



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005
& ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3-2006

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CALIBRATION

Valid To: August 31, 2019

Certificate Number: 3811.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
DC Current ³ – Generate	(0 to 330) µA (0 to 3.3) mA (0 to 33) mA (0 to 330) mA (0 to 1.1) A (1.1 to 3) A (0 to 11) A (11 to 20.5) A	110 µA/A + 0.016 µA 73 µA/A + 0.054 µA 71 µA/A + 0.42 µA 64 µA/A + 7.2 µA 75 µA/A + 0.19 µA 280 µA/A + 96 µA 350 µA/A + 0.79 µA 760 µA/A + 0.84 µA	Fluke 5520A option SC1100
DC Current ³ – Measure	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 3) A	22 µA/A + 1.1 nA 22 µA/A + 7.8 nA 21 µA/A + 79 nA 39 µA/A + 0.081 µA 0.013 % + 12 µA 0.14 % + 0.70 mA	Agilent 3458A, option 002 Agilent 34401A
DC Voltage ³ – Generate	(0 to 330) mV (0 to 3.3) V (0 to 33) V (33 to 330) V (100 to 1000) V	16 µV/V + 0.83 µV 6.5 µV/V + 9.7 µV 7.1 µV/V + 0.10 mV 12 µV/V + 0.78 mV 12 µV/V + 3.3 mV	Fluke 5520A option SC1100

Parameter/Equipment	Range	CMC ^{2, 8} ($\pm$)	Comments
DC Voltage ³ – Measure	(0 to 200) mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1000) V	4 μ V/V + 1.0 μ V 3.3 μ V/V + 3.3 μ V 3.7 μ V/V + 23 μ V 5.9 μ V/V + 0.28 mV 4.2 μ V/V + 4.5 mV	Agilent 3458A, option 002
Resistance ³ – Generate	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω to 1.1 k Ω (1.1 to 3.3) k Ω (3.3 to 11) k Ω (11 to 33) k Ω (33 to 110) k Ω (110 to 330) k Ω 330 k Ω to 1.1 M Ω (1.1 to 3.3) M Ω (3.3 to 11) M Ω (11 to 33) M Ω (33 to 110) M Ω (110 to 330) M Ω 330 M Ω to 1.1 G Ω	45 $\mu\Omega/\Omega$ + 0.0012 Ω 36 $\mu\Omega/\Omega$ + 0.0018 Ω 30 $\mu\Omega/\Omega$ + 0.0020 Ω 32 $\mu\Omega/\Omega$ + 0.0025 Ω 31 $\mu\Omega/\Omega$ + 0.0047 Ω 32 $\mu\Omega/\Omega$ + 0.025 Ω 31 $\mu\Omega/\Omega$ + 0.047 Ω 32 $\mu\Omega/\Omega$ + 0.25 Ω 31 $\mu\Omega/\Omega$ + 0.47 Ω 32 $\mu\Omega/\Omega$ + 4.5 Ω 16 $\mu\Omega/\Omega$ + 54 Ω 69 $\mu\Omega/\Omega$ + 35 Ω 150 $\mu\Omega/\Omega$ + 59 Ω 290 $\mu\Omega/\Omega$ + 2.9 k Ω 580 $\mu\Omega/\Omega$ + 3.4 k Ω 0.35 % + 120 k Ω 1.7 % + 590 k Ω	Fluke 5520A
Resistance ³ – Measure	(0 to 2) Ω (2 to 20) Ω (20 to 200) Ω (0.2 to 2) k Ω (2 to 20) k Ω (20 to 200) k Ω (0.2 to 2) M Ω (2 to 20) M Ω (20 to 200) M Ω 200 M Ω to 2 G Ω	14 $\mu\Omega/\Omega$ + 84 $\mu\Omega$ 16 $\mu\Omega/\Omega$ + 0.10 m Ω 14 $\mu\Omega/\Omega$ + 0.66 m Ω 11 $\mu\Omega/\Omega$ + 1.7 m Ω 12 $\mu\Omega/\Omega$ + 11 m Ω 11 $\mu\Omega/\Omega$ + 0.30 Ω 17 $\mu\Omega/\Omega$ + 4.5 Ω 58 $\mu\Omega/\Omega$ + 0.14 k Ω 0.058 % + 1.4 k Ω 0.58 % + 14 k Ω	Agilent 3458A, option 002

Parameter/Range	Frequency	CMC ^{2, 4, 8} (±)	Comments
Capacitance ³ – Generate			Fluke 5520A option
(0.2 to 0.4) nF	10 Hz to 10 kHz	0.5 % + 0.01 nF	
(0.4 to 1.1) nF	10 Hz to 10 kHz	0.5 % + 0.01 nF	
(1.1 to 3.3) nF	10 Hz to 3 kHz	0.5 % + 0.01 nF	
(3.3 to 11) nF	10 Hz to 1 kHz	0.25 % + 0.01 nF	
(11 to 33) nF	10 Hz to 1 kHz	0.25 % + 0.1 nF	
(33 to 110) nF	10 Hz to 1 kHz	0.25 % + 0.1 nF	
(110 to 330) nF	10 Hz to 1 kHz	0.25 % + 0.3 nF	
330 nF to 1.1 µF	(10 to 600) Hz	0.25 % + 1 nF	
(1.1 to 3.3) µF	(10 to 300) Hz	0.25 % + 3 nF	
(3.3 to 11) µF	(10 to 150) Hz	0.25 % + 10 nF	
(11 to 33) µF	(10 to 120) Hz	0.4 % + 30 nF	
(33 to 110) µF	(10 to 80) Hz	0.45 % + 100 nF	
(110 to 330) µF	(0 to 50) Hz	0.45 % + 300 nF	
330 µF to 1.1 mF	(0 to 20) Hz	0.45 % + 1 µF	
(1.1 to 3.3) mF	(0 to 6) Hz	0.45 % + 3 µF	
(3.3 to 11) mF	(0 to 2) Hz	0.45 % + 10 µF	
(11 to 33) mF	(0 to 0.6) Hz	0.75 % + 30 µF	
(33 to 110) mF	(0 to 0.2) Hz	1.1 % + 100 µF	
AC Voltage Flatness ³ – Measure			
(0.5, 1, or 3) V	10 Hz to 10 MHz	0.28 %	HP 11049, 11050A
	(10 to 30) MHz	0.38 %	11051A with 3458A
	(30 to 60) MHz	1.0 %	
	(60 to 100) MHz	1.9 %	

