



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005,  
ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3

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CALIBRATION

Valid To: September 30, 2017

Certificate Number: 1818.01

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

I. Chemical

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
pH Meters – Fixed Points	4 pH 7 pH 10 pH	0.13 pH 0.13 pH 0.13 pH	Standard buffers

II. Dimensional

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Calipers	(0.1 to 6) in (0.1 to 12) in (0.1 to 24) in (0.1 to 48) in (0.1 to 60) in	(100 + 0.51L) μin (110 + 1.1L) μin (130 + 1.7L) μin (270 + 1.7L) μin (100 + 3.2L) μin	Gage blocks, rings
Gage Blocks	(0.005 to 1) in (1 to 4) in (4 to 26) in	(4.1 + 0.36L) μin (7.4 + 0.27L) μin (7.8 + 2.1L) μin	Pratt & Whitney Labmaster, master gage blocks

Parameter/Equipment	Range	CMC <sup>2, 4</sup> (±)	Comments
Surface Plates – Flatness Repeat Reading Gage	(Up to 72) in diagonal Up to 0.00002 in	240 µin 18 µin	Levels and laser methods
Micrometers	(0.00005 to 1) in (1 to 2) in (2 to 6) in (6 to 12) in (12 to 36) in	(65 + 5L) µin 100 µin (99 + 0.75L) µin (95 + 1.2L) µin (29 + 19L) µin	Gage blocks

### III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2, 5</sup> (±)	Comments
DC Current <sup>3</sup> – Measure	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	23 µA/A + 8 nA 46 µA/A + 5 nA 48 µA/A + 50 nA 47 µA/A + 0.5 µA 0.013 % + 10 µA	Agilent 3458A, option 002
	(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	22 µA/A + 0.4 nA 28 µA/A + 4 nA 28 µA/A + 20 nA 64 µA/A + 0.8 µA 0.025 % + 16 µA 0.053 % + 0.4 mA	Fluke 8508A
DC Current <sup>3</sup> – Generate	Up to 220 µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A	82 µA/A + 8 nA 43 µA/A + 8 nA 41 µA/A + 80 nA 53 µA/A + 0.8 µA 77 µA/A + 25 µA	Fluke 5700A
	(1.1 to 3) A (3 to 11) A (11 to 20) A	0.029 % + 40 µA 0.043 % + 0.5 mA 0.074 % + 0.75 mA	Fluke 5520A
DC Voltage <sup>3</sup> – Measure	(0 to 200) mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1000) V	11 µV/V + 0.1 µV 6.6 µV/V + 0.4 µV 6.8 µV/V + 4 µV 6.8 µV/V + 40 µV 7 µV/V + 1 mV	Fluke 8508A

Parameter/Equipment	Range	CMC <sup>2,5</sup> ( $\pm$ )	Comments
DC Voltage <sup>3</sup> – Generate	Up to 0.22 V (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	15 $\mu$ V/V + 0.6 $\mu$ V 6.7 $\mu$ V/V + 1 $\mu$ V 6.3 $\mu$ V/V + 3.5 $\mu$ V 6.7 $\mu$ V/V + 6.5 $\mu$ V 7.3 $\mu$ V/V + 80 $\mu$ V 9.4 $\mu$ V/V + 0.6 $\mu$ V	Fluke 5700A
Resistance <sup>3</sup> – Measure	(0 to 2) $\Omega$ (2 to 20) $\Omega$ (20 to 200) $\Omega$ (0.2 to 2) k $\Omega$ (2 to 20) k $\Omega$ (20 to 200) k $\Omega$ (0.2 to 2) M $\Omega$ (2 to 20) M $\Omega$ (20 to 200) M $\Omega$ 200 M $\Omega$ to 2 G $\Omega$	17 $\mu\Omega/\Omega$ + 4 $\mu\Omega$ 9.6 $\mu\Omega/\Omega$ + 14 $\mu\Omega$ 8.5 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 8.6 $\mu\Omega/\Omega$ + 0.5 m $\Omega$ 8 $\mu\Omega/\Omega$ + 5 m $\Omega$ 8.8 $\mu\Omega/\Omega$ + 50 m $\Omega$ 11 $\mu\Omega/\Omega$ + 1 $\Omega$ 19 $\mu\Omega/\Omega$ + 0.1 k $\Omega$ 73 $\mu\Omega/\Omega$ + 10 k $\Omega$ 0.099 % + 1 M $\Omega$	Agilent 3458A, option 002
Resistance <sup>3</sup> – Generate	(0 to 11) $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ 330 $\Omega$ to 1.1 k $\Omega$ (1.1 to 3.3) k $\Omega$ (3.3 to 11) k $\Omega$ (11 to 33) k $\Omega$ (3 to 110) k $\Omega$ (110 to 330) k $\Omega$ 330 k $\Omega$ to 1.1 M $\Omega$ (1.1 to 3.3) M $\Omega$ (3.3 to 11) M $\Omega$ (11 to 33) M $\Omega$ (33 to 110) M $\Omega$ (110 to 330) M $\Omega$ 330 M $\Omega$ to 1.1 G $\Omega$	42 $\mu\Omega/\Omega$ + 0.001 $\Omega$ 32 $\mu\Omega/\Omega$ + 0.0015 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.0014 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.002 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.002 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.02 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.02 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.2 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.2 $\Omega$ 30 $\mu\Omega/\Omega$ + 0.2 $\Omega$ 34 $\mu\Omega/\Omega$ + 2 $\Omega$ 34 $\mu\Omega/\Omega$ + 2 $\Omega$ 62 $\mu\Omega/\Omega$ + 30 $\Omega$ 0.014 % + 50 $\Omega$ 0.026 % + 2.5 k $\Omega$ 0.051 % + 3 k $\Omega$ 0.3 % + 100 k $\Omega$ 1.5 % + 500 k $\Omega$	Fluke 5520A
Resistance <sup>3</sup> – Generate, Fixed Points	0 $\Omega$ 1 $\Omega$ 1.9 $\Omega$ 10 $\Omega$ 19 $\Omega$ 100 $\Omega$ 190 $\Omega$ 1 k $\Omega$ 1.9 k $\Omega$ 10 k $\Omega$ 19 k $\Omega$ 100 k $\Omega$ 190 k $\Omega$ 1 M $\Omega$	45 $\mu\Omega$ 83 $\mu\Omega/\Omega$ 48 $\mu\Omega/\Omega$ 42 $\mu\Omega/\Omega$ 31 $\mu\Omega/\Omega$ 13 $\mu\Omega/\Omega$ 14 $\mu\Omega/\Omega$ 11 $\mu\Omega/\Omega$ 12 $\mu\Omega/\Omega$ 10 $\mu\Omega/\Omega$ 11 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 16 $\mu\Omega/\Omega$ 17 $\mu\Omega/\Omega$	Fluke 5700A

