 $\Gamma$ 0.0049 $\Gamma$ 0.0051 $\Gamma$ 0.0078 $\Gamma$ 0.0083 $\Gamma$	HP 4195A HP 8720C
$0.4 < \Gamma \leq 0.6$	9 kHz to 50 MHz (50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0052 $\Gamma$ 0.0065 $\Gamma$ 0.0066 $\Gamma$ 0.011 $\Gamma$ 0.013 $\Gamma$	HP 4195A HP 8720C
$0.6 < \Gamma \leq 0.8$	9 kHz to 50 MHz (50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0052 $\Gamma$ 0.0089 $\Gamma$ 0.0090 $\Gamma$ 0.016 $\Gamma$ 0.020 $\Gamma$	HP 4195A HP 8720C
$0.8 < \Gamma \leq 1.0$	9 kHz to 50 MHz (50 to 500) MHz (0.5 to 2) GHz (2 to 8) GHz (8 to 20) GHz	0.0052 $\Gamma$ 0.012 $\Gamma$ 0.012 $\Gamma$ 0.024 $\Gamma$ 0.030 $\Gamma$	HP 4195A HP 8720C



Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments	
Transmission Magnitude – (Into 50 Ω)	9 kHz to 50 MHz	(10 to 0) dB	0.34 dB	HP 4195A
		(0 to -10) dB	0.21 dB	
		(-10 to -20) dB	0.18 dB	
		(-20 to -30) dB	0.49 dB	
		(-30 to -40) dB	0.29 dB	
		(-40 to -50) dB	0.77 dB	
		(-50 to -60) dB	0.80 dB	
		(-60 to -70) dB	0.70 dB	
	50 MHz to 0.5 GHz	(10 to 0) dB	0.34 dB	HP 8720C
		(0 to -10) dB	0.21 dB	
		(-10 to -20) dB	0.18 dB	
		(-20 to -30) dB	0.49 dB	
		(-30 to -40) dB	0.34 dB	
		(-40 to -50) dB	0.90 dB	
		(-50 to -60) dB	0.94 dB	
		(-60 to -70) dB	1.0 dB	
	(0.5 to 2.0) GHz	(10 to 0) dB	0.34 dB	
		(0 to -10) dB	0.21 dB	
		(-10 to -20) dB	0.18 dB	
		(-20 to -30) dB	0.49 dB	
		(-30 to -40) dB	0.29 dB	
		(-40 to -50) dB	0.77 dB	
		(-50 to -60) dB	0.83 dB	
		(-60 to -70) dB	0.96 dB	
	(2.0 to 8.0) GHz	(10 to 0) dB	0.34 dB	
		(0 to -10) dB	0.22 dB	
		(-10 to -20) dB	0.19 dB	
		(-20 to -30) dB	0.49 dB	
		(-30 to -40) dB	0.30 dB	
		(-40 to -50) dB	0.77 dB	
		(-50 to -60) dB	0.83 dB	
		(-60 to -70) dB	0.88 dB	

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
Transmission Magnitude – (Into 50 Ω) (cont)  (10 to 0) dB (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	(8.0 to 20) GHz	0.35 dB 0.23 dB 0.20 dB 0.49 dB 0.31 dB 0.77 dB 0.85 dB 1.2 dB	HP 8720C
Reflection Phase – (Into 50 Ω, 0° to 360°)  0.0 < $\Gamma$ ≤ 0.4  0.0 < $\Gamma$ ≤ 0.2 0.2 < $\Gamma$ ≤ 0.4  0.0 < $\Gamma$ ≤ 0.2 0.2 < $\Gamma$ ≤ 0.4	9 kHz to 50 MHz  (0.05 to 2.0) GHz  (2.0 to 20) GHz	0.88 °  1.2 ° 0.71 °  1.9 ° 1.2 °	HP 4195A  HP 8720C
Transmission Phase – (Into 50 Ω, 0° to 360°)  (10 to 0) dB (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  (10 to 0) dB (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	9 kHz to 50 MHz  50 MHz to 0.5 GHz	1.1 ° 0.82 ° 3.5 ° 2.4 ° 2.9 ° 1.8 ° 2.7 ° 2.5 °  1.1 ° 0.81 ° 3.5 ° 2.4 ° 3.1 ° 4.0 ° 12 ° 38 °	HP 4195A  HP 8720C