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
AC Voltage ³ – Generate			
(1 to 33) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.053 % + 8.3 µV 0.010 % + 5.9 µV 0.074 % + 5.9 µV 0.27 % + 5.8 µV 0.27 % + 11 µV 0.59 % + 48 µV	Fluke 5520A option SC1100
(33 to 330) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.015 % + 47 µV 0.010 % + 10 µV 0.012 % + 6.8 µV 0.027 % + 6.6 µV 0.061 % + 25 µV 0.15 % + 58 µV	
(0.33 to 3.3) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.15 % + 0.44 mV 0.010 % + 98 µV 0.014 % + 89 µV 0.022 % + 75 µV 0.053 % + 0.12 mV 0.18 % + 0.84 mV	
(3.3 to 33) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.015 % + 4.4 mV 0.010 % + 0.92 mV 0.018 % + 0.84 mV 0.026 % + 0.78 mV 0.067 % + 1.9 mV	
(33 to 330) V	45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.013 % + 9.6 mV 0.014 % + 11 mV 0.018 % + 11 mV 0.014 % + 27 mV 0.15 % + 44 mV	
(330 to 1000) V	45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.022 % + 20 mV 0.018 % + 20 mV 0.022 % + 18 mV	

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
AC Voltage ³ – 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	0.025 % + 6.0 µV 0.011 % + 5.1 µV 0.019 % + 5.1 µV 0.091 % + 4.7 µV 0.56 % + 3.0 µV 4.6 % + 2.6 µV	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	76 µV/V + 6.9 µV 70 µV/V + 5.6 µV 0.015 % + 5.2 µV 0.033 % + 4.6 µV 0.091 % + 3.5 µV 0.35 % + 12 µV 1.2 % + 12 µV 1.7 % + 12 µV	
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	76 µV/V + 53 µV 73 µV/V + 35 µV 0.35 % + 56 µV 0.014 % + 49 µV 0.033 % + 24 µV 0.092 % + 120 µV 1.1 % + 190 µV 1.7 % + 110 µV	
(1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	45 µV/V + 1.7 mV 80 µV/V + 0.38 mV 0.015 % + 0.34 mV 0.034 % + 0.32 mV 0.083 % + 1.3 mV 0.34 % + 1.5 mV 1.1 % + 4.8 mV 1.7 % + 3.8 mV	
(10 to 100) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.023 % + 5.5 mV 0.023 % + 3.5 mV 0.023 % + 3.5 mV 0.040 % + 3.2 mV 0.14 % + 2.7 mV 0.46 % + 12 mV 1.7 % + 12 mV	
(100 to 707) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.040 % + 40 mV 0.045 % + 29 mV 0.069 % + 27 mV 1.4 % + 26 mV 3.4 % + 24 mV	

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
AC Current ³ – Generate			
(29 to 330) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.14 % + 0.12 µA 0.11 % + 0.11 µA 0.092 % + 0.095 µA 0.22 % + 0.14 µA 0.61 % + 0.19 µA 1.2 % + 0.39 µA	Fluke 5520A option SC1100
(0.33 to 3.3) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.14 % + 0.58 µA 0.088 % + 0.41 µA 0.071 % + 0.34 µA 0.15 % + 0.35 µA 0.33 % + 2.4 µA 0.73 % + 2.0 µA	
(3.3 to 33) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.13 % + 5.1 µA 0.065 % + 3.1 µA 0.026 % + 3.6 µA 0.058 % + 3.2 µA 0.15 % + 4.9 µA 0.27 % + 17 µA	
(33 to 330) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.13 % + 34 µA 0.063 % + 39 µA 0.025 % + 43 µA 0.072 % + 59 µA 0.15 % + 0.11 mA 0.28 % + 0.29 mA	
(0.33 to 1.1) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.098 % + 0.80 mA 0.014 % + 0.85 mA 0.44 % + 1.1 mA 1.9 % + 4.1 mA	
(1.1 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.13 % + 0.46 mA 0.034 % + 0.67 mA 0.46 % + 0.91 mA 1.9 % + 4.0 mA	
(3 to 11) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.039 % + 2.9 mA 0.070 % + 2.6 mA 2.3 % + 1.7 mA	
(11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.088 % + 5.3 mA 0.11 % + 5.1 mA 2.3 % + 4.0 mA	

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
AC Current ³ – Measure			
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 0.039 µA 0.17 % + 0.040 µA 0.065 % + 0.040 µA 0.067 % + 0.040 µA	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	0.46 % + 0.25 µA 0.17 % + 0.26 µA 0.067 % + 0.26 µA 0.033 % + 0.27 µA 0.067 % + 0.26 µA 0.46 % + 0.48 µA 0.63 % + 1.7 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	0.46 % + 2.5 µA 0.17 % + 2.5 µA 0.067 % + 2.6 µA 0.033 % + 2.7 µA 0.067 % + 2.6 µA 0.46 % + 4.7 µA 0.63 % + 17 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	0.46 % + 25 µA 0.17 % + 26 µA 0.067 % + 26 µA 0.033 % + 27 µA 0.067 % + 26 µA 0.46 % + 47 µA 0.63 % + 0.17 mA	
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	0.46 % + 0.29 mA 0.18 % + 0.32 mA 0.085 % + 0.34 mA 0.11 % + 0.34 mA 0.34 % + 0.30 mA 1.1 % + 0.49 mA	
(1 to 3) A	(3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	1.3 % + 2.1 mA 0.40 % + 2.2 mA 0.18 % + 2.0 mA	Agilent 34401A

Parameter/Equipment	Range	CMC ² (±)	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	0.50 °C 0.31 °C 0.28 °C 0.28 °C 0.36 °C	
Type R	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.68 °C 0.44 °C 0.42 °C 0.50 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.57 °C 0.45 °C 0.47 °C 0.56 °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	

Parameter/Equipment	Range	CMC ^{2, 8} ($\pm$)	Comments
Oscilloscope Calibration ³ – Generate			
Voltage – DC to 1 M Ω	(1 to 25) mV (25 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 130) V	0.056 % + 48 μ V 0.056 % + 49 μ V 0.056 % + 90 μ V 0.056 % + 0.27 mV 0.056 % + 2.8 mV	Fluke 5520A option SC 1100
DC to 50 Ω	(1 to 25) mV (25 to 110) mV 110 mV to 2.2 V (2.2 to 6.6) V	0.29 % + 48 μ V 0.28 % + 52 μ V 0.27 % + 54 μ V 0.28 % + 69 μ V	
Square Wave – To 50 Ω	(1 to 25) mV (25 to 110) mV 110 mV to 2.2 V (2.2 to 6.6) V	0.29 % + 47 μ V 0.28 % + 55 μ V 0.27 % + 0.52 mV 0.28 % + 0.48 mV	
To 1 M Ω	(1 to 25) mV (25 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 130) V	0.11 % + 48 μ V 0.11 % + 48 μ V 0.11 % + 0.12 mV 0.11 % + 0.28 mV 0.11 % + 5.9 mV	
Rise Time	<300 ps @ 5.0 mV to 2.5 V	59 ps	
Timing			
Sine	(1 to 5) ns	30 ppm	
Sine or Square	10 ns	30 ppm	
Spike or Square	(20 to 50) ns	30 ppm	
Spike, Square, 20 % Pulse	100 ns to 20 ms	30 ppm	
Spike or Square	50 ms to 5 s	(30 + 1200t) ppm	t is time in seconds
Leveled Sine Wave –			
Amplitude 5 mV to 5.5 V	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	4.1 % + 0.35 mV 4.7 % + 0.35 mV 7.0 % + 0.35 mV	
5 mV to 3.5 V	(0.60 to 1.1) GHz	8.1 % + 2.4 ns	
Pulse Width	(1 to 100) ns	5.8 % + 2.4 ns	

