



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

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CALIBRATION

Valid To: June 30, 2023

Certificate Number: 2562.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations^{1,15}:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 3, 8, 10} (±)	Comments
DC Voltage – Generate and Measure			
Fixed Points	10 V	0.70 µV/V	Zener voltage standard
	0 V	0.01 µV	Low thermal short
	0.1 V	1.8 µV/V	Fluke 5730A calibrator with Keysight 3458A DMM (90-day cal cycle)
	1 V	0.73 µV/V	
	10 V	0.73 µV/V	
	100 V	0.73 µV/V	
	1000 V	0.73 µV/V	
Generate	Up to 220 mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 60) V (60 to 220) V (220 to 1000) V	4.5 µV/V + 0.41 µV 4.2 µV/V + 0.72 µV 1.3 µV/V + 6.2 µV 1.5 µV/V + 5.3 µV 2.4 µV/V + 69 µV 2.6 µV/V + 56 µV 3.6 µV/V + 0.62 mV	Multifunction calibrator
Measure	Up to 120 mV (0.12 to 1.2) V (1.2 to 12) V (12 to 120) V (120 to 1100) V	3.6 µV/V + 0.29 µV 3.3 µV/V + 1.7 µV 1.8 µV/V + 18 µV 3.1 µV/V + 0.18 mV 2.9 µV/V + 1.7 mV	AT 3458A, option II

Parameter/Equipment	Range	CMC ^{2, 8, 10} (\pm)	Comments
DC Voltage – Generate and Measure (cont)			
Measure	Up to 200 mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1050) V	1.8 μ V/V + 0.31 μ V 2.3 μ V/V + 0.56 μ V 2.4 μ V/V + 3.3 μ V 4.4 μ V/V + 91 μ V 4.2 μ V/V + 0.66 mV	Fluke 8508A
DC Current – Generate and Measure			
Fixed Points	100 μ A 1 mA 10 mA 20 mA 100 mA 200 mA	1.9 nA 14 nA 0.14 μ A 0.28 μ A 1.4 μ A 2.8 μ A	Guildline 9334A ⁴
Generate	1 A 10 A 20 A	20 μ A 0.55 mA 1.1 mA	Guildline 9330 ⁴ Fluke Y5020 ⁴
Generate	Up to 220 μ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A	40 μ A/A + 5.5 nA 33 μ A/A + 6.2 nA 45 μ A/A + 39 nA 48 μ A/A + 0.62 μ A 70 μ A/A + 12 μ A	Fluke 5700A/EP
Measure	(10 to 100) μ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	50 μ A/A + 0.2 nA 50 μ A/A + 1.5 nA 50 μ A/A + 9.8 nA 0.012 % + 98 nA 0.014 % + 0.98 μ A	AT 3458A

Parameter/Range ¹²	Frequency	CMC ^{2, 8, 11} (\pm)	Comments
AC Voltage – Generate and Measure ¹³			
1 mV	(10 to 30) Hz (30 to 1000) Hz (1 to 120) kHz	0.22 % 0.19 % 0.19 %	Fluke 5790A AC standard w/ 5720A calibrator

Parameter/Range ¹²	Frequency	CMC ^{2, 8, 11} (\pm)	Comments
AC Voltage – Generate and Measure ¹³ (cont)			
1 mV	(120 to 500) kHz (500 to 1000) kHz (1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.20 % 0.20 % 0.20 % 0.28 % 0.28 % 0.28 % 0.40 % 0.84 %	Fluke 5790A AC standard w/ 5720A calibrator
2 mV	(10 to 30) Hz (30 to 1000) Hz (1 to 120) kHz (120 to 500) kHz (500 to 1000) kHz (1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.22 % 0.19 % 0.19 % 0.20 % 0.20 % 0.14 % 0.24 % 0.24 % 0.24 % 0.37 % 0.83 %	
10 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz (1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.04 % 0.033 % 0.02 % 0.032 % 0.045 % 0.097 % 0.14 % 0.09 % 0.09 % 0.13 % 0.13 % 0.13 % 0.21 % 0.44 %	
20 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.03 % 0.019 % 0.014 % 0.025 % 0.034 % 0.080 % 0.11 % 0.093 %	

Parameter/Range ¹²	Frequency	CMC ^{2,8,11} (±)	Comments
AC Voltage – Generate and Measure ¹³ (cont)			
20 mV	(1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.093 % 0.13 % 0.13 % 0.13 % 0.21 % 0.44 %	Fluke 5790A AC standard w/ 5720A calibrator
100 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.023 % 0.10 % 46 μV/V 70 μV/V 0.015 % 0.023 % 0.037 %	
70 mV	(0.5 to 1) MHz (1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.067 % 0.063 % 0.12 % 0.12 % 0.12 % 0.18 % 0.41 %	
200 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz (1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.019 % 83 μV/V 33 μV/V 49 μV/V 0.0072 % 0.016 % 0.027 % 0.061 % 0.063 % 0.13 % 0.13 % 0.13 % 0.19 % 0.42 %	
1 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.017 % 61 μV/V 22 μV/V 37 μV/V 56 μV/V 0.013 % 0.021 % 0.066 %	

