



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

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CALIBRATION

Valid To: July 31, 2027

Certificate Number: 4201.02

In recognition of the successful completion of the A2LA evaluation process (including an assessment of the organization's compliance with R205 – A2LA's Calibration Program Requirements), accreditation is granted to this laboratory at the location listed above, as well as the satellite laboratory location listed below, to perform the following calibrations^{1, 6}:

I. Acoustics & Vibrations

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments
Microphones – Sensitivity (-50 to -20) dB	(20 to 31.5) Hz (31.5 to 5000) Hz (5000 to 6300) Hz (6300 to 8000) Hz (8000 to 10 000) Hz (10 000 to 12 500) Hz (12 500 to 16 000) Hz	Reference to 1 V/Pa 0.13 dB 0.10 dB 0.11 dB 0.24 dB 0.23 dB 0.27 dB 0.34 dB	B&K 4180 Agilent 34401A Agilent 33250A G.R.A.S 12AQ Spektra SQ-4.2 S.M.S.L Head box S2 3-port coupler
Sound Calibrators – Multifunction Calibrator (85 to 134) dB Pistonphone, Sound Calibrator (85 to 134) dB	31.5 Hz (31.5 to 12 500) Hz 250 Hz 1000 Hz	0.14 dB 0.12 dB 0.12 dB 0.12 dB	B&K 4190 Agilent 34401A G.R.A.S 12AQ

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
Sound Level Meters (85 to 134) dB	125 Hz (125 to 3150) Hz (3150 to 8000) Hz	0.4 dB 0.3 dB 0.4 dB	B&K 4190 Agilent 33220A Agilent 34401A G.R.A.S 12AQ 3-port coupler Spektra SQ-4.2 S.M.S.L head box S2
Vibration Transducers – Sensitivity Reference @ 80 Hz (0.001 to 1000) mV/(m/s ²)	5 Hz (5 to 8) Hz (8 to 20) Hz (20 to 630) Hz (630 to 1250) Hz (1250 to 2500) Hz (2500 to 5000) Hz (5000 to 10 000) Hz	2.6 % 2.3 % 1.4 % 1.3 % 1.4 % 1.8 % 2.3 % 3.0 %	Spektra SE-20 Agilent 34401A Agilent 33220A B&K 2693-014 APS PA180DM

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments
Vibration Tester –			
Acceleration (0.1 to 1000) m/s ²	5 Hz (5 to 8) Hz (8 to 10) Hz (10 to 315) Hz (315 to 630) Hz (630 to 1250) Hz (1250 to 3000) Hz	4.2 % 3.9 % 3.7 % 3.3 % 3.2 % 3.4 % 4.2 %	PCB 353B03 B&K 2693-014 Agilent 34401A Agilent 53181A
Displacement (0.001 to 100) mm	5 Hz (5 to 8) Hz (8 to 10) Hz (10 to 80) Hz (80 to 100) Hz (100 to 160) Hz (160 to 315) Hz	5.3 % 5.2 % 3.5 % 3.0 % 3.1 % 3.7 % 8.6 %	
Frequency	(5 to 8) Hz (8 to 3000) Hz	0.58 mHz 5.8 mHz	

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Vibration Calibrator –			
Acceleration	20 Hz (20 to 1250) Hz	2.3 % 2.2 %	PCB 353B03 B&K 2693-014 Agilent 34401A APS PA180DM

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
Vibration Meters – Acceleration (0.1 to 500) m/s ² Velocity (0.1 to 500) mm/s Displacement (1 to 10 000) µm	10 Hz	2.9 %	Spectra SE-20 (with BN-09) B&K 2693-014 Agilent 34401A APS PA180DM
	(10 to 20) Hz	2.0 %	
	(20 to 630) Hz	1.9 %	
	(630 to 1250) Hz	2.1 %	
	(1250 to 2500) Hz	2.2 %	
	10 Hz	2.9 %	
	(10 to 315) Hz	1.9 %	
	(315 to 630) Hz	2.0 %	
	(630 to 1250) Hz	2.3 %	
	10 Hz	2.9 %	
	(10 to 20) Hz	2.1 %	
	(20 to 160) Hz	1.9 %	
	(160 to 315) Hz	2.1 %	

II. Antennas

Parameter/Range	Frequency	CMC ² ($\pm$)	Comments
Loop Antenna – Antenna Factor Up to 110 dB/m	9 kHz to 30 MHz	1.1 dB	Agilent E4440A Agilent 33250A Agilent 3458A IEEE/IEC 291, SAE ARP958 CISPR 16-1-6 ANSI C63.5: Standard loop antenna method
Monopole Antenna – Antenna Factor Up to 110 dB/m	9 kHz to 30 MHz	1.3 dB	Keysight E5061B Keysight 85032F IEEE/IEC 291, CISPR 16-1-4, ANSI C63.5, SAE ARP958, CISPR 16-1-6
Horn, Dipole, Biconical Antenna – Antenna Factor Up to 80 dB/m Balance Up to 20 dB VSWR 1 to 60	(0.7 to 1) GHz (1 to 18) GHz (18 to 40) GHz 700 MHz to 1 GHz (1 to 18) GHz (18 to 40) GHz 700 MHz to 1 GHz (1 to 18) GHz (18 to 40) GHz	0.7 dB 0.89 dB 1.4 dB 0.33 dB 0.38 dB 0.33 dB 0.1 0.1 0.1	Keysight E5080B Keysight 85054D Keysight 85056D Maury 8770F ANSI C63.5, ANSI C63.4, SAE ARP958, CISPR 16-1-6, CISPR 16-1-4 Three antenna method 3 m antenna chamber

III. Dimensional

Parameter/Equipment	Range	CMC ² (±)	Comments
Angle Gauges/Bevel Protractors ³	Up to 360°	0.03°	Comparison to angle gauge blocks
Calipers/Caliper Gauges ³	Up to 1 in (1 to 12) in (12 to 24) in (24 to 40) in	0.10 min 0.40 min 0.0010 in 0.0014 in	Comparison to gauge blocks
Cylinder/Bore Gauges ³	Up to 32 in	92 µin	Comparison to gauge blocks, dial gauge testers
Depth Gauges ³	Up to 0.5 in (0.5 to 4) in (4 to 12) in (12 to 24) in	67 µin 0.000 40 in 0.000 61 in 0.000 94 in	Comparison to gauge blocks
Dial/Test Indicators/Digital Indicators ³	Up to 0.2 in (0.2 to 1) in (1 to 4) in	10 µin 30 µin 11 min	Comparison to gauge blocks or calibration tester
Feeler Gauges	Up to 0.2 in	37 µin	Bench micrometer
Height Gauges/Measuring Machines ³	Up to 4 in (4 to 12) in (12 to 24) in (24 to 40) in	0.14 min 0.35 min 0.63 min 0.0011 in	Comparison to gauge blocks

Parameter/Equipment	Range	CMC ² (±)	Comments
Micrometers ³ –			
Outside	Up to 1 in (1 to 4) in (4 to 20) in	37 µin 0.16 min 0.64 min	Comparison to gauge blocks
Inside	(0.2 to 1.2) in (1.2 to 4) in (4 to 8) in (8 to 40) in	90 µin 0.17 min 0.27 min 0.0012 in	
Depth	Up to 2 in (2 to 6) in	0.11 min 0.11 min	

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 7} (±)	Comments
DC Voltage – Generate ³	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V	1.5 x 10 ⁻⁵ V/V 6.8 x 10 ⁻⁶ V/V 4.5 x 10 ⁻⁶ V/V 6.4 x 10 ⁻⁶ V/V 8.2 x 10 ⁻⁶ V/V	Fluke 5730A
High Voltage	(1 to 3) kV (3 to 10) kV (10 to 20) kV (20 to 25) kV (25 to 30) kV	1.1 x 10 ⁻³ V/V 7.8 x 10 ⁻⁴ V/V 2.1 x 10 ⁻³ V/V 8.5 x 10 ⁻⁴ V/V 1.1 x 10 ⁻³ V/V	Matsusada AU-30P1-L Matsusada AU-30N1-L
DC Current – Generate ³	Up to 10 µA (10 to 100) µA 100 µA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A (1 to 10) A (10 to 20) A (20 to 100) A	7.4 x 10 ⁻⁴ A/A 1.2 x 10 ⁻⁴ A/A 5.4 x 10 ⁻⁵ A/A 5.1 x 10 ⁻⁵ A/A 6.1 x 10 ⁻⁵ A/A 1.1 x 10 ⁻⁴ A/A 1.9 x 10 ⁻⁴ A/A 1.4 x 10 ⁻⁴ A/A 7.0 x 10 ⁻⁴ A/A	Fluke 5730A Fluke 52120A