Parameter/Equipment	Range	CMC <sup>2,5</sup> (±)	Comments
Resistance <sup>3</sup> – Generate, Fixed Points (cont)	1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	17 μΩ/Ω 30 μΩ/Ω 34 μΩ/Ω 0.012 %	Fluke 5700A

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
AC Voltage Flatness <sup>3</sup> – Measure  (0.5, 1 or 3) V	10 Hz to 10 MHz (10 to 30) MHz (30 to 60) MHz (60 to 100) MHz	0.13 % 0.25 % 0.5 % 1.5 %	Agilent 11049A, 11050A, Precision Measurements EL 1300
AC Voltage <sup>3</sup> – 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 500 kHz to 1 MHz	0.056 % + 4.5 μV 0.022 % + 4.5 μV 0.011 % + 4.5 μV 0.038 % + 4.5 μV 0.086 % + 7 μV 0.11 % + 13 μV 0.17 % + 25 μV 0.34 % + 25 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 500 kHz to 1 MHz	0.056 % + 5 μV 0.022 % + 5 μV 0.011 % + 5 μV 0.038 % + 5 μV 0.086 % + 7 μV 0.11 % + 12 μV 0.17 % + 25 μV 0.34 % + 25 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 500 kHz to 1 MHz	0.056 % + 13 μV 0.022 % + 8 μV 0.011 % + 8 μV 0.033 % + 8 μV 0.086 % + 25 μV 0.11 % + 25 μV 0.17 % + 35 μV 0.34 % + 80 μV	
220 mV to 2.2 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	0.051 % + 80 μV 0.017 % + 25 μV 0.008 % + 6 μV 0.013 % + 16 μV	

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
AC Voltage <sup>3</sup> – Generate (cont)			
220 mV to 2.2 V	(50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.026 % + 70 µV 0.044 % + 130 µV 0.11 % + 0.35 mV 0.23 % + 0.85 mV	Fluke 5700A
(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 500 kHz to 1 MHz	0.051 % + 800 µV 0.017 % + 250 µV 0.008 % + 60 µV 0.013 % + 160 µV 0.026 % + 350 µV 0.051 % + 1.5 mV 0.13 % + 4.3 mV 0.27 % + 8.5 mV	
(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 500 kHz to 1 MHz	0.051 % + 8 mV 0.017 % + 2.5 mV 0.009 % + 0.8 mV 0.023 % + 3.5 mV 0.051 % + 8 mV 0.15 % + 90 mV 0.47 % + 90 mV 1.2 % + 190 mV	Subject to (2.2 x 10 <sup>7</sup> ) V-Hz limitation
(220 to 250) V	(15 to 50) Hz	0.041 % + 16 mV	
(220 to 1100) V	50 Hz to 1 kHz	82 µV/V + 3.5 mV	
Inductance <sup>3</sup> – Measure			
10 µH to 100 H	100 Hz; 120 Hz	0.1 % + 1 µH	GenRad 1659 Digibridge
1 µH to 10 H	1 kHz	0.1 % + 0.1 µH	
0.1 µH to 1 H	10 kHz	0.1 % + 0.02 µH	

Parameter/Equipment	Range	CMC <sup>2,5</sup> (±)	Comments
DC High Voltage <sup>3</sup> – Generate	(1 to 10) kV (10 to 20) kV (21 to 50) kV	0.08 % + 0.004 kV 0.2 % 0.4 %	Glassman high voltage PS-EK 50N12.0-11 w/ Vitrek 4670A

Parameter/Equipment	Range	CMC <sup>2,5</sup> (±)	Comments
DC High Voltage <sup>3</sup> – Measure	(1 to 10) kV (10 to 20) kV (21 to 70) kV	0.08 % + 0.004 kV 0.2 % 0.4 %	Vitrek 4670A
AC High Voltage <sup>3</sup> – Measure			
(20 to 100) Hz	(1 to 10) kV <sub>rms</sub> AC (10 to 20) kV <sub>rms</sub> AC	0.2 % + 0.025 kV 0.5 %	Vitrek 4670A
(50 to 60) Hz	(20 to 35) kV <sub>rms</sub> AC	0.4 % + 0.11 kV	

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
AC Current <sup>3</sup> – Generate			
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	0.03 % + 20 nA 0.02 % + 12 nA 0.014 % + 10 nA 0.035 % + 15 nA 0.13 % + 80 nA	Fluke 5700A
220 µA 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	0.03 % + 50 nA 0.02 % + 40 nA 0.014 % + 40 nA 0.024 % + 130 nA 1.3 % + 0.8 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	0.03 % + 0.5 µA 0.02 % + 0.4 µA 0.014 % + 0.4 µA 0.024 % + 0.7 µA 1.3 % + 6 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	0.03 % + 5 µA 0.02 % + 4 µA 0.014 % + 3 µA 0.024 % + 4 µA 1.3 % + 12 µA	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.032 % + 40 µA 0.05 % + 100 µA 0.8 % + 200 µA	

Parameter/Range	Frequency	CMC <sup>2,5</sup> ( $\pm$ )	Comments
AC Current <sup>3</sup> – Generate (cont)			
(2.2 to 3) A	(10 to 100) Hz (100 to 440) Hz	0.12 % + 200 $\mu$ A 0.3 % + 1 mA	Fluke 5700A
(3 to 20) A	(10 to 100) Hz 100 Hz to 1 kHz	0.12 % + 2 mA 1 % + 5 mA	Fluke 5520A
AC Voltage <sup>3</sup> – Measure			
(1 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 to 300) kHz	0.03 % + 3 $\mu$ V 0.02 % + 1.1 $\mu$ V 0.03 % + 1.1 $\mu$ V 0.1 % + 1.1 $\mu$ V 0.5 % + 1.1 $\mu$ V 4 % + 2 $\mu$ V	Agilent 3458A, option 002
(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 (1 to 2) MHz	72 $\mu$ V/V + 4 $\mu$ V 72 $\mu$ V/V + 2 $\mu$ V 0.015 % + 2 $\mu$ V 0.03 % + 2 $\mu$ V 0.08 % + 2 $\mu$ V 0.3 % + 1 $\mu$ V 1 % + 1 $\mu$ V 1.5 % + 1 $\mu$ V	
100 mV to 1 V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	72 $\mu$ V/V + 40 $\mu$ V 72 $\mu$ V/V + 20 $\mu$ V 0.015 % + 20 $\mu$ V 0.03 % + 20 $\mu$ V 0.08 % + 20 $\mu$ V 0.3 % + 10 $\mu$ V 1 % + 10 $\mu$ V 1.5 % + 10 $\mu$ V	
(1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	72 $\mu$ V/V + 400 $\mu$ V 72 $\mu$ V/V + 200 $\mu$ V 0.015 % + 200 $\mu$ V 0.03 % + 200 $\mu$ V 0.08 % + 200 $\mu$ V 0.3 % + 100 $\mu$ V 1 % + 100 $\mu$ V 1.5 % + 100 $\mu$ V	