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

Parameter/Equipment	Range	CMC ^{2, 4, 5, 7} (±)	Comments
Power Sensor Range to Range Calibration Uncertainty ³	(3, 10, 30, 100, 300) μ W (1, 3, 10, 30, 100) mW	0.49 % 0.49 %	Agilent 11683A
Power Meter Accuracy Check ³	(0.1 to 10) mW (0.01 to 0.03) mW	1.6 % 1.6 %	Agilent E4419A E9304AH18
VSWR of Power Sensor ³ – 10 Hz to 500 MHz 10 MHz to 50 GHz	 (1.0 to 1.2) VSWR (1.2 to 1.4) VSWR (1.4 to 1.6) VSWR (1.6 to 1.8) VSWR (1.8 to 2.0) VSWR (1.0 to 1.2) VSWR (1.2 to 1.4) VSWR (1.4 to 1.6) VSWR (1.6 to 1.8) VSWR (1.8 to 2.0) VSWR	 0.0074 VSWR 0.016 VSWR 0.026 VSWR 0.038 VSWR 0.050 VSWR 0.0094 VSWR 0.020 VSWR 0.033 VSWR 0.047 VSWR 0.063 VSWR	 Agilent 4395A, 87512A Agilent 8757D, 85027F

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

Parameter/Equipment	Frequency	CMC ^{2, 4, 5, 7} (±)	Comments
RF Absolute Power ³ – Measure (+20 to -60) dBm	9 kHz to 50 MHz 50 MHz to 5.0 GHz (5.0 to 9.0) GHz (9.0 to 15) GHz (15 to 18) GHz	1.8 % 2.2 % 2.6 % 2.7 % 2.8 %	Agilent E9304A-H18
(+20 to -30) dBm	50 MHz to 7 GHz (7 to 18) GHz (18 to 26) GHz (26 to 33) GHz (33 to 40) GHz (40 to 47) GHz (47 to 50) GHz	1.6 % 1.8 % 2.3 % 3.3 % 3.4 % 4.2 % 4.4 %	Agilent 8487A

Parameter/Range	Frequency	CMC ^{2, 4, 5, 6, 7} (±)	Comments
RF Absolute Power ³ – Measure (cont) (-20 to -70) dBm	50 MHz to 7 GHz (7 to 18) GHz (18 to 26) GHz (26 to 33) GHz (33 to 40) GHz (40 to 48) GHz (48 to 50) GHz	2.0 % 2.3 % 2.4 % 2.3 % 4.1 % 4.0 % 4.1 %	Agilent 8487D
RF Power ³ – Generate (+23 to 0) dBm (+24 to -130) dBm (+14 to -130) dBm (+24 to -130) dBm (+10 to -110) dBm (+5 to -110) dBm (+2.5 to -110) dBm	1 mHz to 80 MHz 10 Hz to 12.5 MHz 12.5 MHz to 4 GHz 12.5 MHz to 2.8 GHz 10 MHz to 26.5 GHz (26.5 to 40) GHz (40 to 50) GHz	0.28 dB + M 0.35 dB 0.64 dB 1.1 dB 1.4 dB 1.6 dB 2.4 dB	Agilent 33250A Fluke 9640A Agilent 83650B
VSWR ³ – Measure (1.0 to 1.2) VSWR (1.2 to 1.4) VSWR (1.4 to 1.6) VSWR (1.6 to 1.8) VSWR (1.8 to 2.0) VSWR (1.0 to 1.2) VSWR (1.2 to 1.4) VSWR (1.4 to 1.6) VSWR (1.6 to 1.8) VSWR (1.8 to 2.0) VSWR	10 Hz to 500 MHz 100 MHz to 50 GHz	0.0074 VSWR 0.016 VSWR 0.026 VSWR 0.038 VSWR 0.050 VSWR 0.0094 VSWR 0.020 VSWR 0.033 VSWR 0.047 VSWR 0.063 VSWR	Agilent 4395A, 87512A Agilent 8757D with 8721A, 85027D

Parameter/Equipment	Frequency	CMC ² (±)	Comments
Antenna VSWR (Reflection Magnitude) ⁹	(0.3 to 1000) MHz	0.50 dB	IEEE 149-1979
	10 MHz to 18 GHz	0.60 dB	AT-4395A, RS-ZVM
Antenna Symmetry ⁹	10 MHz to 6 GHz	0.89 dB	ANSI C63.5 4.4
Antenna Balance ⁹	(20 to 300) MHz	0.50 dB	CISPR 16-1-4
Biconical Antennas ⁹ –			
1 Meter Distance	(30 to 70) MHz (70 to 200) MHz (200 to 300) MHz	0.60 dB 0.95 dB 1.1 dB	SAE ARP 958
3 Meter Distance	(30 to 70) MHz (70 to 200) MHz (200 to 300) MHz	0.60 dB 0.95 dB 1.1 dB	SAE ARP 958, appendix C
3 Meter Distance	(20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	0.60 dB 0.42 dB 0.86 dB 0.95 dB 1.1 dB	ANSI C63.5, Standard site method, horizontal & vertical polarization
3 Meter Distance	(20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	0.60 dB 0.42 dB 0.86 dB 0.95 dB 1.1 dB	ANSI C63.5, Reference antenna method, horizontal & vertical polarization
3 Meter Distance	(20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	0.60 dB 0.42 dB 0.86 dB 0.95 dB 1.1 dB	ANSI C63.5, Identical antenna method, horizontal & vertical polarization
10 Meter Distance	(20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	0.60 dB 0.42 dB 0.86 dB 0.95 dB 1.1 dB	ANSI C63.5, Standard site method, horizontal & vertical polarization