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
DC Current – Generate ³ (cont)	(100 to 200) A (200 to 900) A 900 A to 1 kA (1 to 1.5) kA (1.5 to 2) kA (2 to 2.5) kA	3.8×10^{-4} A/A 3.0×10^{-4} A/A 6.6×10^{-4} A/A 4.5×10^{-4} A/A 3.5×10^{-4} A/A 2.9×10^{-4} A/A	Fluke 5730A Fluke 52120A Fluke 25 Turn 3000A
Resistance – Generate ³	100 m Ω (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (0.1 to 1) k Ω (1 to 10) k Ω (10 to 100) k Ω (0.1 to 1) M Ω (1 to 10) M Ω (10 to 100) M Ω (0.1 to 1) G Ω (1 to 10) G Ω (10 to 100) G Ω	0.61 m Ω 6.2×10^{-4} Ω/Ω 9.9×10^{-5} Ω/Ω 7.5×10^{-5} Ω/Ω 7.1×10^{-5} Ω/Ω 7.1×10^{-5} Ω/Ω 7.1×10^{-5} Ω/Ω 7.5×10^{-5} Ω/Ω 6.9×10^{-5} Ω/Ω 1.2×10^{-4} Ω/Ω 3.3×10^{-4} Ω/Ω 3.7×10^{-4} Ω/Ω 3.7×10^{-4} Ω/Ω	IET HARS-X10-0.0001-K-H IET HARS-B-4-10M-5kV
Fixed Points	1 m Ω 10 m Ω 100 m Ω 1 Ω 10 Ω 100 Ω 1 k Ω 10 k Ω 100 k Ω 1 M Ω 10 M Ω 100 M Ω 1 G Ω 10 G Ω 100 G Ω 1 T Ω	0.41 $\mu\Omega$ 2.1×10^{-4} Ω/Ω 1.3×10^{-4} Ω/Ω 3.3×10^{-5} Ω/Ω 2.7×10^{-5} Ω/Ω 2.5×10^{-5} Ω/Ω 2.5×10^{-5} Ω/Ω 2.5×10^{-6} Ω/Ω 2.5×10^{-5} Ω/Ω 2.8×10^{-5} Ω/Ω 3.6×10^{-5} Ω/Ω 5.6×10^{-5} Ω/Ω 1.2×10^{-3} Ω/Ω 1.2×10^{-3} Ω/Ω 4.1×10^{-3} Ω/Ω 4.0×10^{-2} Ω/Ω	SARC-0.001 SARC-0.01 SARC-0.1 SARC-1 SARC-10 SARC-100 SARC-1K SARC-10K SARC-100K SARC-1M SARC-10M SAX-100M SAC-1G SAC-10G SAC-100G SAC-1T

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
DC Voltage – Measure ³	Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	7.0×10^{-6} V/V 4.0×10^{-6} V/V 4.0×10^{-6} V/V 6.0×10^{-6} V/V 6.0×10^{-6} V/V	Agilent 3458A
	(1 to 4) kV (4 to 9) kV (9 to 10) kV (10 to 30) kV (30 to 50) kV (50 to 70) kV	2.5×10^{-4} V/V 5.1×10^{-4} V/V 7.5×10^{-5} V/V 2.2×10^{-4} V/V 3.6×10^{-4} V/V 4.9×10^{-4} V/V	Vitretek 4700 & HVL-150
DC Current – Measure ³	(0.1 to 1) μ A (1 to 10) μ A (10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	3.0×10^{-4} A/A 8.0×10^{-4} A/A 2.0×10^{-5} A/A 1.4×10^{-5} A/A 1.5×10^{-5} A/A 5.2×10^{-5} A/A 2.4×10^{-4} A/A	Agilent 3458A
	(1 to 10) A (10 to 100) A (100 to 300) A (300 to 500) A (500 to 2000) A	7.3×10^{-4} A/A 7.1×10^{-4} A/A 1.1×10^{-3} A/A 1.1×10^{-3} A/A 2.1×10^{-2} A/A	Keysight 34330A Ohmlabs CS-100 Guildline 9230A-500 Fluke 353

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
DC Resistance – Measure ³	(10 to 100) Ω	$9.0 \times 10^{-6} \Omega/\Omega$	Agilent 3458A IET 1865+
	(0.1 to 1) k Ω	$8.9 \times 10^{-6} \Omega/\Omega$	
	(1 to 10) k Ω	$9.0 \times 10^{-6} \Omega/\Omega$	
	(10 to 100) k Ω	$9.2 \times 10^{-6} \Omega/\Omega$	
	(0.1 to 1) M Ω	$1.0 \times 10^{-5} \Omega/\Omega$	
	(1 to 10) M Ω	$9.0 \times 10^{-6} \Omega/\Omega$	
	(10 to 100) M Ω	$5.2 \times 10^{-5} \Omega/\Omega$	
	(0.1 to 1) G Ω	$2.3 \times 10^{-4} \Omega/\Omega$	
	(1 to 10) G Ω	$1.4 \times 10^{-3} \Omega/\Omega$	
	(10 to 100) G Ω	$8.0 \times 10^{-4} \Omega/\Omega$	
	(0.1 to 1) T Ω	$4.0 \times 10^{-2} \Omega/\Omega$	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage – Generate ³			
2 mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	5.3 μ V 2.7×10^{-3} V/V 2.6×10^{-3} V/V 2.5×10^{-3} V/V 2.5×10^{-3} V/V 2.6×10^{-3} V/V 3.5×10^{-3} V/V 7.1×10^{-3} V/V 1.4×10^{-2} V/V 1.5×10^{-2} V/V	Fluke 5730A
(2 to 10) mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	7.8 μ V 7.6×10^{-4} V/V 6.1×10^{-4} V/V 5.7×10^{-4} V/V 5.7×10^{-4} V/V 7.1×10^{-4} V/V 1.2×10^{-3} V/V 2.5×10^{-3} V/V 4.0×10^{-3} V/V 5.5×10^{-3} V/V	
(10 to 100) mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	43 μ V 4.2×10^{-4} V/V 2.0×10^{-4} V/V 1.6×10^{-4} V/V 1.6×10^{-4} V/V 2.4×10^{-4} V/V 5.8×10^{-4} V/V 1.1×10^{-3} V/V	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage – Generate ³ (cont)			
(10 to 100) mV	(300 to 500) kHz 500 kHz to 1 MHz	2.0×10^{-3} V/V 4.0×10^{-3} V/V	Fluke 5730A
100 mV to 1 V	10 Hz	0.35 mV	
	(10 to 20) Hz	3.3×10^{-4} V/V	
	(20 to 40) Hz	1.3×10^{-4} V/V	
	40 Hz to 1 kHz	6.2×10^{-5} V/V	
	(1 to 20) kHz	6.3×10^{-5} V/V	
	(20 to 50) kHz	1.0×10^{-4} V/V	
	(50 to 100) kHz	1.4×10^{-4} V/V	
	(100 to 300) kHz	5.2×10^{-4} V/V	
	(300 to 500) kHz	1.5×10^{-3} V/V	
	500 kHz to 1 MHz	2.5×10^{-3} V/V	
(1 to 10) V	10 Hz	3.3 mV	
	(10 to 20) Hz	3.3×10^{-4} V/V	
	(20 to 40) Hz	1.3×10^{-4} V/V	
	40 Hz to 1 kHz	6.0×10^{-5} V/V	
	(1 to 20) kHz	6.1×10^{-5} V/V	
	(20 to 50) kHz	1.0×10^{-4} V/V	
	(50 to 100) kHz	1.3×10^{-4} V/V	
	(100 to 300) kHz	4.1×10^{-4} V/V	
	(300 to 500) kHz	1.5×10^{-3} V/V	
	500 kHz to 1 MHz	2.8×10^{-3} V/V	
(10 to 100) V	10 Hz	33 mV	
	(10 to 20) Hz	3.3×10^{-4} V/V	
	(20 to 40) Hz	1.4×10^{-4} V/V	
	40 Hz to 1 kHz	7.7×10^{-5} V/V	
	(1 to 20) kHz	8.0×10^{-5} V/V	
	(20 to 50) kHz	1.2×10^{-4} V/V	
	(50 to 100) kHz	2.3×10^{-4} V/V	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage – Generate ³ (cont)			
(100 to 500) V	50 Hz 50 Hz to 1 kHz	0.20 V 1.0 x 10 ⁻⁴ V/V	Fluke 5730A
(500 to 1000) V	50 Hz 50 Hz to 1 kHz	0.37 V 8.9 x 10 ⁻⁵ V/V	
(1 to 10) kV	50 Hz 60 Hz	0.47 kV 0.47 kV	
(10 to 20) kV	50 Hz 60 Hz	0.48 kV 0.48 kV	
(20 to 30) kV	50 Hz 60 Hz	0.50 kV 0.50 kV	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Current – Generate ³			
20 μ A	1 kHz (1 to 10) kHz	0.012 μ A 5.1 x 10 ⁻³ A/A	Fluke 5730A Fluke 52120A Fluke 5522A
(20 to 100) μ A	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.050 μ A 5.0 x 10 ⁻⁴ A/A 3.2 x 10 ⁻⁴ A/A 2.4 x 10 ⁻⁴ A/A 5.8 x 10 ⁻⁴ A/A 2.1 x 10 ⁻³ A/A	
100 μ A to 1 mA	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.38 μ A 3.6 x 10 ⁻⁴ A/A 2.5 x 10 ⁻⁴ A/A 1.9 x 10 ⁻⁴ A/A 3.9 x 10 ⁻⁴ A/A 2.1 x 10 ⁻³ A/A	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
AC Current – Generate ³ (cont)			
(1 to 10) mA	0 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	4.2 µA 3.6×10^{-4} A/A 2.5×10^{-4} A/A 1.9×10^{-4} A/A 3.3×10^{-4} A/A 1.9×10^{-3} A/A	Fluke 5730A
(10 to 100) mA	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	43 µA 3.6×10^{-4} A/A 2.5×10^{-4} A/A 2.0×10^{-4} A/A 3.2×10^{-4} A/A 1.5×10^{-3} A/A	
100 mA to 1 A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	1.5 mA 1.5×10^{-3} A/A 1.6×10^{-3} A/A 2.2×10^{-3} A/A 1.4×10^{-2} A/A 3.8×10^{-2} A/A 9.0×10^{-2} A/A	Fluke 5730A
(1 to 20) A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	14 mA 7.0×10^{-4} A/A 8.3×10^{-4} A/A 1.5×10^{-3} A/A 4.6×10^{-3} A/A 1.3×10^{-2} A/A 3.3×10^{-2} A/A	
(20 to 100) A	50 to 60) Hz (60 to 400) Hz	3.0×10^{-3} A/A 3.7×10^{-3} A/A	
(100 to 200) A	(50 to 60) Hz (60 to 400) Hz	1.6×10^{-3} A/A 2.3×10^{-3} A/A	
(200 to 300) A	(50 to 60) Hz (60 to 400) Hz	1.1×10^{-3} A/A 1.9×10^{-3} A/A	
(300 to 400) A	(50 to 60) Hz (60 to 400) Hz	8.5×10^{-4} A/A 1.6×10^{-3} A/A	
(400 to 500) A	(50 to 60) Hz (60 to 400) Hz	7.2×10^{-4} A/A 1.5×10^{-3} A/A	
(500 to 750) A	(50 to 60) Hz (60 to 400) Hz	9.0×10^{-4} A/A 4.6×10^{-3} A/A	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Current – Generate ³ (cont)			
(750 to 900) A	(50 to 60) Hz (60 to 400) Hz	7.8×10^{-4} A/A 4.0×10^{-3} A/A	Fluke 5730A
(900 to 1000) A	(50 to 60) Hz (60 to 400) Hz	9.4×10^{-4} A/A 3.7×10^{-3} A/A	Fluke 5730A Fluke 52120A Fluke 25 turn 3000A
(1000 to 1500) A	(50 to 60) Hz (60 to 400) Hz	6.8×10^{-4} A/A 2.8×10^{-3} A/A	
(1500 to 2000) A	(50 to 60) Hz (60 to 400) Hz	5.5×10^{-4} A/A 2.3×10^{-3} A/A	
(2000 to 2500) A	(50 to 60) Hz (60 to 400) Hz	4.7×10^{-4} A/A 2.1×10^{-3} A/A	
(2500 to 3000) A	(50 to 60) Hz (60 to 400) Hz	4.2×10^{-4} A/A 1.9×10^{-3} A/A	
AC Resistance – Generate ³			
1 m Ω 10 m Ω 100 m Ω 1 Ω 10 Ω 100 Ω 1 k Ω 10 k Ω 100 k Ω	1 kHz	6.1 $\mu\Omega$ 16 $\mu\Omega$ 0.33 m Ω 1.3 m Ω 4.2 m Ω 42 m Ω 0.43 Ω 4.2 Ω 42 Ω	Keysight 42030A
Capacitance – Generate ³			
1 pF (1 to 10) pF (10 to 100) pF 100 pF to 1 nF	1 kHz	0.35 fF 3.5 fF 35 fF 0.41 pF	Keysight 16380C
(1 to 10) nF	120 Hz 120 Hz to 1 kHz	0.74 pF 7.4×10^{-5} F/F	
(10 to 100) nF	120 Hz 120 Hz to 1 kHz	9.1 pF 1.3×10^{-3} F/F	
100 nF to 1 μ F	120 Hz 120 Hz to 1 kHz	0.22 pF 1.0×10^{-2} F/F	