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
AC Voltage <sup>3</sup> – Measure (cont)			
(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	0.02 % + 4 mV 0.02 % + 2 mV 0.02 % + 2 mV 0.035 % + 2 mV 0.12 % + 2 mV 0.4 % + 1 mV 1.5 % + 1 mV	Agilent 3458A, option 002
(100 to 1000) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.04 % + 40 mV 0.04 % + 20 mV 0.06 % + 20 mV 1.2 % + 20 mV 3 % + 20 mV	
AC Current <sup>3</sup> – Measure			
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.4 % + 30 nA 0.15 % + 30 nA 0.06 % + 30 nA 0.06 % + 30 nA	Agilent 3458A, option 002
100 µA to 1 mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.4 % + 200 nA 0.15 % + 200 nA 0.06 % + 200 nA 0.03 % + 200 nA 0.06 % + 200 nA 0.4 % + 400 nA 0.55 % + 1.5 µA	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.4 % + 0.2 µA 0.15 % + 0.2 µA 0.06 % + 0.2 µA 0.03 % + 0.2 µA 0.06 % + 0.2 µA 0.4 % + 0.4 µA 0.55 % + 15 µA	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.4 % + 2 µA 0.15 % + 2 µA 0.06 % + 2 µA 0.03 % + 2 µA 0.06 % + 2 µA 0.4 % + 4 µA 0.55 % + 150 µA	



Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
AC Current <sup>3</sup> – Measure (cont)			
100 mA to 1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.4 % + 20 μA 0.16 % + 20 μA 0.08 % + 20 μA 0.1 % + 20 μA 0.3 % + 20 μA 1 % + 40 μA	Agilent 3458A, option 002
(1 to 2) A	10 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz	0.071 % + 240 μA 0.082 % + 240 μA 0.3 % + 240 μA	Fluke 8508A
(2 to 20) A	10 Hz to 2 kHz (2 to 10) kHz	0.09 % + 2.4 mA 0.25 % + 2.4 mA	

Parameter/Equipment	Frequency	CMC <sup>2,5</sup> (±)	Comments
Capacitance <sup>3</sup> – Measure  20 pF to 100 µF  1 pF to 10 µF  0.1 pF to 1 µF	100 Hz; 120 Hz  1 kHz  10 kHz	0.1 % + 2 pF  0.1 % + 1 pF  0.1 % + 0.1 pF	GenRad 1659 RLC Digibridge
Capacitance <sup>3</sup> – Generate  (0.2 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF 330 nF to 1.1 µF (1.1 to 3.3) µF (3.3 to 11) µF (11 to 33) µF (33 to 110) µF (110 to 330) µF 330 µF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 3 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz (10 to 120) Hz (10 to 80) Hz (0 to 50) Hz (0 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	0.5 % + 0.01 nF 0.5 % + 0.01 nF 0.5 % + 0.01 nF 0.25 % + 0.01 nF 0.25 % + 0.1 nF 0.25 % + 0.1 nF 0.25 % + 0.1 nF 0.25 % + 0.3 nF 0.25 % + 1 nF 0.25 % + 3 nF 0.25 % + 10 nF 0.4 % + 30 nF 0.45 % + 100 nF 0.45 % + 300 nF 0.45 % + 1 µF 0.45 % + 3 µF 0.45 % + 10 µF 0.75 % + 30 µF 1.1 % + 100 µF	Fluke 5520A
Time Marker Output – Measuring Equipment <sup>3</sup>	50 kHz to 2.5 GHz	0.004 %	Fluke 9500 oscilloscope calibration system

Parameter/Equipment	Frequency	CMC <sup>2,5</sup> (±)	Comments
Oscilloscope Calibration <sup>3</sup> – Generate			
Voltage – DC to 1 MΩ DC to 50 Ω	1 mV to 200 V 1 mV to 5 V	0.03 % + 25 μV 0.03 % + 25 μV	Fluke 9500B with 9530, 9550 and 9560 heads
Square Wave – 50 Ω	(0.04 to 1) mV 1 mV to 5 V	1.5 % + 10 μV 0.12 % + 10 μV	
Rise Time	150 ps @ 5 mV to 3 V 70 ps @ 25 mV to 2 V 25 ps @ (425 to 575) mV	27 ps 20 ps 8 ps	
Timing	Narrow Triangle 900.91 ns to 55 s	3.4 μs/s	
Leveled Sine Wave –			
Amplitude	5 mV to 5 V	1.5 %	
Single	0.1 Hz to 300 MHz (300 to 550) MHz 550 MHz to 3.0 GHz (3.0 to 6.0) GHz	2 % 2.5 % 3.5 % 5 %	
Dual	wrt Reference Frequency: 0.1 Hz to 1 GHz (1 to 3.2) GHz	10 % 25 %	Fluke 9500B with 9530, 9550 and 9560 heads
Pulse Width	(1 to 100) ns	5 % + 200 ps	
Time Base Accuracy for Oscilloscope Measurement <sup>3</sup>	Up to 10 μs	0.34 %	Fluke 9500 oscilloscope calibration system
Bandwidth Measurement <sup>3</sup>	1 MHz to 2.5 GHz	0.1 %	Fluke 9500 oscilloscope calibration system
Square Wave – Generate <sup>3</sup>	50 kHz to 2.5 GHz	0.3 % + 1 μV	Fluke 9500 oscilloscope calibration system
Level Sine Flatness Measurement <sup>3</sup>	50 kHz to 250 MHz 250 MHz to 2.5 GHz	1.7 % 4.6 %	Fluke 9500 oscilloscope calibration system

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Simulation of Thermocouple Indicators – Measure & Generate			
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.60 °C 0.26 °C 0.24 °C 0.26 °C 0.30 °C	Fluke 5520A
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.36 °C 0.26 °C 0.24 °C 0.27 °C 0.32 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.42 °C 0.27 °C 0.26 °C 0.35 °C 0.50 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.40 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C	
Type R	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.57 °C 0.35 °C 0.33 °C 0.40 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.47 °C 0.36 °C 0.37 °C 0.46 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.75 °C 0.33 °C 0.26 °C 0.24 °C	

IV. Electrical – RF/Microwave: RF Power Sensor Calibration

Parameter/Range	Frequency	CMC <sup>2, 5, 6, 7, 8</sup> (±)	Comments
RF Power Sensor Transfer <sup>3</sup> –  10 μW to 25 mW	10 MHz to 10 GHz (10 to 18) GHz	1.4 % + <i>M</i> 1.4 % + <i>M</i>	Tegam 1803A w/1805B
	100 kHz to 4.2 GHz	1.4 % + <i>M</i>	Tegam F1119 w/1805B
VSWR of Power Sensor <sup>3</sup>	100 kHz to 50 GHz	0.25 dB	Agilent 8757D