Parameter/Equipment	Frequency	CMC ² (±)	Comments
Biconical Antennas ⁹ – (cont)			
10 Meter Distance	(20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	0.60 dB 0.42 dB 0.86 dB 0.95 dB 1.1 dB	ANSI C63.5, Reference antenna method, horizontal & vertical polarization
10 Meter Distance	(20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	0.60 dB 0.42 dB 0.86 dB 0.95 dB 1.1 dB	ANSI C63.5, Identical antenna method, horizontal & vertical polarization
Log-Periodic Antennas ⁹ –			
1 Meter Distance	(200 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1000) MHz (1000 to 6000) MHz	0.48 dB 0.51 dB 0.39 dB 0.60 dB 0.68 dB 1.0 dB 0.49 dB 0.62 dB 1.3 dB	SAE ARP 958D
3 Meter Distance	(200 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1000) MHz (1000 to 6000) MHz	0.48 dB 0.51 dB 0.39 dB 0.60 dB 0.68 dB 1.0 dB 0.49 dB 0.62 dB 1.3 dB	SAE ARP 958D, appendix C
3 Meter Distance	(200 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1000) MHz (1000 to 6000) MHz	0.48 dB 0.51 dB 0.39 dB 0.60 dB 0.68 dB 1.0 dB 0.49 dB 0.62 dB 1.3 dB	ANSI C63.5, Standard site method, horizontal & vertical polarization

Parameter/Equipment	Frequency	CMC ² (±)	Comments
Log-Periodic Antennas ⁹ – (cont)			
3 Meter Distance	(200 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1000) MHz (1000 to 6000) MHz	0.48 dB 0.51 dB 0.39 dB 0.60 dB 0.68 dB 1.0 dB 0.49 dB 0.62 dB 1.3 dB	ANSI C63.5, Identical antenna method, horizontal & vertical polarization
10 Meter Distance	(200 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1000) MHz (1000 to 6000) MHz	0.48 dB 0.51 dB 0.39 dB 0.60 dB 0.68 dB 1.0 dB 0.49 dB 0.62 dB 1.3 dB	ANSI C63.5, Standard site method, horizontal & vertical polarization
10 Meter Distance	(200 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1000) MHz (1000 to 6000) MHz	0.48 dB 0.51 dB 0.39 dB 0.60 dB 0.68 dB 1.0 dB 0.49 dB 0.62 dB 1.3 dB	ANSI C63.5, Identical antenna method, horizontal & vertical polarization
Hybrid Antennas ⁹ –			
1 Meter Distance	(30 to 70) MHz (70 to 200) MHz (200 to 400) MHz (400 to 1000) MHz (1000 to 6000) MHz	1.8 dB 1.3 dB 1.8 dB 1.8 dB 2.6 dB	SAE ARP 958D
3 Meter Distance	(30 to 70) MHz (70 to 200) MHz (200 to 400) MHz (400 to 1000) MHz (1000 to 6000) MHz	1.8 dB 1.3 dB 1.8 dB 1.8 dB 2.6 dB	SAE ARP958D, appendix C

Parameter/Equipment	Frequency	CMC ² (±)	Comments
Hybrid Antennas ⁹ – (cont)			
3 Meter & 10 Meter Distance	(20 to 1000) MHz (1000 to 6000) MHz	1.8 dB 2.6 dB	ANSI C63.5, Standard site method, horizontal & vertical polarization
	(20 to 1000) MHz (1000 to 6000) MHz	1.8 dB 2.6 dB	ANSI C63.5, Identical antenna method, horizontal & vertical polarization
Rod Antennas ³ (ECSM) –			CISPR 25, ANSI C63.5, SAE ARP 958, CISPR 16-1-4
Antenna Factor	10 Hz to 60 MHz	0.34 dB	HP 4395A & HP 87512A, BNC calibration standards

IV. Electrical – RF/Microwave: Signal Generator Calibration

Parameter/Range	Frequency	CMC ^{2, 4, 5, 7} (±)	Comments
Tuned RF Power Relative ³ – Measure			
(0 to -3) dBm	2.5 MHz to 26.5 GHz	0.089 dB	Agilent 8902A
(-3 to -10) dBm	2.5 MHz to 26.5 GHz	0.088 dB	Agilent 11722A
(-10 to -40) dBm	2.5 MHz to 26.5 GHz	0.16 dB	Agilent 11792A
(-40 to -50) dBm	2.5 MHz to 26.5 GHz	0.19 dB	
(-50 to -80) dBm	2.5 MHz to 26.5 GHz	0.28 dB	
(-80 to -90) dBm	2.5 MHz to 26.5 GHz	0.31 dB	
(-90 to -110) dBm	2.5 MHz to 26.5 GHz	0.38 dB	
Sine Wave Distortion ³ – Measure			
400 Hz & 1000 Hz Modulation	Modulation Depths: 1 % to 90 %	0.84 %	Agilent 8903B

Parameter/Range	Frequency	CMC ^{2, 4, 5, 7} (±)	Comments
Amplitude Modulation ³ – Measure			
Rate: 50 Hz to 10 kHz Depth: 5 % to 99 %	150 kHz to 10 MHz	3.0 %	Agilent 8902A
Rate: 20 Hz to 10 kHz Depth: 0 % to 99 %	150 kHz to 10 MHz	4.0 %	
Rate: 50 Hz to 50 kHz Depth: 5 % to 99 %	(10 to 1300) MHz	2.2 %	
Rate: 20 Hz to 100 kHz Depth: 0 % to 99 %	(10 to 1300) MHz	3.0 %	
Rate: 50 Hz to 50 kHz Depth: 5 % to 99 %	(1.3 to 26.5) GHz	2.4 %	Agilent 8902A with 11792A
Rate: 30 Hz to 1 MHz	(26.5 to 50) GHz	1.9 %	Agilent 8565E, option 001
Amplitude Modulation ³ – Generate			
(11 to 13.5) MHz	10 MHz to 50 GHz	1.7 %	HP 83650B
Residual AM	50 Hz to 3 kHz bandwidth	0.0060 %	HP 11715A, 8903B
AM Distortion	50 % AM, 20 Hz to 100 kHz rates	0.11 %	
	95 % AM, 20 Hz to 100 kHz rates	0.16 %	
AM Flatness	50 Hz to 50 kHz rates	0.16 %	
	20 Hz to 100 kHz rates	0.32 %	
AM Linearity	<95 % AM	0.18 %	
	<99 % AM	0.27 %	
Incidental ΦM	12.5 MHz carrier, 50 % AM, 1 kHz rate, 50 Hz to 3 kHz bandwidth	0.020 radians	