Parameter/Range	Frequency	CMC ^{2,7} (±)	Comments
Inductance – Generate ³			
100 µH 100 µH to 10 H	100 Hz	34 nH 1.2 x 10 ⁻³ H/H	IET 1482 series
100 µH 100 µH to 10 H	200 Hz	34 nH 1.2 x 10 ⁻³ H/H	
100 µH 100 µH to 10 H	400 Hz	34 nH 1.2 x 10 ⁻³ H/H	
100 µH 100 µH to 1 H (1 to 10) H	1 kHz	31 nH 1.2 x 10 ⁻³ H/H 1.3 x 10 ⁻³ H/H	
100 µH 100 µH to 100 mH	10 kHz	34 nH 1.2 x 10 ⁻³ H/H	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage – Measure ³			
10 mV	10 Hz 10 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	3.6 μ V 3.6×10^{-4} V/V 4.8×10^{-4} V/V 3.6×10^{-3} V/V 3.6×10^{-3} V/V 1.3×10^{-2} V/V	Fluke 8588A
(10 to 100) mV	10 Hz 10 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	8 μ V 8.0×10^{-5} V/V 2.5×10^{-4} V/V 6.4×10^{-4} V/V 6.4×10^{-4} V/V 2.7×10^{-3} V/V 1.3×10^{-2} V/V	
100 mV to 1 V	10 Hz 10 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.08 mV 8.0×10^{-5} V/V 2.5×10^{-4} V/V 6.4×10^{-4} V/V 6.4×10^{-4} V/V 2.7×10^{-3} V/V 1.3×10^{-2} V/V	
(1 to 10) V	10 Hz 10 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.8 mV 8.0×10^{-5} V/V 2.5×10^{-4} V/V 6.4×10^{-4} V/V 6.4×10^{-4} V/V 2.7×10^{-3} V/V 1.3×10^{-2} V/V	
(10 to 100) V	10 Hz 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	8 mV 2.5×10^{-4} V/V 6.4×10^{-4} V/V 7.0×10^{-3} V/V	
(100 to 700) V	50 Hz 50 Hz to 1 kHz (1 to 10) kHz	0.09 V 1.3×10^{-4} V/V 1.3×10^{-4} V/V	
700 V to 1 kV	(50 to 60) Hz (60 to 400) Hz	2.3×10^{-3} V/V 4.8×10^{-3} V/V	Vitretek 4700
(1 to 9) kV	(50 to 60) Hz	1.9×10^{-3} V/V	
(9 to 10) kV	(50 to 60) Hz	6.1×10^{-3} V/V	
(10 to 50) kV	(50 to 60) Hz	5.9×10^{-3} V/V	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Current – Measure ³			
100 μ A	10 Hz (10 to 40) Hz 40 Hz to 5 kHz	38 nA 4.0×10^{-4} A/A 7.0×10^{-4} A/A	Fluke 8588A
100 μ A to 1 mA	10 Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz	0.36 μ A 4.0×10^{-4} A/A 3.6×10^{-4} A/A 3.6×10^{-4} A/A 6.4×10^{-4} A/A	
(1 to 10) mA	10 Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz	3.6 μ A 4.0×10^{-4} A/A 3.6×10^{-4} A/A 3.6×10^{-4} A/A 6.4×10^{-4} A/A	
(10 to 100) mA	10 Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz	36 μ A 4.0×10^{-4} A/A 3.6×10^{-4} A/A 3.6×10^{-4} A/A 6.4×10^{-4} A/A	
100 mA to 1 A	10 Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz	0.42 mA 5.0×10^{-4} A/A 5.0×10^{-4} A/A 5.0×10^{-4} A/A 8.0×10^{-4} A/A	Fluke 8588A Ohmlabs CS-10 Ohmlabs CS-100
(1 to 10) A	(40 to 100) Hz 100 Hz to 1 kHz	4.6×10^{-4} A/A 1.1×10^{-3} A/A	
(10 to 50) A	(40 to 100) Hz 100 Hz to 1 kHz	1.2×10^{-3} A/A 2.1×10^{-3} A/A	
(50 to 100) A	(40 to 100) Hz 100 Hz to 1 kHz	1.2×10^{-3} A/A 2.1×10^{-3} A/A	
(100 to 300) A (300 to 600) A (600 to 800) A (800 to 1000) A (1000 to 1400) A	60 Hz	2.0×10^{-4} A/A 1.0×10^{-4} A/A 7.3×10^{-5} A/A 5.8×10^{-4} A/A 4.6×10^{-2} A/A	Fluke 353

Parameter/Range	Frequency	CMC ^{2,7} (±)	Comments
AC Resistance – Measure ³			
1 kHz	100 mΩ (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (0.1 to 1) kΩ	2.6 mΩ $2.7 \times 10^{-3} \Omega/\Omega$ $1.3 \times 10^{-3} \Omega/\Omega$ $1.3 \times 10^{-3} \Omega/\Omega$ $1.3 \times 10^{-3} \Omega/\Omega$	HP 4284A
1 kHz	(1 to 10) kΩ (10 to 100) kΩ	$1.3 \times 10^{-3} \Omega/\Omega$ $1.3 \times 10^{-3} \Omega/\Omega$	HP 4284A
Capacitance – Measure ³			
1 kHz	10 pF 10 pF to 1 μF	37 fF $3.7 \times 10^{-3} \text{ F/F}$	HP 4284A
Inductance – Measure ³			
1 kHz	100 μH (0.1 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H	22 nH $3.5 \times 10^{-3} \text{ H/H}$ $1.2 \times 10^{-3} \text{ H/H}$ $1.2 \times 10^{-3} \text{ H/H}$ $1.2 \times 10^{-3} \text{ H/H}$	HP 4284A
Power – Generate ³			
AC Power: 0.6 W (0.6 to 2.4) W (2.4 to 24) W (24 to 60) W (60 to 120) W (120 to 240) W (240 to 600) W 600 W to 2.4 kW	(50 to 60) Hz	0.51 mW $7.6 \times 10^{-4} \text{ W/W}$ $1.2 \times 10^{-3} \text{ W/W}$ $9.4 \times 10^{-4} \text{ W/W}$ $1.1 \times 10^{-3} \text{ W/W}$ $9.7 \times 10^{-4} \text{ W/W}$ $7.9 \times 10^{-4} \text{ W/W}$ $8.4 \times 10^{-4} \text{ W/W}$	Fluke 6105A
(2.4 to 4.8) kW		$8.0 \times 10^{-4} \text{ W/W}$	Fluke 6105A
(4.8 to 6) kW (6 to 60) kW (60 to 120) kW (120 to 240) kW		$9.7 \times 10^{-4} \text{ W/W}$ $8.4 \times 10^{-4} \text{ W/W}$ $8.0 \times 10^{-4} \text{ W/W}$ $8.0 \times 10^{-4} \text{ W/W}$	Fluke 6105A / 52120A Fluke 25 Turn 3000 A coil
Power Factor: Lag/Lead 0.1 Lag/Lead 0.5 Lag/Lead 1.0	(50 to 60) Hz	0.01 0.002 0.0008	Fluke 5522A Fluke 6105A