Parameter/Equipment	Range	CMC <sup>2, 5</sup> (±)	Comments
Range to Range Calibration Uncertainty <sup>3</sup>	(3, 10, 30, 100, 300) μW (1, 3, 10, 30, 100) mW	0.49 % 0.49 %	Agilent 11683A
Power Meter Accuracy Check <sup>3</sup>	(0.1 to 10) mW (0.01 to 0.03) mW	1.4 % 1.5 %	Agilent 432A

V. Electrical – RF/Microwave: RF/Microwave Calibration

Parameter/Equipment	Frequency	CMC <sup>2, 5, 6, 7, 8</sup> (±)	Comments
RF Absolute Power <sup>3</sup> – Measure			
(+20 to -60) dBm	9 kHz to 6 GHz (1 to 6) GHz	1.1 % + <i>M</i> 1.7 % + <i>M</i>	Agilent E9304A
(+20 to -30) dBm	10 MHz to 1 GHz (1 to 2) GHz (2 to 4) GHz (4 to 6) GHz (6 to 8) GHz (8 to 10) GHz (10 to 12) GHz (12 to 14) GHz (14 to 16) GHz (16 to 18) GHz 18 GHz	1.4 % + <i>M</i> 1.6 % + <i>M</i> 1.4 % + <i>M</i> 1.5 % + <i>M</i> 1.5 % + <i>M</i> 1.7 % + <i>M</i> 1.9 % + <i>M</i> 2.1 % + <i>M</i> 2.6 % + <i>M</i> 2.9 % + <i>M</i> 3.2 % + <i>M</i>	Agilent 8481A
(-30 to -70) dBm	10 MHz to 1 GHz (1 to 2) GHz (2 to 4) GHz (4 to 6) GHz (6 to 8) GHz (8 to 10) GHz (10 to 12) GHz (12 to 14) GHz (14 to 16) GHz (16 to 18) GHz 18 GHz	1.4 % + <i>M</i> 1.9 % + <i>M</i> 1.8 % + <i>M</i> 1.8 % + <i>M</i> 1.8 % + <i>M</i> 2 % + <i>M</i> 2.2 % + <i>M</i> 2.8 % + <i>M</i> 3.2 % + <i>M</i> 3.4 % + <i>M</i> 3.7 % + <i>M</i>	



Parameter/Range	Frequency	CMC <sup>2, 5, 6, 7, 8</sup> (±)	Comments
RF Absolute Power <sup>3</sup> – Measure (con't)			
(+20 to -30) dBm	50 MHz to 1 GHz	1.3 % + <i>M</i>	Agilent 8481D
	(1 to 2) GHz	1.6 % + <i>M</i>	
	(2 to 4) GHz	1.6 % + <i>M</i>	
	(4 to 6) GHz	1.6 % + <i>M</i>	
	(6 to 8) GHz	1.7 % + <i>M</i>	
	(8 to 10) GHz	1.8 % + <i>M</i>	
	(10 to 12) GHz	1.8 % + <i>M</i>	
	(12 to 14) GHz	1.9 % + <i>M</i>	
	(14 to 16) GHz	2.1 % + <i>M</i>	
	(16 to 18) GHz	2.2 % + <i>M</i>	
	(18 to 22) GHz	2.3 % + <i>M</i>	
	(22 to 26.5) GHz	1.8 % + <i>M</i>	
	(26.5 to 28) GHz	2.1 % + <i>M</i>	
	(28 to 30) GHz	2.3 % + <i>M</i>	
	(30 to 33) GHz	2.1 % + <i>M</i>	
	(33 to 34.5) GHz	2.3 % + <i>M</i>	
	(34.5 to 37) GHz	2.1 % + <i>M</i>	
	(37 to 40) GHz	2.3 % + <i>M</i>	
	(40 to 42) GHz	2.6 % + <i>M</i>	
	(42 to 44) GHz	3.2 % + <i>M</i>	
(44 to 46) GHz	3.6 % + <i>M</i>		
(46 to 48) GHz	4.1 % + <i>M</i>		
(48 to 50) GHz	4.5 % + <i>M</i>		
50 GHz	5 % + <i>M</i>		
(-30 to -70) dBm	50 MHz to 1 GHz	1.7 % + <i>M</i>	Agilent 8487D
	(1 to 2) GHz	2 % + <i>M</i>	
	(2 to 4) GHz	2 % + <i>M</i>	
	(4 to 6) GHz	2 % + <i>M</i>	
	(6 to 8) GHz	2.3 % + <i>M</i>	
	(8 to 10) GHz	2.3 % + <i>M</i>	
	(10 to 12) GHz	2.3 % + <i>M</i>	
	(12 to 14) GHz	2.8 % + <i>M</i>	
	(14 to 16) GHz	2.8 % + <i>M</i>	
	(16 to 18) GHz	2.8 % + <i>M</i>	
	(18 to 22) GHz	2.8 % + <i>M</i>	
	(22 to 26.5) GHz	2.8 % + <i>M</i>	
	(26.5 to 28) GHz	3 % + <i>M</i>	
	(28 to 30) GHz	3 % + <i>M</i>	
	(30 to 33) GHz	3 % + <i>M</i>	
	(33 to 34.5) GHz	3 % + <i>M</i>	
	(34.5 to 37) GHz	3 % + <i>M</i>	
	(37 to 40) GHz	3 % + <i>M</i>	
	(40 to 42) GHz	3 % + <i>M</i>	
	(42 to 44) GHz	2.9 % + <i>M</i>	
(44 to 46) GHz	2.9 % + <i>M</i>		
(46 to 48) GHz	3.1 % + <i>M</i>		
(48 to 50) GHz	4.5 % + <i>M</i>		
50 GHz	4.5 % + <i>M</i>		

Parameter/Range	Frequency	CMC <sup>2, 5, 6, 7, 8</sup> ( $\pm$ )	Comments
RF Power <sup>3</sup> – Generate			
(+23 to 0) dBm	1 $\mu$ Hz to 80 MHz	0.1 dB + <i>M</i>	Agilent 33250A
(+24 to -130) dBm	10 Hz to 12.5 MHz	0.05 dB + <i>M</i>	Fluke 9640A
(+14 to -130) dBm	12.5 MHz to 4 GHz	0.06 dB + <i>M</i>	
(+10 to -110) dBm	10 MHz to 26.5 GHz	0.6 dB + <i>M</i>	Agilent 83650B
(+5 to -110) dBm	(26.5 to 40) GHz	0.8 dB + <i>M</i>	
(+2.5 to -110) dBm	(40 to 50) GHz	1.5 dB + <i>M</i>	
VSWR <sup>3</sup> – Measure	5 Hz to 500 MHz	0.93 %	Agilent 8751A
	100 kHz to 50 GHz	1.1 % of indicated value	Agilent 8757D w/ 8721A, 85027C, 85027E, 85027D