Parameter/Range	Frequency	CMC ^{2, 4, 5, 7} (±)	Comments
Phase Modulation ³ – Measure Rate: 200 Hz to 10 kHz 200 Hz to 20 kHz	(10 to 1300) MHz 10 MHz to 26.5 GHz	5.1 % 5.1 %	Agilent 8902A, 11972A
Pulse Repetition Frequency ³ – Measure	3 Hz to 80 MHz	2.3 parts in 10 ⁶ + 1.5 Hz	Agilent 53132A
Frequency Modulation ³ – Measure Rate: 20 Hz to 10 kHz Dev.: ≤40 kHz Peak Rate: 50 Hz to 100 kHz Dev.: ≤400 kHz Peak Rate: (20 to 200) kHz Dev.: ≤400 kHz Peak 30 Hz to 1 MHz	250 kHz to 10 MHz (10 to 1300) MHz (0.10 to 26.5) GHz (26.5 to 50) GHz	2.7 % 1.9 % 6.0 % 1.4 %	Agilent 8902A With Agilent 11793A Agilent 8565E opt 001
Single Sideband Phase Noise (SSB) ³	30 Hz to 1.3 GHz (1.3 to 50 GHz)	1.2 dB 1.4 dB	Agilent 8565E
Frequency Accuracy ³	10 Hz to 125 MHz 50 MHz to 46 GHz (46 to 50) GHz	4.1 Hz + 0.59 % 56 Hz + 0.59 % 4.7 kHz	Agilent 53152A opt 48 Agilent 8565E

V. Electrical – RF/Microwave: Spectrum Analyzer/EMI Receiver Calibration/Signal Analyzers

Parameter/Equipment	Frequency	CMC ^{2, 4, 5, 7} ($\pm$)	Comments
Frequency Modulation ³ – Generate			
250 kHz to 40 GHz	For 400 Hz & 1000 Hz internal modulation	4.3 %	Agilent 83650B
10 MHz to 50 GHz	1 MHz rate, 1 MHz deviation	2.6 %	
(11 to 13.5) MHz, (88 to 108) MHz, (352 to 432) MHz			
Residual FM	50 Hz to 15 kHz bandwidth	0.14 Hz	HP 11715A, 8903B
FM Distortion	12.5 MHz, 12.5 kHz deviation, <10 kHz modulation rate 100 MHz, 100 kHz deviation, <100 kHz modulation rate 400 MHz, 400 kHz deviation, <100 kHz modulation rate	0.021 %	
FM Flatness	DC to 100 kHz rates DC to 200 kHz rates DC to 10 MHz	0.27 %	
Frequency Accuracy ³	10 Hz to 125 MHz 50 MHz to 46 GHz (46 to 50) GHz	4.1 Hz + 0.59 % 56 Hz + 0.59 % 4.7 kHz	Agilent 53152A opt 48 Agilent 8565E
Span Accuracy ³	1 kHz to 2 MHz (2 to 500) MHz	2.5 Hz 1.0 kHz	Fluke 9640
Residual FM ³ (At 500 MHz)	5 kHz span & 1 kHz RBW	0.31 kHz	Fluke 9640, Agilent 83650A
Cal Output Port Check ³	300 MHz -20 dBm	1.7 Hz 0.55 dB	Agilent 53132A, Agilent E9304A, Agilent E4419A

Parameter/Equipment	Frequency	CMC ^{2, 4, 5, 7} ($\pm$)	Comments
Average Noise ³	9 kHz to 50 GHz	0.31 dB	50 Ω load
Residuals ³	20 Hz to 50 GHz	0.31 dB	50 Ω load
Reference Level ³ – Log Scale	50 MHz	0.29 dB	Fluke 9640
Linear Scale	50 MHz	0.47 dB	Agilent 83650B
Attenuator Check ³	50 MHz	0.15 dB	Agilent 8902A
Log Fidelity ³	50 MHz	1.1 dB	Fluke 9640
Linear Fidelity ³	50 MHz	1.1 dB	Agilent 83650B (based on Agilent 8593E)
BW Accuracy ³	20 Hz to 50 GHz	1.6 Hz	Agilent 83650B
BW Switching ³	20 Hz to 50 GHz	1.2 dB	Agilent 83650B
2 nd Harmonic Distortion ³	200 Hz to 80 MHz 10 MHz to 50 GHz	2.3 dB 2.3 dB	Fluke 9640 Agilent 83650B
3 rd Order Intermodulation ³	200 Hz to 80 MHz (10 to 50) GHz	2.3 dB 2.4 dB	Fluke 9640 Agilent 83650B
Noise Sidebands ³	200 Hz to 80 MHz (10 to 50) GHz	0.76 dB 0.94 dB	Fluke 9640 Agilent 83650B
System Sidebands ³	200 Hz to 80 MHz (10 to 50) GHz	0.48 dB 0.66 dB	Fluke 9640 Agilent 83650B
Sweep Time ³	10 MHz to 50 GHz	6.1 %	Agilent 83650B

Parameter/Equipment	Range	CMC ^{2, 5, 7} ($\pm$)	Comments
Harmonic Measurements ³	30 Hz to 50 GHz 200 Hz to 80 MHz (10 to 50) GHz	0.63 dB 0.81 dB 1.0 dB	Agilent 8565E Fluke 9640 Agilent 83650B (based on Agilent 8565E)
Frequency Response ³	9 kHz to 18 GHz 50 MHz to 50 GHz	0.75 dB 0.79 dB	Agilent E9304A-H18 Agilent 8487A
Gain Compression ³	200 Hz to 80 MHz (10 to 50) GHz	1.5 dB 1.5 dB	Fluke 9640 Agilent 83650B
Source Errors for CISPR Bands A & B for Impulse Spectral Amplitude ³	Band A (10 to 150) kHz Band B (0.15 to 30) MHz	0.81 dB 0.81 dB	IGUU 2918
Source Errors for CISPR Bands C & D for Impulse Spectral Amplitude ³	Band C & D (30 to 1000) MHz	1.1 dB	IGUU 2918
Source Errors for Sinewave Output for CISPR Checks ³ (at 60 dB/ μ V)	100 kHz (1, 10, & 100) MHz	0.26 dB 0.26 dB	IGUU 2918
Peak & Average Detector Response ³	Band A through D	1.3 dB	IGUU 2918
Source Errors for Frequency Response ³	Band A Band B Band C Band D	0.60 dB 0.60 dB 0.60 dB 0.60 dB	Agilent 8565E
Impulse BW Measurement ³	Above 1 GHz	3.7 kHz	Agilent 83650, 33250A