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
Power – Generate ³ (cont)			
Total Harmonic Distortion THD-V (0.5 to 20) % THD-I (0.5 to 20) %	(50 to 60) Hz	0.050 % 0.048 %	Fluke 6105A
Perpetual Flicker	P _{inst max} Range (1 to 4000) cpm: 1 P _{st} Range 0.25 (0.25 to 5)	0.50 % 0.49 % 0.52 %	Fluke 6105A Zimmer LMG 611 Pst: percent short-term cpm: rectangular changes per minute
Power – Measure ³			
AC Power: 18 mW (18 to 36) mW (36 to 180) mW (180 to 360) mW (360 to 750) mW 750 mW to 1.2 W (1.2 to 3.6) W (3.6 to 12) W (12 to 600) W 600 W to 1.2 kW (1.2 to 2.4) kW	(50 to 60) Hz	17 µW 5.7×10^{-4} W/W 4.0×10^{-4} W/W 4.3×10^{-4} W/W 4.0×10^{-4} W/W 7.0×10^{-4} W/W 4.0×10^{-4} W/W 3.9×10^{-4} W/W 3.5×10^{-4} W/W 7.0×10^{-4} W/W 4.6×10^{-4} W/W	Zimmer LMG 611
Power Factor Lag/Lead 0.1 Lag/Lead 0.5 Lag/Lead 1.0	(50 to 60) Hz	0.020 0.0040 0.0017	

Parameter/Equipment	Range	CMC ^{2, 7} (±)	Comments
Electrical Simulation of Thermocouples ³ –			
Type E	(-250 to -100) °C (-100 to 650) °C (650 to 1000) °C	0.17 °C 0.20 °C 0.20 °C	Fluke 5522A
Type J	(-210 to -100) °C (-100 to 760) °C (760 to 1200) °C	0.17 °C 0.21 °C 0.21 °C	
Type K	(-200 to -100) °C (-100 to 1000) °C (1000 to 1372) °C	0.18 °C 0.33 °C 0.33 °C	
Type S	(0 to 250) °C (250 to 1400) °C (1400 to 1767) °C	0.30 °C 0.38 °C 0.38 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 400) °C	0.22 °C 0.17 °C 0.16 °C	
Power – Generate ³ DC Power	0.12 V·A (0.12 to 0.24) V·A (0.24 to 0.6) V·A (0.6 to 1.2) V·A (1.2 to 2.4) V·A (2.4 to 4.8) V·A (4.8 to 6) V·A (6 to 12) V·A (12 to 24) V·A (24 to 60) V·A (60 to 120) V·A (120 to 240) V·A (240 to 480) V·A (480 to 600) V·A (0.6 to 1.2) kV·A (1.2 to 2.4) kV·A (2.4 to 4.8) kV·A (4.8 to 20) kV·A	0.070 % 0.038 % 0.022 % 0.019 % 0.015 % 0.014 % 0.018 % 0.016 % 0.015 % 0.033 % 0.029 % 0.046 % 0.046 % 0.069 % 0.064 % 0.12 % 0.12 % 0.12 %	Fluke 5522A

Parameter/Equipment	Range	CMC ^{2, 7} (±)	Comments
Electrical Stimulation of RTDs ³ – PT385, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 200) °C (200 to 300) °C (300 to 400) °C (400 to 500) °C (500 to 600) °C (600 to 700) °C (700 to 800) °C	0.041 °C 0.066 °C 0.066 °C 0.066 °C 0.073 °C 0.081 °C 0.081 °C 0.16 °C 0.16 °C	Fluke 5522A

V. Electrical – DC/Low Frequency Equipment

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
Oscilloscope ³ –			
DC Voltage 1 M Ω	1 mV (1 to 1.9) mV (1.9 to 2.3) mV (2.3 to 5) mV (5 to 6) mV (6 to 19) mV (19 to 23) mV (23 to 50) mV (50 to 60) mV (60 to 190) mV (190 to 230) mV (230 to 500) mV (500 to 600) mV 600 mV to 2.3 V (2.3 to 190) V	0.030 mV 1.6×10^{-2} V/V 1.3×10^{-2} V/V 6.1×10^{-3} V/V 5.2×10^{-3} V/V 1.9×10^{-3} V/V 1.6×10^{-3} V/V 8.7×10^{-4} V/V 7.7×10^{-4} V/V 4.5×10^{-4} V/V 4.2×10^{-4} V/V 3.5×10^{-4} V/V 3.4×10^{-4} V/V 3.1×10^{-4} V/V 3.0×10^{-4} V/V	Fluke 9500B Fluke 5522A
@50 Ω	0 mV Up to 2.5 mV (2.5 to 9.9) mV (9.9 to 25) mV (25 to 110) mV 110 mV to 7.0 V	0.047 mV 2.2×10^{-2} V/V 7.6×10^{-3} V/V 4.8×10^{-3} V/V 3.4×10^{-3} V/V 3.0×10^{-3} V/V	
Square Wave Signal 50 Ω , 1 kHz	1 mV (1 to 2) mV (2 to 5) mV (5 to 10) mV (10 to 20) mV (20 to 50) mV (50 to 100) mV (100 to 200) mV 200 mV to 5 V	0.050 mV 2.7×10^{-2} V/V 1.3×10^{-2} V/V 7.6×10^{-3} V/V 5.3×10^{-3} V/V 3.9×10^{-3} V/V 3.4×10^{-3} V/V 3.2×10^{-3} V/V 3.0×10^{-3} V/V	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
Oscilloscope ³ – (cont)			
3 dB Bandwidth (0.06 to 3) V	50 kHz to 550 MHz 550 MHz to 40 GHz	3.4×10^{-2} V/V 2.4×10^{-2} V/V	Keysight E8257D Keysight N1914A Keysight N8487A H.P. 11667C
Time Marker	0.5 ns (0.5 to 1) ns (1 to 2) ns (2 to 5) ns (5 to 10) ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1) μ s (1 to 2) μ s (2 to 5) μ s (5 to 10) μ s (10 to 20) μ s (20 to 50) μ s (50 to 100) μ s (100 to 200) μ s (200 to 500) μ s (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 500) ms (0.5 to 5) s	6.2 fs 6.2×10^{-6} s/s 3.1×10^{-6} s/s 1.3×10^{-6} s/s 6.2×10^{-6} s/s 3.1×10^{-6} s/s 1.3×10^{-6} s/s 6.2×10^{-6} s/s 3.1×10^{-6} s/s 1.3×10^{-6} s/s 6.2×10^{-6} s/s 3.1×10^{-6} s/s 1.3×10^{-6} s/s 6.2×10^{-6} s/s 3.1×10^{-6} s/s 1.3×10^{-6} s/s 7.1×10^{-6} s/s 4.7×10^{-6} s/s 3.7×10^{-6} s/s 7.1×10^{-6} s/s 4.7×10^{-6} s/s 3.7×10^{-6} s/s 7.1×10^{-6} s/s 4.3×10^{-6} s/s 8.7×10^{-5} s/s 1.2×10^{-3} s/s	
Frequency	100 mHz (100 to 200) mHz (200 to 500) mHz (0.5 to 1) Hz (1 to 2) Hz (2 to 5) Hz (5 to 10) Hz (10 to 20) Hz (20 to 50) Hz (50 to 100) Hz (100 to 200) Hz (200 to 500) Hz	1.4 μ Hz 8.4×10^{-6} Hz/Hz 6.5×10^{-6} Hz/Hz 8.7×10^{-6} Hz/Hz 6.8×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 8.6×10^{-6} Hz/Hz 6.8×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 8.6×10^{-6} Hz/Hz 6.8×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz	Fluke 9500B

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
Oscilloscope ³ – (cont)			
Frequency	(0.5 to 1) kHz (1 to 2) kHz (2 to 5) kHz (5 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz (0.5 to 1) MHz (1 to 2) MHz (2 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 50) MHz (50 to 100) MHz (100 to 200) MHz (200 to 500) MHz (0.5 to 1) GHz (1 to 2) GHz	8.6×10^{-6} Hz/Hz 8.4×10^{-6} Hz/Hz 6.5×10^{-6} Hz/Hz 8.7×10^{-6} Hz/Hz 6.8×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 8.6×10^{-6} Hz/Hz 6.8×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 3.1×10^{-6} Hz/Hz 1.4×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 3.1×10^{-6} Hz/Hz 1.4×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 3.1×10^{-6} Hz/Hz 1.4×10^{-6} Hz/Hz 6.2×10^{-6} Hz/Hz 3.1×10^{-6} Hz/Hz	Fluke 9500B
Leakage Current Network ³			
20 Hz to 1 MHz	Input Voltage to Output Voltage Ratio (1 to 1384)	0.45 % of ratio	Fluke 5730A Fluke 8588A
20 Hz to 1 MHz	Input Voltage to Output Voltage Ratio (0.5 to 689)	0.50 % of ratio	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
Probes ³ – Bandwidth			
50 kHz (0.05 to 100) MHz (100 to 300) MHz (300 to 500) MHz	(100 to 300) mV	3.9×10^{-2} V/V 4.2×10^{-2} V/V 5.9×10^{-2} V/V 6.1×10^{-2} V/V	Fluke 9500B Tektronix DPO 4054
50 kHz (0.05 to 100) MHz (100 to 300) MHz (300 to 500) MHz	(0.3 to 3) V	4.2×10^{-2} V/V 6.0×10^{-2} V/V 7.3×10^{-2} V/V 7.4×10^{-2} V/V	
Current Shunts ³			
DC:	Up to 0.001 Ω (0.001 to 0.01) Ω (0.01 to 0.1) Ω (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω	0.15 $\mu\Omega$ 4.0×10^{-4} Ω/Ω 1.2×10^{-4} Ω/Ω 6.2×10^{-5} Ω/Ω 5.0×10^{-5} Ω/Ω 5.3×10^{-5} Ω/Ω 1.2×10^{-4} Ω/Ω	Fluke 5730A Fluke 52120A Agilent 3458A
40 Hz	Up to 0.001 Ω (0.001 to 0.01) (0.01 to 0.1) Ω (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω	0.48 $\mu\Omega$ 1.3×10^{-3} Ω/Ω 5.2×10^{-4} Ω/Ω 3.3×10^{-4} Ω/Ω 3.6×10^{-4} Ω/Ω 3.6×10^{-4} Ω/Ω 4.1×10^{-4} Ω/Ω	
(40 to 100) Hz	Up to 0.001 Ω (0.001 to 0.01) Ω (0.01 to 0.1) Ω (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω	0.66 $\mu\Omega$ 2.1×10^{-3} Ω/Ω 4.3×10^{-4} Ω/Ω 3.3×10^{-4} Ω/Ω 3.1×10^{-4} Ω/Ω 3.1×10^{-4} Ω/Ω 3.4×10^{-4} Ω/Ω	
100 Hz to 1 kHz	Up to 0.001 Ω (0.001 to 0.01) Ω (0.01 to 0.1) Ω (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω	2.1 $\mu\Omega$ 2.1×10^{-3} Ω/Ω 4.2×10^{-4} Ω/Ω 2.9×10^{-4} Ω/Ω 3.0×10^{-4} Ω/Ω 3.0×10^{-4} Ω/Ω 3.3×10^{-4} Ω/Ω	