Parameter/Equipment	Frequency	CMC <sup>2,7</sup> (±)	Comments
Transmission Phase – (Into 50 Ω, 0° to 360°) (cont)			
(10 to 0) dB (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	(0.5 to 2.0) GHz	1.1 ° 0.81 ° 3.5 ° 2.4 ° 2.9 ° 1.9 ° 3.0 ° 5.4 °	HP 8720C
(10 to 0) dB (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	(2.0 to 8.0) GHz	1.2 ° 0.91 ° 3.5 ° 2.4 ° 2.9 ° 1.9 ° 2.9 ° 4.7 °	
(10 to 0) dB (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	(8.0 to 20) GHz	1.3 ° 1.1 ° 3.5 ° 2.4 ° 3.0 ° 2.0 ° 3.4 ° 7.2 °	
RF Power – Generate <sup>3</sup>			
(13.52 to 24) dBm (-56 to 13.52) dBm	DC to 20 MHz	0.37 dB 0.42 dB	HP 3325A, w/8482A on 438A
(-60 to 13) dBm (-120 to -60) dBm	(0.01 to 26.5) GHz	2.2 dB 2.6 dB	HP 83630B w/11792A on 8902A

Parameter/Equipment	Frequency	CMC <sup>2, 5, 7</sup> ( $\pm$ )	Comments
RF Power – Measure <sup>3</sup>			
Reference – 1 mW	50 MHz	0.33 %	HP478A H75
(-30 to +20) dBm	100 kHz to 2.6 GHz	1.5 %	HP 8902A w/: 11722A
(-30 to +20) dBm	50 MHz to 2 GHz	1.7 %	
	(2 to 18) GHz	3.1 %	
	(18 to 26.5) GHz	3.5 %	
(-30 to +20) dBm	50 MHz to 12 GHz	2.3 %	HP 8485A w/ 438A
	(12 to 18) GHz	3.1 %	
	(18 to 26.5) GHz	3.5 %	
RF Attenuation – Tuned RF Power Measure <sup>3</sup>			
(0 to -10) dB	150 kHz to 1.3 GHz	0.064 dB	HP 8902A w/: HP 11722A
(-10 to -20) dB		0.067 dB	
(-20 to -30) dB		0.069 dB	
(-30 to -40) dB		0.082 dB	
(-40 to -50) dB		0.10 dB	
(-50 to -60) dB		0.10 dB	
(-60 to -70) dB		0.11 dB	
(-70 to -80) dB		0.11 dB	
(-80 to -90) dB		0.14 dB	
(-90 to -100) dB		0.14 dB	
(-100 to -110) dB		0.15 dB	
(-110 to -120) dB		0.18 dB	
(0 to -10) dB	(1.3 to 26.5) GHz	0.064 dB	HP 11792A or HP 11793A
(-10 to -20) dB		0.067 dB	
(-20 to -30) dB		0.080 dB	
(-30 to -40) dB		0.082 dB	
(-40 to -50) dB		0.10 dB	
(-50 to -60) dB		0.10 dB	
(-60 to -70) dB		0.11 dB	
(-70 to -80) dB		0.11 dB	
(-80 to -85) dB		0.14 dB	

Parameter/Equipment	Frequency	CMC <sup>2, 5, 7</sup> (±)	Comments
Phase Modulation – Measure <sup>3</sup>  Rate: 200 Hz to 10 kHz Rate: 200 Hz to 20 kHz	150 kHz to 10 MHz 10 MHz to 26.5 GHz	3.5 % + 1 LSD 3.5 % + 1 LSD	HP 8902A w/: 11722A/11792A /11793A
Amplitude Modulation – Measure <sup>3</sup>  Depths: 5 % to 99 % Rate: 50 Hz to 10 kHz Rate: 50 Hz to 50 kHz  Depths: 5 % to 99 % Rate: 20 Hz to 10 kHz Rate: 20 Hz to 100 kHz	150 kHz to 10 MHz 10 MHz to 1.3 GHz (1.3 to 26.5) GHz  150 kHz to 10 MHz 10 MHz to 1.3 GHz (1.3 to 26.5) GHz	2.4 % + 1 LSD 1.2 % + 1 LSD 1.8 % + 1 LSD  3.5 % + 1 LSD 3.5 % + 1 LSD 3.5 % + 1 LSD	HP 8902A w/ 11722A/11793A/ 11792A
Frequency Modulation – Measure <sup>3</sup>  Dev.: ≤ 40 kHz peak Rate: 20 Hz to 10 kHz  Dev.: ≤ 400 kHz peak Rate: 50 Hz to 100 kHz Rate: 20 Hz to 200 kHz  Rate: 50 Hz to 100 kHz Rate: 20 Hz to 200 kHz	250 kHz to 10 MHz  10 MHz to 1.3 GHz  (1.3 to 26.5) GHz	2.3 % + 1 LSD  1.2 % + 1 LSD 5.8 % + 1 LSD  1.2 % + 1 LSD 5.8 % + 1 LSD	HP 8902A w/: 11722A/11793A/ 11792A
Average Noise & Residuals (DANL) <sup>3</sup>	20 Hz to 26.5 GHz, (-30 to -170) dBm	0.76 dB	50 Ω load