Parameter/Equipment	Range	CMC ^{2, 5, 6, 7} ($\pm$)	Comments
ISN ³ –			
Phase	150 kHz to 80 MHz	3.0°	CISPR: 22 & 16-1-2, HP 4395A & HP 87512A
Insertion Loss	150 kHz to 80 MHz	0.35 dB	
Impedance	150 kHz to 80 MHz	2.4 Ω	
Longitudinal Conversion Loss	150 kHz to 2 MHz (2 to 80) MHz	1.1 dB 1.7 dB	
Decoupling Attenuation	150 kHz to 80 MHz	0.35 dB	
LISN ³ –			
Insertion Loss	9 kHz to 108 MHz	0.66 dB + M	ANSI C63.4, CISPR: 25 & 16-1-2; HP-4395A & HP- 87512A, RS-ZVM BNC Type “N” calibration standards
	(108 to 400) MHz	0.86 dB + M	
	150 kHz to 100 MHz	0.38 dB	
	(100 to 200) MHz	0.61 dB	
	(200 to 400) MHz	1.4 dB	
	(400 to 600) MHz	1.3 dB	
	(600 to 800) MHz	1.4 dB	
	800 MHz to 1 GHz	2.3 dB	
Impedance – Magnitude	9 kHz to 100 MHz	0.68 Ω	
	(100 to 200) MHz	0.77 Ω	
	(200 to 400) MHz	0.91 Ω	
	150 kHz to 100 MHz	0.35 Ω	
	(100 to 200) MHz	1.3 Ω	
	(200 to 400) MHz	2.3 Ω	
	(400 to 600) MHz	2.2 Ω	
	(600 to 800) MHz	1.9 Ω	
	800 MHz to 1 GHz	2.2 Ω	
Impedance – Phase	9 kHz to 100 MHz	3.5°	
	(100 to 200) MHz	3.3°	
	(200 to 400) MHz	3.2°	
Isolation	9 kHz to 100 MHz	0.36 dB	
	(100 to 200) MHz	1.1 dB	
	(200 to 400) MHz	1.6 dB	

Parameter/Equipment	Range	CMC ^{2, 5, 6, 7} ($\pm$)	Comments
Current Probes & Bulk Current Injection Probes ³ –			
Insertion Loss	10 Hz to 500 MHz 500 MHz to 2.4 GHz	0.77 dB + <i>M</i> 1.2 dB + <i>M</i>	CISPR 16-1-2, IEC/EN 61000-4-6; HP4395 HP87512 & RS-ZVM BNC & Type “N” calibration standards
Transfer Impedance	10 Hz to 500 MHz 500 MHz to 2.4 GHz	0.77 dB + <i>M</i> 1.2 dB + <i>M</i>	
CDN's & Adapters ³ – (50 to 150) Ω			IEC/EN 61000-4-6 CISPR 16-1-2
Adapter Insertion Loss	10 kHz to 230 MHz	1.2 dB + <i>M</i>	HP 4395A & HP 87512A, BNC & Type “N” calibration standards
Coupling Factor	10 kHz to 230 MHz	1.1 dB + <i>M</i>	
Impedance	10 kHz to 230 MHz	3.5 Ω	
Reflection S_{11}/S_{22} – Magnitude ³			RS-ZVM Agilent 4395A HP-8757 HP-85027D
10 MHz to 50 GHz	(0 to -40) dB	1.2 dB	
10 Hz to 500 MHz	(0 to -10) dB	0.64 dB	
(0.5 to 18) GHz	(-10 to -60) dB	0.45 dB	
	(-60 to -80) dB	0.56 dB	
	(-80 to -100) dB	3.5 dB	
10 MHz to 20 GHz	(10 to 3) dB	1.0 dB	
	(3 to -15) dB	0.89 dB	
	(-15 to -25) dB	1.4 dB	
	(-25 to -35) dB	3.5 dB	

Parameter/Range	Frequency	CMC ² (±)	Comments
Reflection S ₁₁ /S ₂₂ – Phase ³ 10 Hz to 500 MHz (0 to -10) dB (-10 to -60) dB (-60 to -80) dB (-80 to -100) dB 10 MHz to 20 GHz	(0 to 180)° (0 to 180)°	3.5° 0.72° 2.2° 21° 7.0°	Agilent 4395A RS-ZVM
Transmission S ₁₂ /S ₂₁ – Magnitude ³ 10 MHz to 50 GHz 10 Hz to 500 MHz (0.5 to 18) GHz 10 MHz to 20 GHz	(0 to -40) dB (0 to -10) dB (-10 to -60) dB (-60 to -80) dB (-80 to -100) dB (10 to 3) dB (3 to -15) dB (-15 to -25) dB (-25 to -35) dB	1.2 dB 0.64 dB 0.45 dB 0.56 dB 3.5 dB 1.0 dB 0.89 dB 1.4 dB 3.5 dB	HP-8757 HP-85027D Agilent 4395A RS-ZVM

VI. Electrical – RF/Microwave: Network Analyzer Calibration

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Non-Sweep Linearity Test (NA) ³	(-90 to 20) dBm	0.25 dB	Agilent E4419B, Agilent 8481D
Frequency Accuracy Test (NA) ³	10 Hz to 2 GHz (2 to 46) GHz	0.59 % 0.59 %	Agilent 53152A
Source Level Accuracy/Flatness Test (NA) ³	100 kHz to 4.2 GHz (1 to 26.5) GHz (26.5 to 50) GHz 100 kHz to 4 GHz (1 to 26.5) GHz (26.5 to 50) GHz	0.14 dB 0.16 dB 0.27 dB 0.14 dB 0.16 dB 0.27 dB	Agilent E4419B, 8482A, Agilent E4419B, 8487A Agilent 8482A, Agilent 8487A

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Power Sweep Linearity Test (NA) ³	(0 to 20) dB	0.30 dB	Agilent E4419B, 8482A, 11667A
	(0 to 20) dB	0.38 dB	Agilent E4419B, 8487A, 11667A
Harmonics/Non-Harmonic Test (NA) ³	(-30 to -120) dBc	0.32 dB	Agilent 8565E
Receiver Noise Level Test (NA) ³	(-30 to -120) dBm	0.33 dB	Agilent 85032-60017
Input Crosstalk Test (NA) ³	(-30 to -120) dB	0.26 dB	Agilent 85032-60017
Input Impedance Test (NA) ³	(0 to 110) dB	0.30 dB	Agilent 8757D
Absolute Amplitude Accuracy Test (NA) ³	(0 to -60) dBm	3.5 %	Agilent E4419B, HP 8482A HP 11667A HP 3458A
Magnitude Ratio/Phase Dynamic Accuracy Test (NA) ³ –			
Magnitude Ratio Dynamic	(0 to -100) dB	0.52 dB	Agilent 11667A HP 8496H HP 8494H Agilent E9304AH18
Phase Dynamic	(0 to -100) dB	0.064°	
Receiver Trace Noise (NA) ³	300 kHz to 50 GHz	0.32 dB	Matched load
Magnitude Ratio/Phase Frequency Response Test (NA) ³ –			
Magnitude Ratio Accuracy	100 kHz to 50 GHz	0.52 dB	Agilent 11667A 11667C HP 8496H HP 8494H Agilent E9304AH18
Phase Frequency Response	100 kHz to 50 GHz	0.64°	