VI. Electrical – RF/EMC Equipment

Parameter/Range	Frequency	CMC ^{2, 4, 7} ($\pm$)	Comments
RF Power Meters ³ – Instrument Accuracy	3 μ W to 100 mW	2.9 mW/W	Keysight 11683A
0 dBm	1 mW at 50 MHz	0.038 dB	R&S NRP50T

Parameter/Equipment	Range	CMC ^{2, 4, 7} ($\pm$)	Comments
Display Linearity ³ – Measuring Equipment	(0 to 40) dB (40 to 96) dB	0.16 dB 0.19 dB	Keysight E8257D Keysight J7211C
Spectrum Analyzer ³ –			
Frequency Readout	5 Hz to 50 GHz	$9.6 \times 10^{-4} \cdot \text{SPAN}$	SRS FS740 Agilent 33250A Keysight E8257D
Marker Frequency Counter	5 Hz to 50 GHz	0.06 Hz	
Span	5 Hz to 50 GHz	$1.4 \times 10^{-3} \cdot \text{SPAN}$	
Resolution Bandwidth	10 Hz to 100 MHz	$2.2 \times 10^{-1} \text{ RBW}$	
Input Attenuator Accuracy ³ – Measuring Equipment	(0 to 30) dB (30 to 70) dB	0.16 dB 0.17 dB	Keysight E8257D Keysight J7211C
Displayed Average Noise Level ³ – Measuring Equipment	3 Hz to 50 GHz	1.7 dB	Terminations in the calibration kits
Frequency Response ³ – Measuring Equipment	10 Hz to 50 MHz 50 MHz to 7 GHz (7 to 12) GHz (12 to 26) GHz (26 to 32) GHz (32 to 40) GHz (45 to 50) GHz	0.06 dB 0.07 dB 0.08 dB 0.09 dB 0.11 dB 0.12 dB 0.19 dB	Agilent 33250A, Keysight E8257D, R&S SMA100B R&S NRP50T Keysight N1914A, Keysight N8487A

Parameter/Equipment	Range	CMC ^{2,7} ($\pm$)	Comments
Spurious Response ³ – Measuring Equipment	9 kHz to 50 GHz	0.45 dB	R&S SMA100B Keysight E8257D R&S FSMR3050
Pulse Response ³ – Measuring Equipment			
Pulse Response	9 kHz to 1 GHz	0.70 dB	Keysight N5173B Keysight E8257D Schwarzbeck IGU 2918 CISPR 16-1-1 ANSI C63.5
Repetition Frequency Response	9 kHz to 1 GHz	0.05 dB	
ISN ³ –			
Impedance	9 kHz to 1 GHz	3.2 Ω	Keysight E5061B Keysight 85032F calibration fixture CISPR 22, CISPR 32, CISPR 16-1-2
Phase Angle	9 kHz to 1 GHz	0.8°	
Voltage Division Factor/Isolation	9 kHz to 1 GHz	0.12 dB	
Longitudinal Conversion Loss	9 kHz to 1 GHz	0.27 dB	
LISN ³ –			
Impedance	10 Hz to 1 GHz	0.5 Ω	Keysight E5061B Keysight 85032F calibration fixture ANSI C63.4, CISPR 25, CISPR 16-1-2, MIL-STD- 461F, ISO 7637-2
Phase Angle	10 Hz to 1 GHz	1.2°	
Voltage Division Factor/Isolation	10 Hz to 1 GHz	0.12 dB	
CDN ³ –			
Impedance	10 Hz to 1 GHz	3.7 Ω	Keysight E5061B Keysight 85032F calibration fixture IEC/EN 61000-4-6 CISPR 16-1-2
Phase Angle	10 Hz to 1 GHz	1.4°	
Voltage Division Factor/Isolation	10 Hz to 1 GHz	0.12 dB	

Parameter/Equipment	Range	CMC ^{2,7} ($\pm$)	Comments
EM Clamps – Coupling Factor	9 kHz to 1 GHz	0.30 dB	Keysight E5061B Keysight 85032F IEC/EN 61000-4-6
Decoupling Factor	9 kHz to 1 GHz	0.30 dB	
Impedance	9 kHz to 1 GHz	1.3 Ω	
RF Current Probe ³ – Transfer Impedance	5 Hz to 500 MHz 500 MHz to 3 GHz	0.54 dB 1.1 dB	Keysight E5061B Keysight 85032F calibration fixture CISPR 16-1-2, IEC/EN 61000-4-6
Absorbing Clamps Clamp Factor	30 MHz to 1 GHz	1.8 dB	Keysight E5061B Keysight 85032F CISPR 16-1-3 CISPR 16-1-4
Noise Impulse Simulators ³ – Output Voltage	(100 to 200) V (200 to 500) V (0.5 to 1) kV (1 to 2) kV (2 to 3) kV (3 to 4) kV (4 to 5) kV	28 mV/V 27 mV/V 28 mV/V 57 mV/V 51 mV/V 46 mV/V 45 mV/V	Tektronix DPO 7354 Tektronix P6015A Tektronix P5100A
Pulse Width	(0.08 to 1) μ s	12 ms/s	
Surge Generators ³ – Output Voltage Voltage	(1 to 500) V (0.5 to 1) kV (1 to 2) kV (2 to 4) kV (4 to 6) kV (6 to 20) kV	28 mV/V 28 mV/V 57 mV/V 40 mV/V 37 mV/V 41 mV/V	Tektronix DPO 7354 Tektronix P6015A Tektronix P5100A Pearson 110 Weinschel 24-40-34-LIM IEC/EN 61000-4-5 IEC/EN 61000-4-12 ISO 7637-2 MIL-STD-461F
Undershoot	Up to 150 V (150 to 600) V (0.6 to 1.2) kV	33 mV/V 30 mV/V 92 mV/V	

Parameter/Equipment	Range	CMC ^{2,7} ($\pm$)	Comments
Surge Generators ³ – Output Voltage (cont)			
Undershoot	(1.2 to 1.8) kV (1.8 to 2.4) kV (2.4 to 3.0) kV (3.0 to 4.5) kV (4.5 to 5.4) kV (5.4 to 6.0) kV	67 mV/V 58 mV/V 53 mV/V 47 mV/V 46 mV/V 45 mV/V	Tektronix DPO 7354 Tektronix P6015A Tektronix P5100A Pearson 110 Weinschel 24-40-34-LIM IEC/EN 61000-4-5 IEC/EN 61000-4-12 ISO 7637-2 MIL-STD-461F
Front Time	(0.1 to 1.6) μ s (1.6 to 5) μ s (5 to 30) μ s	10 ms/s 6.7 ms/s 11 ms/s	
Time to Half Value Time	(10 to 50) μ s (50 to 700) μ s (0.7 to 1) ms (1 to 2) ms (2 to 10) ms (10 to 40) ms 40 ms to 1 s (1 to 3) s	10 ms/s 7.1 ms/s 5.0 ms/s 10 ms/s 3.0 ms/s 5.0 ms/s 3.0 ms/s 6.7 ms/s	
Output Current: Current	(1 to 20) A (20 to 50) A (50 to 100) A (100 to 500) A (0.5 to 2) kA (2 to 3) kA	38 mA/A 37 mA/A 38 mA/A 37 mA/A 38 mA/A 37 mA/A	
Undershoot	Up to 300 A (300 to 900) A	40 mA/A 38 mA/A	
Output Current: Front Time	(1 to 5) μ s (5 to 10) μ s	10 ms/s 7.8 ms/s	
Time to Half Value Time	(10 to 25) μ s (25 to 50) μ s	12 ms/s 8.3 ms/s	
Phase (220 V / 60 Hz)	Up to 4.17 ms (4.17 to 8.33) ms (8.33 to 12.5) ms (12.5 to 16.67) ms	12 ms/s 6.0 ms/s 4.0 ms/s 3.0 ms/s	

Parameter/Equipment	Range	CMC ^{2, 7} (±)	Comments
Surge Generators ³ – Output Voltage (cont)			
Phase (230 V / 50 Hz)	Up to 5 ms (5 to 10) ms (10 to 15) ms (15 to 20) ms	10 ms/s 5.0 ms/s 3.3 ms/s 2.3 ms/s	Tektronix DPO 7354 Tektronix P6015A Tektronix P5100A Pearson 110 Weinschel 24-40-34-LIM IEC/EN 61000-4-5 IEC/EN 61000-4-12 ISO 7637-2 MIL-STD-461F
(ISO 7637-2 only) Rise/Fall Time	(1 to 5) ms (5 to 10) ms	6.0 ms/s 3.0 ms/s	
Damped Time Constant	(1 to 2.5) µs (1 to 2) ms (20 to 26) ms (26 to 60) ms (60 to 400) ms	8.0 ms/s 15 ms/s 12 ms/s 17 ms/s 5.0 ms/s	
DC Cut Time	(5 to 10) ms (100 to 120) ms (120 to 200) ms (200 to 300) ms (0.3 to 1) s	3.0 ms/s 2.5 ms/s 5.0 ms/s 3.3 ms/s 3.0 ms/s	
Pulse Width	(2 to 2.82) µs (1 to 2) ms (50 to 100) ms (100 to 400) ms (0.4 to 1) s (1 to 2) s	7.1 ms/s 15 ms/s 3.0 ms/s 5.0 ms/s 3.0 ms/s 2.5 ms/s	
Oscillatory Wave Only			
Rise/Fall Time	(0.1 to 0.5) µs	20 ms/s	
Pulse Width	(1 to 6.4) µs (6.4 to 10) µs (10 to 70) µs (70 to 500) µs	7.8 ms/s 10 ms/s 4.3 ms/s 4.0 ms/s	
Frequency	1 kHz to 10 MHz (10 to 30) MHz (30 to 100) MHz	6.0 mHz/Hz 2.0 mHz/Hz 5.8 mHz/Hz	