Parameter/Range	Frequency	CMC <sup>2,7</sup> ( $\pm$ )	Comments
Phase Noise – Measure <sup>3</sup>			
Carrier Frequency: (10 to 100) MHz (-66 to -175) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 2.1 dB	HP 8563E
100 MHz to 1 GHz (-46 to -173) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 3.6 dB	
(1 to 3) GHz (+10 to -170) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 3.5 dB	
(3 to 7) GHz (+17 to -166) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 2.9 dB	
(7 to 10) GHz (+20 to -175) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 3.1 dB	
(10 to 16) GHz (+24 to -171) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 2.8 dB	
(16 to 26.5) GHz (+28 to -167) dBc	1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset	1.1 dB 1.1 dB 1.1 dB 3.2 dB	
2 <sup>nd</sup> Harmonic Distortion <sup>3</sup>	200 Hz to 20 MHz (0 to -120) dB	2.8 dB	HP 8360B
	20 MHz to 26.5 GHz (0 to -120) dB	3.7 dB	

IV. Mechanical

Parameter/Equipment	Range	CMC <sup>2, 5, 7</sup> (±)	Comments
Scales & Balances <sup>3</sup>	(5 to 50) mg (50 to 500) mg 500 mg to 2 g (2 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g  500 g to 1 kg (1 to 2) kg (2 to 5) kg (5 to 10) kg (10 to 20) kg (20 to 35) kg  (0.25 to 0.5) lb (0.5 to 10) lb (10 to 25) lb (25 to 50) lb (50 to 100) lb (100 to 500) lb	17 µg 30 µg 65 µg 72 µg 87 µg 91 µg 0.14 mg 0.31 mg 0.86 mg 1.4 mg  2.9 mg 6.1 mg 14 mg 20 mg 2.3 g 2.4 g  0.0006 lb 0.0013 lb 0.0037 lb 0.016 lb 0.049 lb 0.11 lb	Class S weights           Class 1 weights           Class 1 weights           Class F weights           Class F weights
Durometer Calibration <sup>3</sup> – A, B, C, D  Spring Force Calibration	(10 to 100) duro  Type A, B  Type C, D	0.69 duro  0.58 duro	Rex RDC-1 Durocalibrator
Torque – Measure Equipment <sup>3</sup>	(5 to 50) lbf·in (25 to 250) lbf·in (100 to 1000) lbf·in (25 to 250) lbf·ft  (250 to 2000) lbf·ft	0.30 % 0.30 % 0.39 % 0.39 %  0.13 %	CDI TTPM-41 4 in 1 transducer system w/ 950DT    AKO TSD 1200 TSD 2011



Parameter/Equipment	Range	CMC <sup>2, 5, 7</sup> (±)	Comments
Pressure – Measuring Equipment <sup>3</sup>			
Pneumatic	(-14.3 to 100) psig	0.031 psi	DPI 620 calibrator w/ PM620-10G
	(0 to 0.25) in·H <sub>2</sub> O (0.25 to 2) in·H <sub>2</sub> O (2 to 10) in·H <sub>2</sub> O	0.0017 in·H <sub>2</sub> O 0.0029 in·H <sub>2</sub> O 0.014 in·H <sub>2</sub> O	Heise PTE-1 w/ HQS-1
Hydraulic	(0 to 500) psig (500 to 10 000) psig	0.023 % 0.023 %	Pressurements DPT W2200/3
Force <sup>3</sup> – Tension and Compression (Load Cells, Force Gauges, Dynamometers)	(5 to 200) lbf (200 to 1000) lbf (1 to 2) klb (2 to 5) klb (5 to 10) klb (10 to 25) klb (25 to 50) klb (50 to 100) klb (100 to 200) klb	0.045 % 0.020 % 0.017 % 0.018 % 0.017 % 0.017 % 0.017 % 0.017 % 0.024 %	Morehouse Precision Interface 1600 gold series
(Force Gauges)	Up to 1 lbf (1 to 10) lbf (10 to 50) lbf (50 to 100) lbf (100 to 500) lbf	0.060 % 0.017 % 0.032 % 0.050 % 0.022 %	1140BCW-200k Class F weights
Vibration – Accelerometer Frequency Response			
(0.02 to 5000) pC/g (0.05 to 10 000) mV/g	(0.5 to 10) Hz (> 10 to 99) Hz 100 Hz (> 100 to 920) Hz (> 921 to 5000) Hz (> 5 to 10) kHz (> 10 to 15) kHz (> 15 to 20) kHz	2.2 % 1.7 % 1.3 % 1.4 % 1.7 % 2.2 % 2.8 % 3.5 %	Modal Shop 9155C