#### VI. Electrical – RF/Microwave: Signal Generator Calibration

Parameter/Range	Frequency	CMC <sup>2, 5, 6, 8</sup> ( $\pm$ )	Comments
Tuned RF Power Relative <sup>3</sup> – Measure			
(0 to -3) dBm	2.5 MHz to 26.5 GHz	0.02 dB	Agilent 8902A
(-3 to -10) dBm	2.5 MHz to 26.5 GHz	0.02 dB	Agilent 11722A
(-10 to -40) dBm	2.5 MHz to 26.5 GHz	0.08 dB	Agilent 11792A
(-40 to -50) dBm	2.5 MHz to 26.5 GHz	0.14 dB	Agilent 11793A
(-50 to -80) dBm	2.5 MHz to 26.5 GHz	0.2 dB	
(-80 to -90) dBm	2.5 MHz to 26.5 GHz	0.26 dB	
(-90 to -110) dBm	2.5 MHz to 26.5 GHz	0.3 dB	
Sine Wave Distortion <sup>3</sup> – Measure			
400 Hz and 1000 Hz Modulation	Modulation Depths: 1 % to 90 %	0.84 %	Agilent 8903B



Parameter/Range	Frequency	CMC <sup>2, 5, 6, 8</sup> (±)	Comments
Amplitude Modulation <sup>3</sup> – Measure			
Rate: 50 Hz to 10 kHz Depth: 5 % to 99 %	150 kHz to 10 MHz	2.5 %	Agilent 8902A
Rate: 20 Hz to 10 kHz Depth: 0 % to 99 %	150 kHz to 10 MHz	3.6 %	
Rate: 50 Hz to 50 kHz Depth: 5 % to 99 %	(10 to 1300) MHz	1.6 %	
Rate: 20 Hz to 100 kHz Depth: 0 % to 99 %	(10 to 1300) MHz	3.6 %	
Rate: 50 Hz to 50 kHz Depth: 5 % to 99 %	(1.3 to 26.5) GHz	2.1 %	Agilent 8902A with 11793A, 11792A
Rate: 30 Hz to 1 MHz	(26.5 to 50) GHz	1.4 %	Agilent 8565E, option 001
Phase Modulation <sup>3</sup> – Measure			
Rate: 200 Hz to 10 kHz 200 Hz to 20 kHz	(10 to 1300) MHz 10 MHz to 26.5 GHz	3.6 % 4.7 %	Agilent 8902A with 11793A, 11792A
Pulse Repetition Frequency <sup>3</sup> – Measure	3 Hz to 26.5 GHz 30 Hz to 50 GHz	150 Hz 150 Hz	Agilent E4440A Agilent 8565E
Frequency Modulation <sup>3</sup> – Measure			
Rate: 20 Hz to 10 kHz Dev.: ≤ 40 kHz peak	250 kHz to 10 MHz	2.4 %	Agilent 8902A
Rate: 50 Hz to 100 kHz Dev.: ≤ 400 kHz peak	(10 to 1300) MHz	1.3 %	
Rate: (20 to 200) kHz Dev.: ≤ 400 kHz peak	(0.10 to 26.5) GHz	5.8 %	With Agilent 11793A, 11792A
30 Hz to 1 MHz	(26.5 to 50) GHz	150 Hz	Agilent 8565E, option 001

Parameter/Range	Frequency	CMC <sup>2, 5, 6, 8</sup> ( $\pm$ )	Comments
Single Sideband Phase Noise (SSB) <sup>3</sup>	(10 to 1300) MHz	1 dB	Agilent 8902A with option 036/037
Frequency Accuracy <sup>3</sup>	(1.5, 4, 9, 16, 21) GHz (21, 26.5, 40) GHz	3 kHz	Agilent 8902A
	50 GHz	5 kHz	Agilent 8565E

VII. Electrical – RF/Microwave: Spectrum Analyzer/EMI Receiver Calibration

Parameter/Range	Frequency	CMC <sup>2, 6, 8</sup> ( $\pm$ )	Comments	
Frequency Modulation <sup>3</sup> – Generate	250 kHz to 40 GHz	For 400 Hz and 1000 Hz internal modulation	3.5 % + 20 Hz	Agilent E8257C
	10 MHz to 50 GHz	1 MHz rate, 1 MHz deviation	10 %	Agilent 83650B
Frequency Accuracy <sup>3</sup>	(1.5, 4, 9, 16, 21) GHz (21, 26.5, 40) GHz	3 kHz	Agilent 83650B	
	50 GHz	5 kHz		
Span Accuracy <sup>3</sup>	1 kHz to 2 MHz	1 Hz	Agilent 3335A	
	(2 to 500) MHz	1 kHz	Agilent 86350A	
Residual FM <sup>3</sup> (At 500 MHz)	5 kHz span and 1 kHz RBW	0.24 kHz	Agilent 3335A Agilent 86350A	
Cal Output Port Check <sup>3</sup>	300 MHz -20 dBm	1.2 Hz 0.44 dB	Agilent 53132A Agilent E9304A & 8482A (based on Agilent 8593E)	
Average Noise <sup>3</sup>	9 kHz to 50 GHz	0.31 dB	50 $\Omega$ load	

Parameter/Range	Frequency	CMC <sup>2, 6, 8</sup> ( $\pm$ )	Comments
Residuals <sup>3</sup>	20 Hz to 50 GHz	0.31 dB	50 $\Omega$ load
Reference Level <sup>3</sup> – Log Scale	50 MHz	0.14 dB	Agilent 11792 with: Agilent 3335A
Linear Scale	50 MHz	0.32 dB	Agilent 83650B (based on Agilent 8593E)
Attenuator Check <sup>3</sup>	50 MHz	0.15 dB	Agilent 8593E
Log Fidelity <sup>3</sup>	50 MHz 50 MHz	1.1 dB 1.1 dB	Agilent 3335A Agilent 83650B (based on Agilent 8593E)
Linear Fidelity <sup>3</sup>	50 MHz 50 MHz	1 dB 1 dB	Agilent 3335A Agilent 83650B (based on Agilent 8593E)
BW Accuracy <sup>3</sup>	20 Hz to 50 GHz	1 Hz	Agilent 83650B (based on Agilent 8565E)
BW Switching <sup>3</sup>	20 Hz to 50 GHz	1.1 dB	Agilent 83650B (based on Agilent 8565E)
2 <sup>nd</sup> Harmonic Distortion <sup>3</sup>	30 Hz to 50 GHz 200 Hz to 80 MHz (10 to 50) GHz	1.4 dB 1.4 dB 1.4 dB	Agilent 8565E Agilent 3335A Agilent 83650B (based on Agilent 8565E)
3 <sup>rd</sup> Order Intermodulation <sup>3</sup>	200 Hz to 80 MHz (10 to 50) GHz	0.5 dB 0.5 dB	Agilent 3335A Agilent 83650B (based on Agilent 8565E)
Noise Sidebands <sup>3</sup>	200 Hz to 80 MHz (10 to 50) GHz	0.7 dB 0.8 dB	Agilent 3335A Agilent 83650B (based on Agilent 8565E)