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
Burst Pulse Generators ³			
Output Voltage:			Tektronix DPO 7354 TESEQ INA265B
50 Ω	1 V to 4 kV	36 mV/V	
1 k Ω	1 V to 8 kV	50 mV/V	IEC/EN 61000-4-4, MIL-STD-461F, ISO 7637-2
Rise/Fall Time	(1 to 10) ns (0.1 to 1) μ s	4.6 ms/s 5.8 ms/s	
Pulse Width	(10 to 100) ns (100 to 150) ns	2.3 ms/s 3.1 ms/s	
Repetition Frequency	(1 to 2.5) kHz (2.5 to 5) kHz 100 kHz	0.23 mHz/Hz 0.12 mHz/Hz 0.58 mHz/Hz	
Duration	(10 to 50) μ s (0.5 to 0.75) ms (0.75 to 2.0) ms (2.0 to 10) ms (10 to 20) ms	2.3 ms/s 7.7 ms/s 2.9 ms/s 2.3 ms/s 1.5 ms/s	
Burst Rate	(50 to 100) ms (100 to 200) ms (200 to 300) ms (0.3 to 1) s	2.3 ms/s 2.9 ms/s 1.9 ms/s 2.3 ms/s	
Damped Oscillatory Wave Rise/Fall Time	(1 to 5) ns	4.6 ms/s	
Oscillatory Frequency	(90 to 100) kHz (0.5 to 1) MHz (2 to 3) MHz (9 to 10) MHz (10 to 30) MHz (90 to 100) MHz	2.3 mHz/Hz 5.8 mHz/Hz 3.8 mHz/Hz 5.8 mHz/Hz 2.3 mHz/Hz 2.9 mHz/Hz	
Repetition Rate	(100 to 200) μ s	2.9 ms/s	
Duration	(40 to 50) ms	2.3 ms/s	
Burst Period	(200 to 300) ms	1.9 ms/s	

Parameter/Equipment	Range	CMC ^{2, 4, 7} (±)	Comments
Electrostatic Discharge Simulators –			
Voltage	(0.2 to 0.5) kV (0.5 to 1) kV (1 to 2) kV (2 to 4) kV (4 to 6) kV (6 to 8) kV (8 to 10) kV (10 to 15) kV (15 to 20) kV (20 to 25) kV (25 to 30) kV	2.0 % 1.5 % 1.3 % 1.2 % 1.0 % 1.2 % 1.2 % 1.2 % 1.3 % 1.3 % 1.2 %	ESDEMC ES105-100
Current (Ip)	Up to 7.5 A (7.5 to 15) A (15 to 22.5) A (22.5 to 30) A (30 to 45) A (45 to 56) A (56 to 75) A (75 to 94) A (94 to 150) A	3.3 % 2.3 % 3.0 % 2.5 % 2.9 % 2.8 % 2.6 % 2.5 % 2.8 %	Tektronix DPO 7354 ESD target, V/A transducer IEC/EN 61000-4-2 ISO 10605
T1	30 ns, 65 ns Up to 4 A (4 to 8) A (8 to 12) A (12 to 16) A (16 to 24) A (24 to 30) A (30 to 40) A (40 to 50) A (50 to 80) A	2.0 % 1.9 % 2.1 % 2.0 % 2.0 % 2.3 % 2.3 % 2.2 % 2.3 %	
T2	60 ns, 130 ns Up to 2 A (2 to 4) A (4 to 6) A (6 to 8) A (8 to 12) A (12 to 15) A (15 to 20) A (20 to 25) A (25 to 40) A	2.3 % 2.0 % 2.1 % 2.1 % 2.2 % 2.4 % 2.4 % 2.3 % 2.4 %	

Parameter/Equipment	Range	CMC ^{2, 4, 7} (±)	Comments
Electrostatic Discharge Simulators – (cont)			
T3	180 ns, 400 ns Up to 0.55 A (0.55 to 1.1) A (1.10 to 1.7) A (1.7 to 2.2) A (2.2 to 3.3) A (3.3 to 4.1) A (4.1 to 5.5) A (5.5 to 7.0) A (7.0 to 11) A	5.5 % 3.2 % 5.6 % 3.5 % 4.7 % 3.8 % 3.9 % 2.9 % 4.0 %	Tektronix DPO 7354 ESD target, V/A transducer IEC/EN 61000-4-2 ISO 10605
T4	360 ns, 800 ns Up to 0.30 A (0.30 to 0.60) A (0.60 to 0.90) A (0.90 to 1.2) A (1.2 to 1.8) A (1.8 to 2.3) A (2.3 to 3.0) A (3.0 to 4.0) A (4.0 to 6.0) A	9.6 % 5.1 % 10 % 5.7 % 8.1 % 6.0 % 6.2 % 4.0 % 6.6 %	
Rise/Fall Time	(0.5 to 1) ns	1.2 %	
Dip Simulators ³ –			
Output Voltage	Up to 100 V (100 to 220) V (220 to 230) V (230 to 400) V	1.1 mV/V 2.3 mV/V 2.2 mV/V 1.5 mV/V	Tektronix DPO 7354 HP 34401A Pintek DP-15K Pintek DP-30K IEC/EN 61000-4-11
Line Frequency	(49 to 51) Hz (59 to 61) Hz	0.12 mHz/Hz 0.13 mHz/Hz	
Dip & Up Voltage	(50 to 60) Hz (1 to 120) V 0 % (1 to 10) V, (1 to 40) % (10 to 48) V, (40 to 70) % (48 to 84) V, (70 to 80) % (84 to 96) V,	0.52 V/V 0.12 V/V 69 mV/V 61 mV/V	

Parameter/Equipment	Range	CMC ^{2, 4, 7} ($\pm$)	Comments
Dip Simulators ³ – (cont) Dip & Up Voltage	(50 to 60) Hz (1 to 120) V (80 to 120) % (96 to 144) V	59 mV/V	Tektronix DPO 7354 HP 34401A Pintek DP-15K Pintek DP-30K IEC/EN 61000-4-11
	(120 to 220) V 0 % (1 to 10) V (1 to 40) % (10 to 88) V (40 to 70) % (88 to 154) V (70 to 80) % (154 to 176) V (80 to 120) % (176 to 264) V	0.52 V/V 66 mV/V 42 mV/V 39 mV/V 50 mV/V	
	(220 to 230) V 0 % (1 to 10) V (1 to 40) % (10 to 92) V (40 to 70) % (92 to 160) V (70 to 80) % (160 to 180) V (80 to 120) % (180 to 300) V	0.52 V/V 64 mV/V 41 mV/V 38 mV/V 48 mV/V	
	(230 to 380) V 0 % (1 to 10) V (1 to 40) % (10 to 150) V (40 to 70) % (150 to 270) V (70 to 80) % (270 to 300) V (80 to 120) % (300 to 500) V	1 V/V 80 mV/V 49 mV/V 44 mV/V 34 mV/V	
Dip & Up Period	(5 to 20) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms 500 ms to 1 s (1 to 5) s (5 to 10) s	10 ms/s 3 ms/s 5 ms/s 4 ms/s 3 ms/s 4 ms/s 3 ms/s	

Parameter/Equipment	Range	CMC ^{2, 4, 7} ($\pm$)	Comments
Dip Simulators ³ – (cont)			
Dip & Up Period	(220 V, 60 Hz) (1 to 2.0) ms (2.0 to 4.2) ms (4.2 to 6.3) ms (6.3 to 8.3) ms (8.3 to 10) ms (10 to 13) ms (13 to 15) ms (15 to 17) ms	14 ms/s 7.2 ms/s 4.8 ms/s 3.6 ms/s 2.9 ms/s 2.4 ms/s 2.1 ms/s 1.8 ms/s	Tektronix DPO 7354 HP 34401A Pintek DP-15K Pintek DP-30K IEC/EN 61000-4-11
Phase Shifting	(230 V, 50 Hz) (1 to 2.5) ms (2.5 to 5) ms (5 to 7.5) ms (7.5 to 10) ms (10 to 13) ms (13 to 15) ms (15 to 18) ms (18 to 20) ms	12 ms/s 6.0 ms/s 4.0 ms/s 3.0 ms/s 2.4 ms/s 2.0 ms/s 1.7 ms/s 1.5 ms/s	
Rise & Fall Time	(0.1 to 1.0) μ s (1.0 to 5.0) μ s (5.0 to 10) μ s	10 ms/s 4.0 ms/s 2.0 ms/s	
Normalized Site Attenuation (NSA) Measurement ⁹	30 MHz to 1 GHz	1.2 dB	Keysight E5080B Keysight 85054D CISPR 16-1-4 ANSI C63.4, ANSI C63.25.2 Standard antenna pair Semi anechoic chamber (SAC) and/or Open Area Test Site (OATS)
Site Voltage Standing Wave Ratio (sVSWR) ⁹	(1 to 6) GHz (6 to 18) GHz	1.4 dB 1.5 dB	Keysight E5063A Keysight 85054D CISPR 16-1-4 ANSI C63.4, ANSI C63.25.1 Semi anechoic chamber (SAC) and/or Open Area Test Site (OATS)