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Receiver Input Impedance (NA) ³	(0 to 120) dB return loss	0.30 dB	ZVM
Receiver Magnitude Accuracy (NA) ³	100 kHz to 4 GHz (1 to 50) GHz	0.19 dB 0.24 dB	Agilent 438A, 8482A, Agilent 438A, 8487A
	100 kHz to 4 GHz (1 to 50) GHz	0.19 dB 0.24 dB	Agilent E4419B, 8482A, Agilent E4419B, 8487A
Receiver Phase Compression (NA) ³	100 kHz to 4 GHz (1 to 50) GHz	0.13 dB 0.29 dB	Agilent 438A, 8482A, Agilent 438A, 8487A
	100 kHz to 4 GHz (1 to 50) GHz	0.19 dB 0.24 dB	Agilent E4419B, 8482A, Agilent E4419B, 8487A
Port Match (NA) ³	10 MHz to 20 GHz	0.67 dB	ZVM
Switch Repeatability (NA) ³	10 MHz to 20 GHz	0.67 dB	Associated network analyzer used with S parameter test set
Effective Source Match (NA) ³	10 MHz to 20 GHz	0.67 dB	ZVM
Directivity ³	10 MHz to 20 GHz	0.67 dB	RS-ZV-Z32
Current Monitor Conversion Factors ³	(0.001 to 1) V/A	0.088 %	Agilent 3458A

VII. Electrical RF/Microwave: Device Specific Parameters

EMI receivers (CISPR 16-1), EFT/Burst Generators (EN 61000-4-4), ESD Guns & Targets (IEC 61000-4-2, ANSI C63.16, SAE J1113-13), Surge Generators (EN 61000-4-5), Generators for Voltage Dips, Short Interrupts & 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	Range	CMC ^{2, 4} ($\pm$)	Comments
EFT/Burst Generator ³ –			
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 $\pm$ 30 %	0.74 ns	
Impulse Duration	150 ns $\pm$ 30 %	0.74 ns	
Burst Duration	15 ms $\pm$ 20 % 0.75 ms $\pm$ 20 %	0.74 ns	
Burst Period	300 ms $\pm$ 20 %	0.74 ns	
Repetition Rate	1 kHz to 50 Mhz	23 Hz (freq) 2.8 % (volt)	
Mains Harmonic Emissions ³	(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) ³	(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
RF Pre-Amplifiers, Amplifiers ³ –			IEEE 291
Gain	10 Hz to 10 MHz (10 to 20) GHz (20 to 50) GHz	0.80 dB 1.0 dB 1.0 dB	Agilent 4395A RS-ZVM 83650B

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
ESD Simulators –			IEC/EN 61000-4-2; ISO 10605; SAE J1113-13
Contact Voltage (Positive & Negative)	(0.5 to 2) kV (2 to 8) kV (8 to 15) kV (15 to 30) kV	2.6 % 0.7 % 0.6 % 0.54 %	TEK TDS 5104B IEC ESD Target Applied Kilovolt 149-3
Rise Time	(0.7 to 1) ns	65 ps	
Peak Current	(6.8 to 33) A	5.0 %	
30 ns Current	(2.8 to 20.8) A	5.6 %	
60 ns Current	(1.4 to 10.4) A	6.1 %	
Air Discharge Voltage (Positive & Negative)	(0 to 2) kV (2 to 20) kV (20 to 40) kV	0.15 % 0.61 % 1.2 %	
Rise Time	(0.7 to 1) ns	61 ps	
RC Time Constant (at ± 15 kV)	600 ns ± 130 ns (for 330 pF probe) 300 ns ± 60 ns (for 150 pF probe)	7.2 ns 6.0 ns	
Surge Generator ³ – Ring/ Impulse/ PQF			EN 61000-4-5; IEC 61000-4-8; IEC 61000-4-9; IEC 61000-4-10; IEC 61000-4-11; IEC 6100-4-12 UL 864; UL 1449; ISO 7637-2; ISO 17069 ITU Rec K.17, K.20, ITU Rec K.21; SBC-TP-76200;
Front Time Open Short	(0.1 to 50) µs	0.74 ns	
Rise Time Open Circuit Short Circuit	(0.1 to 50) µs	1.2 ns	
Time to Half-Value Impulse Duration	(20 to 1500) µs	0.74 ns	
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	Range	CMC ² (±)	Comments
General RF Insertion Loss/Gain ³	9 kHz to 18 GHz	0.38 dB	Agilent E9304A-H18, Agilent E4419B
	10 MHz to 1 GHz	0.40 dB	Agilent 8481A
	(1 to 2) GHz	0.39 dB	
	(2 to 4) GHz	0.39 dB	
	(4 to 6) GHz	0.39 dB	
	(6 to 8) GHz	0.40 dB	
	(8 to 10) GHz	0.40 dB	
	(10 to 12) GHz	0.40 dB	
	(12 to 14) GHz	0.41 dB	
	(14 to 16) GHz	0.41 dB	
	(16 to 18) GHz	0.42 dB	
	10 MHz to 1 GHz	0.38 dB	Agilent 8481D Agilent E4419B
	(1 to 2) GHz	0.37 dB	
	(2 to 4) GHz	0.37 dB	
	(4 to 6) GHz	0.37 dB	
	(6 to 8) GHz	0.38 dB	
	(8 to 10) GHz	0.38 dB	
	(10 to 12) GHz	0.39 dB	
	(12 to 14) GHz	0.39 dB	
	(14 to 16) GHz	0.40 dB	
	(16 to 18) GHz	0.40 dB	
	50 MHz to 1 GHz	0.40 dB	Agilent E4419B, Agilent 8487A
	(1 to 2) GHz	0.40 dB	
	(2 to 4) GHz	0.40 dB	
	(4 to 6) GHz	0.40 dB	
	(6 to 8) GHz	0.40 dB	
	(8 to 10) GHz	0.40 dB	
	(10 to 12) GHz	0.40 dB	
	(12 to 14) GHz	0.40 dB	
	(14 to 16) GHz	0.40 dB	
	(16 to 18) GHz	0.40 dB	
	(18 to 22) GHz	0.40 dB	
	(22 to 26.5) GHz	0.40 dB	
	(26.5 to 28) GHz	0.40 dB	
	(28 to 30) GHz	0.40 dB	
	(30 to 33) GHz	0.40 dB	
	(33 to 34.5) GHz	0.40 dB	
	(34.5 to 37) GHz	0.40 dB	
	(37 to 40) GHz	0.41 dB	
	(40 to 42) GHz	0.42 dB	
	(42 to 44) GHz	0.42 dB	
	(44 to 46) GHz	0.43 dB	
	(46 to 48) GHz	0.44 dB	
	(48 to 50) GHz	0.45 dB	