Parameter/Equipment	Range	CMC <sup>2,5</sup> (±)	Comments
Impact Hammer	(0 to 5000) lbf	2.8 %	Modal Shop 9155C hammer calibration system
Shock	Up to 10 000 g	1.9 %	Modal Shop 9525 pneumatic shock exciter

#### V. Thermodynamics

Parameter/Equipment	Range	CMC <sup>2,7</sup> (±)	Comments
Temperature – Measure <sup>3</sup>	(-100 to 420) °C (> 420 to 500) °C	0.021 °C 0.062 °C	Hart 5618B PRT w/ 1502
Temperature – Measuring Equipment <sup>3</sup>	(-20 to 100) °C (> 100 to 500) °C	0.024 °C 0.091 °C	Hart 7025 w/ 1502 & 5615, Hart 9122A w/ 1502 & 5618B
IR Temperature – Measuring Equipment <sup>3</sup>	(50 to 100) °C (100 to 200) °C (200 to 300) °C (300 to 400) °C (400 to 500) °C	0.75 °C 1.8 °C 3.0 °C 4.1 °C 5.9 °C	Hart 9132 $\epsilon = 0.95, \lambda = (8 \text{ to } 14) \mu\text{m}$
Relative Humidity – Measure <sup>3</sup>	(20 to 90) % RH (> 90 to 100) % RH	1.4 % RH 2.1 % RH	Vaisala MI70 w/ probe HMP746
Relative Humidity – Measuring Equipment <sup>3</sup>	(20 to 90) % RH (> 90 to 100) % RH	1.4 % RH 2.1 % RH	Vaisala MI70 w/ probe HMP76

## VI. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2, 4, 5, 7</sup> ( $\pm$ )	Comments
Frequency – Measuring Equipment <sup>3</sup>	DC to 1 kHz > 1 kHz to 20 MHz	47 $\mu$ Hz/Hz 29 pHz/Hz	HP 3325B
	10 MHz to 26.5 GHz	22 pHz/Hz	HP 83630B GPS
Frequency – Measure <sup>3</sup>	0.1 Hz to 1 kHz (1 to 1000) kHz (1 to 225) MHz 225 MHz to 3 GHz	47 $\mu$ Hz/Hz 0.28 nHz/Hz 4.9 pHz/Hz 12 pHz/Hz	HP 53131A opt 030
	(100 to 500) MHz (0.5 to 26.5) GHz	2.9 nHz/Hz 22 pHz/Hz	HP 5351B
Tachometers	(10 to 100 000) rpm	0.0023 rpm + 0.6R	GPS w/ HP3325

<sup>1</sup> This laboratory offers commercial and field calibration service.

<sup>2</sup> Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal 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.

<sup>3</sup> 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.

<sup>4</sup> The stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMC'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.

<sup>5</sup> In the statement of CMC,  $L$  is the numerical value of the nominal length of the device measured in inches.  $R$  is the resolution. In the statement of CMC, the value is defined as the percentage of reading, unless otherwise noted.

<sup>6</sup> This scope meets A2LA's *P112 Flexible Scope Policy*.

<sup>7</sup> The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.



# Accredited Laboratory

A2LA has accredited

**TEKTRONIX, INC.**

*Novi, MI*

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 the requirements of ANSI/NCSL Z540.3-2006 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 13<sup>th</sup> day of June 2022.

A blue ink signature of the Vice President of Accreditation Services.

Vice President, Accreditation Services  
For the Accreditation Council  
Certificate Number 2357.15  
Valid to June 30, 2024

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