Parameter/Range	Frequency	CMC <sup>2, 5, 6, 8</sup> ( $\pm$ )	Comments
System Sidebands <sup>3</sup>	200 Hz to 80 MHz (10 to 50) GHz	0.48 dB 0.52 dB	Agilent 3335A Agilent 83650B (based on Agilent 8565E)
Sweep Time <sup>3</sup>	10 MHz to 50 GHz	6.1 %	Agilent 83650B (based on Agilent 8565E)
Harmonic Measurements <sup>3</sup>	30 Hz to 50 GHz 200 Hz to 80 MHz (10 to 50) GHz	0.5 dB 0.6 dB 0.8 dB	Agilent 8565E Agilent 3335A Agilent 83650B (based on Agilent 8565E)
Tracking Generator Non-Harmonics <sup>3</sup>	9 kHz to 2.9 GHz	0.59 dB	Agilent 8565E
Tracking Generator Feedthrough <sup>3</sup>	9 kHz to 2.9 GHz	0.63 dB	50 $\Omega$ load, 909F
Tracking Absolute Amplitude Output <sup>3</sup>	9 kHz to 2.9 GHz	0.61 dB	Agilent E9304A Agilent E4418B
Frequency Response <sup>3</sup>	9 kHz to 40 GHz 50 MHz to 50 GHz	1.1 dB 1.3 dB	Agilent 8902A Agilent 8487A (based on Agilent 8565E)
Gain Compression <sup>3</sup>	200 Hz to 80 MHz (10 to 50) GHz	1.5 dB 1.5 dB	Agilent 3335A Agilent 83650B (based on Agilent 8565E)
Source Errors for CISPR Bands A and B for Impulse Spectral Amplitude <sup>3</sup>	Band A (10 to 150 kHz)  Band B (0.15 to 30 MHz)	0.82 dB  0.82 dB	IGUU 2916

Parameter/Range	Frequency	CMC <sup>2, 6, 8</sup> (±)	Comments
Source Errors for CISPR Bands C and D for Impulse Spectral Amplitude <sup>3</sup>	Band C and D (30 to 1000 MHz)	1.1 dB	IGUU 2916
Pulse Generator <sup>3</sup> – Level Change	Band A through D	0.5 dB	Agilent E4440
Source Errors for Sinewave Output for CISPR Checks <sup>3</sup> (at 60 dB/μV)	100 kHz (1, 10, and 100) MHz	0.26 dB 0.26 dB	IGUU 2916
Peak & Average Detector Response <sup>3</sup>	Band A through D	1.3 dB	IGUU 2916
Source Errors for Frequency Response <sup>3</sup>	Band A Band B Band C Band D	0.53 dB 0.62 dB 0.57 dB 0.69 dB	Agilent 8565E
Impulse BW Measurement <sup>3</sup>	Above 1 GHz	3.7 kHz	Agilent 83630B, 33250A

#### VIII. Electrical – RF/Microwave: Network Analyzer Calibration

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
Non-Sweep Linearity Test (NA) <sup>3</sup>	(-90 to +20) dBm	0.24 dB	Agilent 438A, E4418B, Agilent 8481D
Frequency Accuracy Test (NA) <sup>3</sup>	10 Hz to 26.5 GHz	12 Hz	Agilent 53151A rubidium frequency standard
Source Level Accuracy/Flatness Test (NA) <sup>3</sup>	10 Hz to 50 GHz	0.14 dB	Agilent 438A, E4418B, 8482A, 8487A, and 34401A

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
Power Sweep Linearity Test (NA) <sup>3</sup>	(0 to 20) dB	0.23 dB	Agilent 438A, E4418B, and 8481D
Harmonics/Non-Harmonic Test (NA) <sup>3</sup>	(-30 to -120) dBc	0.46 dB	Agilent 8563E
Receiver Noise Level Test (NA) <sup>3</sup>	(-30 to -120) dBm	0.31 dB	HP909C, opt 012
Input Crosstalk Test (NA) <sup>3</sup>	(-30 to -120) dB	0.23 dB	Agilent 909C, opt 012
Input Impedance Test (NA) <sup>3</sup>	(0 to 110) dB	0.37 dB	Agilent 8753D/E
Absolute Amplitude Accuracy Test (NA) <sup>3</sup>	(0 to -60) dBm	0.13 dB	Agilent 438A, E4418B, and 8482A
Magnitude Ratio/Phase Dynamic Accuracy Test (NA) <sup>3</sup> –			
Magnitude Ratio Dynamic	(0 to -100) dB	0.37 dB	Agilent 11667A, P8496A/G, and N4693A
Phase Dynamic	(0 to -100) dB	0.06°	
Receiver Trace Noise (NA) <sup>3</sup>	300 kHz to 50 GHz	0.33 dB	Agilent 11850C
Magnitude Ratio/Phase Frequency Response Test (NA) <sup>3</sup> –			
Magnitude Ratio Accuracy	100 kHz to 50 GHz	0.37 dB	Agilent 1167A, P8496A/G, and N4693A
Phase Frequency Response	100 kHz to 50 GHz	0.6°	
Receiver Input Impedance (NA) <sup>3</sup>	(0 to 120) dB return loss	0.37 dB	Agilent 85032B, N4693A

Parameter/Equipment	Frequency	CMC <sup>2,5</sup> (±)	Comments
Receiver Magnitude Accuracy (NA) <sup>3</sup>	300 kHz to 50 GHz	0.1 dB	Agilent 438A, E4418B, 8482A, 8487A
Receiver Phase Compression (NA) <sup>3</sup>	300 kHz to 50 GHz	0.1 dB	Agilent 438A, E4418B, 8482A, 8487A
Port Match (NA) <sup>3</sup>	300 kHz to 50 GHz	0.1 dB	Agilent 85032B, 85044A, N4693A
Switch Repeatability (NA) <sup>3</sup>	300 kHz to 50 GHz	0.1 dB	Associated network analyzer used with S parameter test set
Effective Source Match (NA) <sup>3</sup>	300 kHz to 50 GHz	0.1 dB	Agilent 85031B, N4693A
Directivity <sup>3</sup>	300 kHz to 50 GHz	0.1 dB	Agilent 85031B, N4693A
Current Monitor Conversion Factors <sup>3</sup>	(0.001 to 1) V/A	0.05 %	Fluke 5700A, Agilent 3458A