Parameter/Equipment	Range	CMC ² (±)	Comments
General RF Insertion Loss/Gain ³ (cont)	50 MHz to 1 GHz	0.38 dB	Agilent E4419B, Agilent 8487D
	(1 to 2) GHz	0.38 dB	
	(2 to 4) GHz	0.38 dB	
	(4 to 6) GHz	0.39 dB	
	(6 to 8) GHz	0.39 dB	
	(8 to 10) GHz	0.40 dB	
	(10 to 12) GHz	0.40 dB	
	(12 to 14) GHz	0.40 dB	
	(14 to 16) GHz	0.40 dB	
	(16 to 18) GHz	0.40 dB	
	(18 to 22) GHz	0.40 dB	
	(22 to 26.5) GHz	0.40 dB	
	(26.5 to 28) GHz	0.40 dB	
	(28 to 30) GHz	0.40 dB	
	(30 to 33) GHz	0.40 dB	
	(33 to 34.5) GHz	0.40 dB	
	(34.5 to 37) GHz	0.40 dB	
	(37 to 40) GHz	0.41 dB	
	(40 to 42) GHz	0.42 dB	
	(42 to 44) GHz	0.42 dB	
	(44 to 46) GHz	0.43 dB	
	(46 to 48) GHz	0.44 dB	
	(48 to 50) GHz	0.45 dB	
	50 MHz to 1 GHz	0.38 dB	
	(1 to 2) GHz	0.38 dB	
	(2 to 4) GHz	0.38 dB	
	(4 to 6) GHz	0.39 dB	
	(6 to 8) GHz	0.39 dB	
	(8 to 10) GHz	0.39 dB	
	(10 to 12) GHz	0.39 dB	
	(12 to 14) GHz	0.40 dB	
	(14 to 16) GHz	0.40 dB	
	(16 to 18) GHz	0.40 dB	
	(18 to 22) GHz	0.40 dB	
	(22 to 26.5) GHz	0.40 dB	
	(26.5 to 28) GHz	0.40 dB	
	(28 to 30) GHz	0.40 dB	
	(30 to 33) GHz	0.40 dB	
	(33 to 34.5) GHz	0.40 dB	
	(34.5 to 37) GHz	0.40 dB	
	(37 to 40) GHz	0.40 dB	
	(40 to 42) GHz	0.40 dB	
	(42 to 44) GHz	0.40 dB	
	(44 to 46) GHz	0.40 dB	
	(46 to 48) GHz	0.43 dB	
	(48 to 50) GHz	0.43 dB	

Parameter/Equipment	Range	CMC ^{2, 4, 8} (±)	Comments
Impedance ³ – Measure, 50 Ω Terminations	10 Hz to 500 MHz 10 MHz to 20 GHz	3.9 % 3.0 %	Agilent 4395A, 85032F R&S ZVM, ZV-Z32
Impedance ³ – Measure, 50 Ω Devices	10 Hz to 500 MHz 10 MHz to 20 GHz	3.9 % 3.0 %	Agilent 4395A, 85032F R&S ZVM, ZV-Z32
Attenuation Measurements ³ – (0 to 100) dB (0 to 80) dB	 100 kHz to 18 GHz (18 to 40) GHz	 0.24 dB 0.34 dB	 Agilent 8902A, 11792A
Rise/Fall Time ³ – Measure Voltage Measure	(200 ps to 1000 s)/div (1 mV to 10 V)/div	18 μs/s + 64 ps 2.0 %	TDS 5104B TDS 5104B

VIII. Thermodynamics

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measuring Equipment	(5 to 60) °C	0.14 °C	Rotronics HG2-S101 & Rotronics H290D sensor
Temperature – Measure	(-70 to 0) °C (0 to 200) °C (200 to 420) °C	0.030 °C 0.055 °C 0.038 °C	Fluke 5618B & 1523
Relative Humidity – Measure	(0 to 90) % RH (90 to 100) % RH	1.3 % RH 2.4 % RH	Vaisala HMI41, HMP46
Relative Humidity – Generate	(5 to 90) % RH (90 to 95) % RH	0.81 % RH 1.0 % RH	Rotronics HG2-S101 & Rotronics H290D sensor

IX. Time & Frequency

Parameter/Equipment	Frequency	CMC ^{2, 4} ($\pm$)	Comments
Frequency ³ – Measuring Equipment	1 μ Hz to 80 MHz	2.5 μ Hz/Hz + 1 μ Hz	Agilent 33250
	10 Hz to 4 GHz	0.03 nHz/Hz + 0.6 mHz	Fluke 9640
	10 MHz to 50 GHz	0.03 nHz/Hz + 0.6 Hz	Agilent 83650B w/ option 008
Frequency ³ – Measure	1 mHz to 225 MHz 225 MHz to 46 GHz (46 to 50) GHz 10 MHz	0.62 nHz/Hz + 18 pHz 0.13 μ Hz/Hz + 12 Hz 0.59 % 6.2 mHz	Agilent 53132A, Agilent 53132A Agilent 8565E rubidium locked
Time Interval ³ – Measure	500 ps to 400 s	19 μ Hz/Hz + 24 ps	TDS 5104A
Frequency Stability ³	10 MHz for $\tau=10$ s	0.016 nHz/ Hz	Agilent 53132A rubidium locked

¹ This laboratory offers commercial 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. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

³ 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.

⁴ In the statement of CMC, all percentages shall be read as percent of reading, unless otherwise noted.

- ⁵ 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.
- ⁶ 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.
- ⁷ 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.
- ⁸ 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. CMCs are expressed as either a specific value that covers the full range or as a fraction/percentage of the reading plus a fixed floor specification.
- ⁹ The ground plane of size of remote calibration site is 16×24 square meters. These calibrations are performed only at the Nemko facility, located at 1500 Peter Robinson Rd. West Carleton, Ontario, K0A 1L0. As a supplement to the standard(s) requirements Liberty Laboratory procedures provide for vertical and/or horizontal polarizations.



Accredited Laboratory

A2LA has accredited

KEYSIGHT TECHNOLOGIES CANADA

Kanata, ON, CANADA

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 and the requirements of ANSI/NCSLI 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 8 January 2009).



Presented this 11th day of December 2017.

A handwritten signature in blue ink, likely of the President and CEO, is written over a horizontal line.

President and CEO
For the Accreditation Council
Certificate Number 3811.01
Valid to August 31, 2019

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