Parameter/Equipment	Range	CMC ^{2, 4, 7} ($\pm$)	Comments
Shield Effectiveness ⁹	9 kHz to 30 MHz (30 to 200) MHz 200 MHz to 1 GHz (1 to 18) GHz	1.4 dB 1.1 dB 1.1 dB 1.0 dB	Keysight E5063A Keysight N5173B Agilent E4440B Keysight 85054D IEEE 299 MIL-STD-285 EN 50147-1 Semi anechoic chamber (SAC) or shield room only
Field Uniformity – Measure ⁹	80 MHz to 6 GHz	1.1 dB	AR FL7006 Keysight N9030A Keysight N5173B Semi anechoic chamber (SAC) only

VII. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2, 7, 8} ($\pm$)	Comments
RF Absolute Power – Measure ³			
0 dBm	1 mW at 50 MHz	0.038 dB	R&S NRP50T
(-60 to 20) dBm	9 kHz to 6 GHz	0.04 dB	Keysight N1914A Keysight E9304A
(-70 to 20) dBm	10 MHz to 1 GHz (1 to 14) GHz (14 to 18) GHz	0.05 dB 0.06 dB 0.07 dB	Keysight E4412A
	50 MHz to 1 GHz (1 to 8) GHz (8 to 18) GHz (18 to 30) GHz	0.05 dB 0.06 dB 0.07 dB 0.09 dB	Keysight E4413A
(-20 to 10) dBm	50 MHz to 1 GHz (1 to 8) GHz (8 to 18) GHz (18 to 26.5) GHz (26.5 to 33) GHz	0.05 dB 0.06 dB 0.09 dB 0.08 dB 0.09 dB	Keysight N8487A

Parameter/Range	Frequency	CMC ^{2, 7, 8} (±)	Comments
RF Absolute Power – Measure ³ (cont)			
(-20 to 10) dBm	(33 to 40) GHz (40 to 50) GHz	0.09 dB 0.15 dB	Keysight N8487A
(-30 to 20) dBm	50 MHz to 1 GHz	0.19 dB	
	(1 to 8) GHz	0.19 dB	
	(8 to 18) GHz	0.20 dB	
	(18 to 26.5) GHz	0.20 dB	
	(26.5 to 33) GHz	0.20 dB	
	(33 to 40) GHz (40 to 50) GHz	0.20 dB 0.43 dB	
RF Relative Power – Measure ³			
(-60 to 20) dB	9 kHz to 6 GHz	0.052 dB	Agilent N1914A Agilent E9304A H18
(-70 to 20) dB	10 MHz to 18 GHz 50 MHz to 26.5 GHz	0.052 dB 0.052 dB	Agilent N1911A Keysight N1914A Agilent E9304A H18
(-30 to 20) dB	50 MHz to 50 GHz	0.052 dB	Keysight E4412A
(-35 to 20) dB	DC to 50 GHz	0.052 dB	Keysight E4413A Keysight N8487A R&S NRP50T
Tuned RF Level Relative– Measure ³			
(0 to 10) dB	9 kHz to 18 GHz	0.026 dB	R&S FSMR3050
-(10 to 20) dB		0.026 dB	
-(20 to 30) dB		0.026 dB	
-(30 to 40) dB		0.026 dB	
-(40 to 50) dB		0.026 dB	
-(50 to 60) dB		0.026 dB	
-(60 to 70) dB		0.026 dB	
-(70 to 80) dB		0.026 dB	
-(80 to 90) dB		0.026 dB	
-(90 to 100) dB		0.026 dB	
-(100 to 110) dB		0.026 dB	
-(110 to 120) dB		0.026 dB	

Parameter/Range	Frequency	CMC ^{2, 7, 8} (±)	Comments
Tuned RF Level Relative– Measure ³ (cont)			
(0 to 10) dB	18 GHz to 26.5 GHz	0.030 dB	R&S FSMR3050
-(10 to 20) dB		0.030 dB	
-(20 to 30) dB		0.030 dB	
-(30 to 40) dB		0.030 dB	
-(40 to 50) dB		0.030 dB	
-(50 to 60) dB		0.030 dB	
-(60 to 70) dB		0.030 dB	
-(70 to 80) dB		0.030 dB	
-(80 to 90) dB		0.030 dB	
-(90 to 100) dB		0.030 dB	
-(100 to 110) dB		0.030 dB	
-(110 to 120) dB		0.030 dB	
(0 to 10) dB	26.5 GHz to 50 GHz	0.058 dB	
-(10 to 20) dB		0.058 dB	
-(20 to 30) dB		0.058 dB	
-(30 to 40) dB		0.058 dB	
-(40 to 50) dB		0.058 dB	
-(50 to 60) dB		0.058 dB	
-(60 to 70) dB		0.058 dB	
-(70 to 80) dB		0.058 dB	
-(80 to 90) dB		0.058 dB	
-(90 to 100) dB		0.058 dB	
-(100 to 110) dB		0.058 dB	

Parameter/Equipment	Range	CMC ^{2, 7, 8} (±)	Comments
RF Power Sensor – Calibration Factor ³	9 kHz to 10 MHz 10 MHz to 8 GHz (8 to 12) GHz (12 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	2.3 % CF 2.6 % CF 2.7 % CF 4.3 % CF 4.8 % CF 7.1 % CF	Agilent N1914A Keysight E9304A Keysight E4412A Keysight E4413A Keysight N8487A (DUT VSWR is assumed for calculation of CMC mismatch uncertainty.)

Parameter/Range	Frequency	CMC ^{2, 4, 7} (±)	Comments
Harmonics & Non-Harmonic Spurious – Measure ³ <-40 dBc	9 kHz to 20 GHz (20 to 50) GHz	1.4 dB 1.7 dB	R&S FSMR3050
Amplitude Modulation – Measure ³ Rate: 10 Hz to 10 kHz Depth: Up to 100 % Rate: 10 Hz to 100 kHz Depth: Up to 20 % (20 to 100) % Rate: 10 Hz to 100 kHz Depth: Up to 20 % (20 to 100) %	100 kHz to 10 MHz 10 MHz to 3 GHz (3 to 30) GHz (30 to 50) GHz	0.17 % Depth 0.17 % Depth 0.12 % Depth 0.17 % Depth 0.12 % Depth 0.66 % Depth 0.24 % Depth	R&S FSMR3050
Frequency Modulation – Measure ³ Rate: 10 Hz to 10 kHz Deviation: max. 50 kHz (peak) Rate: 10 Hz to 100 kHz Rate: 100 kHz to 200 kHz Deviation: max. 5 MHz (peak)	200 kHz to 10 MHz RF 10 MHz to 50 GHz RF	1.1 % Deviation 1.1 % Deviation 3.1 % Deviation	R&S FSMR3050

Parameter/Range	Frequency	CMC ^{2, 4, 7} ($\pm$)	Comments
Phase Modulation – Measure ³ Rate: 50 Hz to 10 kHz Rate: 50 Hz to 100 kHz Deviation: max. 1000 rad	200 kHz to <10 MHz RF	1.1 % 1.1 %	R&S FSMR3050
Resolution Bandwidth ³ – 3 dB Bandwidth 6 dB Bandwidth Switching Error	10 Hz to 100 MHz 10 Hz to 100 MHz 10 Hz to 100 MHz	2.2 x 10 ⁻¹ RBW 3.7 x 10 ⁻² RBW 0.042 dB	R&S SMA100B
Overall Selectivity ³ – Measuring Equipment 10 Hz to 100 MHz	9 kHz to 40 GHz	0.08 dB	R&S SMA100B