#### IX. Electrical RF/Microwave: Device Specific Parameters

EMI receivers (CISPR 16-1), EFT/Burst Generators (EN 61000-4-4), ESD Guns and Targets (IEC 61000-4-2, ANSI C63.16, SAE J1113-13), Surge Generators (EN 61000-4-5), Generators for Voltage Dips, Short Interrupts and Voltage Variations (EN 61000-4-11), Ring Wave Generators (ANSI C62.41), Network Analyzers, Impulse Generators (CISPR 16-1), Oscilloscopes, Power Meters, Power Sensors, Signal Generators, Spectrum Analyzers, 50 Ω Terminators

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
General RF Insertion Loss/Gain <sup>3</sup>	9 kHz to 6 GHz	0.42 dB	Agilent E9304A, Agilent E4418B
	10 MHz to 18 GHz	0.42 dB	Agilent E4412A, Agilent E4418B
	(18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	0.6 dB 0.8 dB 1.1 dB	Agilent E4418B, 8487A

Parameter/Equipment	Frequency	CMC <sup>2,5,7</sup> (±)	Comments	
Impedance <sup>3</sup> – Measure, 50 Ω Terminations	30 kHz to 6 GHz	0.93 %	Agilent 8753D, 85032B cal kit, S11 – 1 port calibration	
	10 MHz to 18 GHz	0.95 %	Agilent E8364B, N4690A cal kit, S11 – 1 port calibration	
	(18 to 50) GHz	1 %	Agilent E8364B, N4693A cal kit, S11 – 1 port calibration	
Pin Depth <sup>3</sup>	± 0.02 in	120 μin	Gage	
Impedance <sup>3</sup> – Measure 50 Ω devices	30 kHz to 6 GHz	<i>M</i> + 2.9 %	Agilent 8753D, 85032B cal kit, S11 – 1 port calibration	
Attenuation Measurements <sup>3</sup> –				
	(0 to 100) dB	100 kHz to 18 GHz	0.24 dB	Agilent 8902A, 11792A
(0 to 80) dB	(18 to 40) GHz	0.31 dB	Agilent E8364B, N4693A cal kit	
EFT/Burst Generator <sup>3</sup> –				
	Voltage	10 V to 6 kV	2.8 %	EN 61000-4-4; IEC 61000-4-4, IEC 61000-4-4(2004, 2011); GR 1089 CORE ISO 7637-2 Tektronix TDS 5104B
	Rise Time	5 ns ± 30 %	0.74 ns	
	Impulse Duration	150 ns ± 30 %	0.74 ns	
	Burst Duration	15 ms ± 20 % 0.75 ms ± 20 %	0.74 ns	
	Burst Period	300 ms ± 20 %	0.74 ns	
Repetition Rate	1 kHz to 50 Mhz	23 Hz (freq) 2.8 % (volt)		



Parameter/Equipment	Frequency	CMC <sup>2,5</sup> (±)	Comments
ESD Simulators <sup>3</sup> –			EN 61000-4-2;
Contact Voltage (Positive and Negative)	(2 to 8) kV	1.9 %	TEK TDS 540 with 6015A probe; Agilent 54845A with IEC ESD target
Rise Time	(0.7 to 1) ns	61 ps	
Peak Current	(6.8 to 33) A	2.6 %	
30 ns Current	(2.8 to 20.8) A	3.5 %	
60 ns Current	(1.4 to 10.4) A	9 %	
Air Discharge Voltage (Positive and Negative)	(0 to 25) kV	1.9 %	TEK TDS 540 TEK 6015A probe IEC ESD target
Rise Time	(0.7 to 1) ns	61 ps	
RC Time Constant (at ± 15 kV)	600 ns ± 130 ns (for 330 pF probe)	61 ps	
	300 ns ± 60 ns (for 150 pF probe)	61 ps	
Indicated Voltage	(2 to 25) kV	1.9 %	SAE J1113-13 with 54845A and target
Surge Generator <sup>3</sup> – Ring/ Impulse/ PQF			
Front Time Open Short	(0.1 to 50) µs	0.74 ns	EN61000-4-5; IEC61000-4-8; IEC61000-4-9; , IEC61000-4-10; IEC61000-4-11; IEC6100-4-12
Rise Time Open Circuit Short Circuit	(0.1 to 50) µs	1.2 ns	UL 864; UL 1449; ISO 7637-2; ISO 17069
Time to Half-Value Impulse Duration	(20 to 1500) µs	0.74 ns	ITU Rec K.17, K.20, ITU Rec K.21; SBC-TP-76200;
Voltage	10 V to 18 kV	2.8 %	
Current	(0.001 to 5) kA	2.8 %	
Frequency	100 kHz to 1 MHz	23 Hz (freq) 2.9 % (volt)	
Phase Synchronization	50 Hz 60 Hz 400 Hz	0.11° 0.095° 0.21°	GR1089CORE Tektronix TDS 5104B ANSI 62.41, 1991

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
Mains Harmonic Emissions <sup>3</sup>	(100 to 280) V (0.1 to 20) A (20 to 60) A (0.5 to 179.5)°	0.07 % + 270 mV 0.2 % 0.1 A 0.1°	IEC 61000-3-2; IEC 61000-4-7; IEC 61000-4-13; IEC 61000-4-14; IEC 61000-4-15; 61000-3-11
Voltage Fluctuations (Flicker) <sup>3</sup>	(100 to 280) V (0.1 to 20) A (20 to 60) A	0.1 % + 370 mV 0.2 % 0.1 A	IEC 61000-3-3 61000-3-12
Rise/Fall Time <sup>3</sup> – Measure	(200 ps to 1000 s)/div	2 % + 50 ps	TDS 5104B
Voltage Measure	(1 mV to 10 V)/div	2 %	TDS 5104B

#### X. Mechanical

Parameter/Equipment	Frequency	CMC <sup>2,5</sup> (±)	Comments
Accelerometers – Versus Primary Standard	(5 to 9) Hz (10 to 99) Hz 100 Hz (101 to 920) Hz (921 to 5000) Hz (5001 to 10 000) Hz (10 to 15) kHz	1.7 % 1.2 % 0.79 % 1.1 % 1.4 % 1.9 % 2.3 %	Modal Shop 9155 workstation with 396C10/C11 air bearing shaker
Accelerometers Versus Secondary Standard	(5 to 9) Hz (10 to 99) Hz 100 Hz (101 to 920) Hz (921 to 5000) Hz (5001 to 10 000) Hz (10 to 15) kHz	2.7 % 1.8 % 1.4 % 1.6 % 1.9 % 2.3 % 3 %	Modal Shop 9155 workstation with 396C10/C11 air bearing shaker
Barometers	(22 to 34) inHg (750 to 1150) mBar	0.011 inHg 0.39 mBar	DPI 740

Parameter/Equipment	Frequency	CMC <sup>2.5</sup> (±)	Comments
Pressure Gauges	Up to 100 psi Up to 300 psi Up to 1000 psi Up to 3000 psi	0.040 psi 0.17 psi 0.24 psi 1.7 psi	Additel 681 digital gages
Scales & Balances	(0.01 to 200) g 200 g to 3.3 kg (3.3 to 40) kg (50 to 300) lb	0.00016 + 0.015 % 0.0016 + 0.015 % 0.00011 + 0.015 % 0.00015 + 0.015 %	Class 1 weights, Class F weights
Mass – Measure	(1 to 200) g (0.2 to 3.2) kg (3.2 to 40) kg  (0.0022 to 0.44) lbf (0.44 to 7.1) lbf (7.1 to 88) lbf	0.027 mg + 3.7 ppm 5.4 mg + 0.063 ppm 170 mg + 3.2 ppm  0.00000038 lb + 2.8 ppm 0.000026 lb + 1.6 ppm 0.00034 lb + 11 ppm	Substitution method using reference weights
Torque Wrench, Torque Screwdriver, Torque Watch	(0.5 to 400) in·oz (5 to 50) in·lb (25 to 250) in·lb (100 to 1000) in·lb (25 to 250) ft·lb (100 to 1000) ft·lb	0.018 in·oz + 0.59 % 0.00078 in·lb + 0.59 % 0.014 in·lb + 0.59 % 0.0091 in·lb + 0.59 % 0.012 ft·lb + 0.59 % 0.0039 ft·lb + 0.59 %	CDI torque transducers
Torque Transducers	(0.5 to 400) in·oz (5 to 50) in·lb (25 to 250) in·lb (100 to 1000) in·lb (25 to 250) ft·lb (100 to 1000) ft·lb	0.020 in·oz 0.0065 in·lb 0.027 in·lb 0.10 in·lb 0.013 ft·lb 0.21 ft·lb	Dead weights, CDI deployable torque calibration system

XI. Thermodynamics

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
IR Temperature – Measure, Fixed Points	35 °C 100 °C 200 °C 350 °C 500 °C	1.2 °C 1.3 °C 1.5 °C 1.9 °C 2.6 °C	Fluke 4181
Relative Humidity – Measure	(10 to 35) % RH (35 to 65) % RH (65 to 90) % RH (90 to 95) % RH	0.18 % RH 0.40 % RH 0.52 % RH 0.98 % RH	Rotronics HG2-S101 and Rotronics H290D sensor
Temperature – Measure	(5 to 60) °C  (-40 to 0) °C (0 to 200) °C (200 to 420) °C	0.14 °C  0.030°C 0.055°C 0.038°C	Rotronics HG2-S101 and Rotronics H290D sensor  Fluke 5618B & 1523
Temperature Measuring Equipment	(-40 to 0) °C (0 to 200) °C (200 to 420) °C	0.030°C 0.055°C 0.038°C	Fluke 5618B & 1523, comparison to reference thermometer

XII. Time & Frequency

Parameter/Equipment	Frequency	CMC <sup>2, 6, 8</sup> (±)	Comments
Frequency <sup>3</sup> – Measuring Equipment	1 µHz to 80 MHz  10 Hz to 4 GHz  10 MHz to 50 GHz	2.5 µHz/Hz + 1 µHz  0.03 nHz/Hz + 0.6 mHz  0.03 nHz/Hz + 0.6 Hz	With GPS conditioning: Agilent 33250  Fluke 9640  Agilent 83650B w/ option 008
Frequency <sup>3</sup> – Measure	1 Hz to 200 MHz 200 MHz to 50 GHz	0.06 nHz/Hz + 25 pHz 0.04 nHz/Hz + 2 Hz	With GPS conditioning: Agilent 5335A, 53132A, Agilent 53151A, 53132A, 8565E

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
Time Interval <sup>3</sup> – Measure	500 ps to 400 s	19 µHz/Hz + 24 ps	Tektronix TDS 7404B oscilloscope
10 MHz Source <sup>3</sup> (Rubidium)	10 MHz	0.03 nHz/Hz	Rubidium frequency standard referenced to GPS
Frequency <sup>3</sup> – Measure	10 MHz	0.003 nHz/Hz	Agilent 53132A referenced to GPS

<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. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of  $k = 2$ . The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

<sup>3</sup> Field calibration service is available for this calibration and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. 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> In the statement of CMC,  $L$  is the numerical value of the nominal length of the device measured in inches

<sup>5</sup> In the statement of CMC, all percentages shall be read as percent of reading, unless otherwise noted.

<sup>6</sup> Some of the types of instruments calibrated under these parameters are EMI Receivers, EFT/Burst Generators, ESD Guns and Targets, Surge Generators, Generators for Voltage Dips, Short Interrupts and Variations, Ring Wave Generators, Network Analyzers, Click Analyzers, Impulse Generators, Power Meters, Power Sensors, Signal Generators, Spectrum Analyzers, Attenuators and Terminations.

<sup>7</sup> In the statement of CMC,  $M$  is the mismatch uncertainty for the unit under test. Mismatch uncertainties, due to the reflection coefficient of the device to be calibrated, are to be included in the overall measurement uncertainty. The approach of determining expanded uncertainties, expressed at approximately the 95 % level of confidence, (using a coverage factor of  $k = 2$ ) is to be applied for this calculation as well.

<sup>8</sup> Instruments are calibrated against manufacturer's specifications. These calibrations may also, at customer request, be based on conformance to the calibration requirements of various standards such as CISPR 16-1-1, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-11, EN 61000-4-5, IEC 61000-4-2, IEC 61000-3-2, IEC 61000-4-7, IEC 61000-4-8, IEC 61000-4-9, IEC 61000-4-10, IEC 61000-4-11, IEC 61000-4-12, IEC 61000-4-13, IEC 61000-4-14, IEC 61000-4-15, ANSI 62.41:1991, ANSI C63.16, ANSI C62-41, UL 864, UL 1449, ISO 7637-2, ISO 17069, ITU Rec K.17, ITU Rec K.20, ITU Rec K.21, SBC-TP-76200, GR1089CORE and SAE J1113-13. Other standards may apply and the customer should contact the lab for further information.





## Accredited Laboratory

A2LA has accredited

# WORLD CAL, A DIVISION OF LIBERTY CALIBRATION, LLC

*Elk Horn, IA*

for technical competence in the field of

## Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSLI Z540-1-1994, ANSI/NCSLI Z540.3-2006, and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).



Presented this 7<sup>th</sup> day of December 2015.

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

President & CEO  
For the Accreditation Council  
Certificate Number 1818.01  
Valid to September 30, 2017  
Revised on November 30, 2016

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