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
Reflection S11/S22 – Measure ³			
(0 to 0.1) lin (0 to 180) ° (0.1 to 0.2) lin (0 to 180) ° (0.2 to 0.3) lin (0 to 180) ° (0.3 to 0.4) lin (0 to 180) ° (0.4 to 0.5) lin (0 to 180) ° (0.5 to 0.6) lin (0 to 180) ° (0.6 to 0.7) lin (0 to 180) ° (0.7 to 0.8) lin (0 to 180) ° (0.8 to 0.9) lin (0 to 180) ° (0.9 to 1) lin (0 to 180) °	10 Hz to 2 GHz	0.010 (lin) 5.2° 0.019 (lin) 4.0° 0.019 (lin) 3.4° 0.019 (lin) 1.6° 0.019(lin) 1.4° 0.020 (lin) 1.4° 0.021 (lin) 1.4° 0.022 (lin) 1.4° 0.025 (lin) 1.4° 0.026 (lin) 1.4°	Keysight E5061B Keysight E5063A Keysight E5080B Keysight 85032F Keysight 85054D Keysight 85052D Keysight 85056D Phase uncertainty is 180 ° when $\frac{\Delta mag}{mag} \geq 1$.
(0 to 0.1) lin (0 to 180) ° (0.1 to 0.2) lin (0 to 180) ° (0.2 to 0.3) lin (0 to 180) ° (0.3 to 0.4) lin (0 to 180) ° (0.4 to 0.5) lin (0 to 180) ° (0.5 to 0.6) lin (0 to 180) ° (0.6 to 0.7) lin (0 to 180) ° (0.7 to 0.8) lin (0 to 180) ° (0.8 to 0.9) lin (0 to 180) ° (0.9 to 1) lin (0 to 180) °	(2 to 20) GHz	0.011 (lin) 5.3° 0.019 (lin) 4.0° 0.018 (lin) 4.1° 0.021 (lin) 1.6° 0.02 (lin) 1.6° 0.023 (lin) 1.6° 0.025 (lin) 1.6° 0.027 (lin) 1.6° 0.029 (lin) 1.6° 0.029 (lin) 1.6°	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
Reflection S11/S22 – Measure ³ (cont.)			
(0 to 0.1) lin (0 to 180) ° (0.1 to 0.2) lin (0 to 180) ° (0.2 to 0.3) lin (0 to 180) ° (0.3 to 0.4) lin (0 to 180) ° (0.4 to 0.5) lin (0 to 180) ° (0.5 to 0.6) lin (0 to 180) ° (0.6 to 0.7) lin (0 to 180) ° (0.7 to 0.8) lin (0 to 180) ° (0.8 to 0.9) lin (0 to 180) ° (0.9 to 1) lin (0 to 180) °	(20 to 40) GHz	0.018 (lin) 9.3° 0.023 (lin) 5.0° 0.024 (lin) 5.0° 0.027 (lin) 4.1° 0.029 (lin) 3.9° 0.032 (lin) 3.8° 0.036 (lin) 3.8° 0.040 (lin) 3.8° 0.045 (lin) 3.8° 0.049 (lin) 3.8°	Keysight E5061B Keysight E5063A Keysight E5080B Keysight 85032F Keysight 85054D Keysight 85052D Keysight 85056D Phase uncertainty is 180 ° when $\frac{\Delta mag}{mag} \geq 1$.
(0 to 0.1) lin (0 to 180) ° (0.1 to 0.2) lin (0 to 180) ° (0.2 to 0.3) lin (0 to 180) ° (0.3 to 0.4) lin (0 to 180) ° (0.4 to 0.5) lin (0 to 180) ° (0.5 to 0.6) lin (0 to 180) ° (0.6 to 0.7) lin (0 to 180) ° (0.7 to 0.8) lin (0 to 180) ° (0.8 to 0.9) lin (0 to 180) ° (0.9 to 1) lin (0 to 180) °	(40 to 50) GHz	0.026 (lin) 13° 0.059 (lin) 10° 0.059 (lin) 4.7° 0.060 (lin) 4.7° 0.062 (lin) 4.1° 0.066 (lin) 4.1° 0.071 (lin) 4.1° 0.079 (lin) 4.1° 0.089 (lin) 4.1° 0.10 (lin) 4.1°	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
Transmission S12/S21 – Measure ³			
(0 to 10) dB (0 to 180) ° (10 to 20) dB (0 to 180) ° (20 to 30) dB (0 to 180) ° (30 to 40) dB (0 to 180) ° (40 to 50) dB (0 to 180) ° (50 to 60) dB (0 to 180) °	10 Hz to 2 GHz	0.12 dB 0.50° 0.12 dB 0.61° 0.12 dB 0.71° 0.21 dB 2.2° 0.59 dB 3.5° 1.8 dB 12°	Keysight E5061B Keysight E5063A Keysight E5080B Keysight 85032F Keysight 85054D Keysight 85052D Keysight 85056D
(0 to 10) dB (0 to 180) ° (10 to 20) dB (0 to 180) ° (20 to 30) dB (0 to 180) ° (30 to 40) dB (0 to 180) ° (40 to 50) dB (0 to 180) ° (50 to 60) dB (0 to 180) °	(2 to 20) GHz	0.14 dB 1.2° 0.15 dB 2.2° 0.16 dB 2.0° 0.22 dB 4.0° 0.23 dB 4.1° 0.61 dB 4.3°	
(0 to 10) dB (0 to 180) ° (10 to 20) dB (0 to 180) ° (20 to 30) dB (0 to 180) ° (30 to 40) dB (0 to 180) ° (40 to 50) dB (0 to 180) ° (50 to 60) dB (0 to 180) °	(20 to 40) GHz	0.21 dB 1.2° 0.29 dB 2.0° 0.28 dB 2.9° 0.36 dB 8.3° 0.47 dB 8.9° 0.70 dB 10°	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
Transmission S12/S21 – Measure (cont)			
(0 to 10) dB	(40 to 50) GHz	0.33 dB	Keysight E5061B Keysight E5063A Keysight E5080B Keysight 85032F Keysight 85054D Keysight 85052D Keysight 85056D
(0 to 180) °		2.1°	
(10 to 20) dB		0.33 dB	
(0 to 180) °		5.3°	
(20 to 30) dB		0.76 dB	
(0 to 180) °		5.3°	
(30 to 40) dB		0.98 dB	
(0 to 180) °		14°	
(40 to 50) dB		1.3 dB	
(0 to 180) °		15°	
(50 to 60) dB		2.5 dB	
(0 to 180) °		18°	

VIII. Mechanical

Parameter/Equipment	Range	CMC ^{2, 4, 5} (±)	Comments
Pressure & Vacuum ³	(-12 to < 0) psi Up to 1 psi Up to 30 psi Up to 300 psi	0.40 % 0.29 % 0.11 % 0.23 %	Pressure calibrators
Torque – Measure	(1 to 10) lbf·in (10 to 20) lbf·in (20 to 50) lbf·in (50 to 100) lbf·in (100 to 250) lbf·in (250 to 500) lbf·in (41.5 to 75) lbf·ft (75 to 185) lbf·ft (185 to 360) lbf·ft (360 to 750) lbf·ft (750 to 1100) lbf·ft (1100 to 1850) lbf·ft	0.88 % 0.29 % 0.27 % 0.44 % 0.42 % 0.27 % 0.25 % 0.25 % 0.22 % 0.18 % 0.49 % 0.25 %	Torque tool tester

Parameter/Equipment	Range	CMC ^{2, 4, 5} ($\pm$)	Comments
Scales and Balances ³	(0.001 to 20) g (20 to 200) g (200 to 400) g (400 to 600) g (600 to 1200) g (1.2 to 3) kg (3 to 5) kg (5 to 15) kg (15 to 30) kg (30 to 91) kg (91 to 140) kg (140 to 230) kg	0.033 mg 0.16 mg 0.25 mg 0.35 mg 6.1 mg 12 mg 18 mg 0.27 g 0.28 g 1.9 g 5.8 g 14 g	Standard weights

IX. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 5} ($\pm$)	Comments
Temperature – Measure & Measuring Equipment ³	(-90 to 420) °C	0.09 °C	Fluke 1529 Fluke 5626 Sika TP17166S, Sika TP17450S, Sika TP17ZERO Ametek PTC-125A
Temperature – Source	(-90 to 420) °C	0.04 °C	Fluke 1529 Fluke 5626
Humidity – Measure & Measuring Equipment ³	(5 to 95) % RH	1.7 % RH	Environmental chamber Michell Optidew Vision, precision dewpoint meter

X. Time and Frequency

Parameter/Equipment	Range	CMC ^{2, 5} ($\pm$)	Comments
Frequency – Generate ³	1 Hz to 1 MHz 1 MHz to 1 GHz (1 to 50) GHz	0.000 062 Hz 0.0062 Hz 0.62 Hz	SRS FS740 Agilent 53230A Agilent 33220A Keysight E8257D
Frequency – Measure ³	1 Hz to 1 MHz 1 MHz to 1 GHz (1 to 50) GHz	0.000 072 Hz 0.0064 Hz 0.62 Hz	GPS system with SRS FS740 Agilent 53230A Keysight 53152A
Timer / Stopwatch ³	(1 to 3600) s	0.020 s	HS-3 (stopwatch) PGZSY ZSD-009

SATELLITE FACILITY

Open Area Test Site (OATS)

HCT AMERICA, INC.
1177 Comstock Road
Hollister, CA 95023
Mr. Kent Kim Phone: 408 731 0040

I. Antenna Calibrations

Parameter/Range	Frequency	CMC ² (±)	Comments
Dipole Antennas – Antenna Factor Up to 80 dB/m	20 MHz to 18 GHz	0.8 dB	Keysight E5080B Keysight 85054D ANSI C63.5, SAE ARP958, CISPR 16-1-6
Biconical Antennas – Antenna Factor Up to 80 dB/m	(20 to 300) MHz (0.3 to 18) GHz	0.7 dB 0.89 dB	Keysight E5080B Keysight 85054D ANSI C63.5, SAE ARP958, CISPR 16-1-6; Three antenna method Standard antenna pair
Log Periodic Antennas – Antenna Factor Up to 80 dB/m	20 MHz to 6 GHz	0.82 dB	Keysight E5080B Keysight 85054D ANSI C63.5, SAE ARP958, CISPR 16-1-6; Three antenna method Standard antenna pair
Hybrid Antennas – Antenna Factor Up to 80 dB/m	20 MHz to 6 GHz	0.82 dB	Keysight E5080B Keysight 85054D ANSI C63.5, SAE ARP958, CISPR 16-1-6; Three antenna method Standard antenna pair

Parameter/Range	Frequency	CMC ² (±)	Comments
Horn Antenna – Antenna Factor Up to 80 dB/m	(0.7 to 1) GHz (1 to 18) GHz (18 to 40) GHz	0.7 dB 0.89 dB 1.4 dB	Keysight E5080B Keysight 85054D ANSI C63.5, ANSI C63.4 SAE ARP958, CISPR 16-1-6, CISPR 16-1-4; Three antenna method
Dipole/Biconical/Hybrid/ Log Periodic/Horn Antenna Symmetry Up to 20 dB Balance Up to 20 dB VSWR 1 to 60	20 MHz to 1 GHz (1 to 18) GHz (18 to 40) GHz 20 MHz to 1 GHz (1 to 18) GHz (18 to 40) GHz 20 MHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	0.33 dB 0.38 dB 0.33 dB 0.33 dB 0.38 dB 0.33 dB 0.1 0.1 0.1	Keysight E5080B Keysight 85054D ANSI C63.5, ANSI C63.4 CISPR 16-1-6, CISPR 16-1-4;

¹ This laboratory offers commercial calibration service and field calibration service.

² Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. 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 In the statement of CMC, % is the percent of reading.

⁵ 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.

⁶ This scope meets A2LA's *P112 Flexible Scope Policy*.

⁷ 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.

⁸ Mismatch uncertainty is not included in the expression of CMC for all microwave power measurement including Calibration Factor.

⁹ This Calibration is performed as a field service only.



Accredited Laboratory

A2LA has accredited

HCT AMERICA, INC.

Milpitas, CA

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 22nd day of September 2025.

A blue ink signature of Mr. Trace McInturff.

Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 4201.02
Valid to July 31, 2027

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