Parameter/Range ¹²	Frequency	CMC ^{2, 8, 11} (±)	Comments	
AC Voltage – Generate and Measure ¹³ (cont)				
1 V	(1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.068 % 0.13 % 0.13 % 0.13 % 0.19 % 0.42 %	Fluke 5790A AC standard w/ 5720A calibrator	
2 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.017 % 60 µV/V 21 µV/V 37 µV/V 56 µV/V 0.013 % 0.021 % 0.070 %		
3 V	(0.5 to 1) MHz (1 to 2) MHz (2 to 3) MHz (3 to 5) MHz (5 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.076 % 0.080 % 0.14 % 0.15 % 0.15 % 0.26 % 0.55 %		
10 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.016 % 59 µV/V 22 µV/V 38 µV/V 63 µV/V 0.015 % 0.032 % 0.094 %		
20 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.016 % 59 µV/V 22 µV/V 38 µV/V 63 µV/V 0.015 % 0.032 % 0.094 %		
44 V	(300 to 500) kHz	0.032 %		Fluke 5790A AC standard w/ 5720A calibrator

Parameter/Range ¹²	Frequency	CMC ^{2, 8, 11} (\pm)	Comments
AC Voltage – Generate and Measure ¹³ (cont)			
60 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.016 % 60 μ V/V 26 μ V/V 45 μ V/V 73 μ V/V 0.016 %	Fluke 5790A AC standard w/ 5720A calibrator
100 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.017 % 62 μ V/V 25 μ V/V 54 μ V/V 77 μ V/V	
200 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.017 % 63 μ V/V 25 μ V/V 54 μ V/V 76 μ V/V	
5725 A Range 300 V	40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.031 % 0.031 % 0.11 %	Fluke 5790A/3 AC standard w/ 5720A/3 calibrator 5725A amplifier
5725A 750V Range 600 V	50 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.029 % 0.029 % 0.11 %	Fluke 5790A AC standard w/ 5720A calibrator 5725A amplifier
1000 V	50 Hz to 1 kHz 40 Hz to 20 kHz	0.010 % 0.029 %	
AC Current – Measure			
100 μ A	1 kHz	0.017 %	AT 3458A
1 mA	1 kHz	0.014 %	
10 mA	1 kHz	0.014 %	
100 mA	1 kHz	0.016 %	
1 A	1 kHz	0.028 %	

Parameter/Range ¹²	Frequency	CMC ^{2, 8} (\pm)	Comments
AC Current – Measure (cont)			
10 A	(45, 4500, 1000) Hz	1.2 mA	AT 3458A DMM & Y5020A shunt
11 A	(45, 500, 1000) Hz	1.3 mA	
20 A	(45, 500, 1000) Hz	2.2 mA	
AC Current – Generate			
(0 to 220) μ A	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.023 % + 0.022 μ A 0.016 % + 0.015 μ A 0.011 % + 0.013 μ A 0.027 % + 0.034 μ A 0.10 % + 0.081 μ A	Fluke 5700A/EP
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.023 % + 0.15 μ A 0.016 % + 0.10 μ A 0.011 % + 0.095 μ A 0.019 % + 0.17 μ A 0.10 % + 0.64 μ A	
(2.2 to 22) mA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.023 % + 2.4 μ A 0.016 % + 1.3 μ A 0.011 % + 0.95 μ A 0.019 % + 1.4 μ A 0.10 % + 5.0 μ A	
(22 to 220) mA	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.023 % + 24 μ A 0.016 % + 12 μ A 0.011 % + 93 μ A 0.019 % + 13 μ A 0.1 % + 47 μ A	
(0.22 to 2.2) A	(10 to 20) Hz (20 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.025 % + 140 μ A 0.025 % + 140 μ A 0.025 % + 140 μ A 0.039 % + 160 μ A 0.62 % + 890 μ A	
(3 to 10.9999) A	(45 to 100) Hz (100 to 1000) Hz (1 to 5) kHz	0.42 mA/A + 0.84 mA 0.74 mA/A + 0.59 mA 23 mA/A + 22 μ A	
(11 to 20.5) A	(45 to 100) Hz (100 to 1000) Hz (1 to 5) kHz	0.91 mA/A + 1.1 mA 1.1 mA/A + 0.87 mA 25 mA/A + 42 μ A	

Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
AC Current – Generate (cont) (100 to 1000) A*	(50 to 400) Hz	0.24 % + 0.02 A	Fluke coil *Coil ampere turns
Phase – Measure Sinewave Voltage to Voltage – 20 mV to 350 V	(0.010 to 5) kHz (5 to 50) kHz (50 to 75) kHz (75 to 100) kHz	0.053° 0.056° 0.10° 0.15°	Clarke Hess 6000 phase meter
Sinewave Voltage to Current – 20 mV to 350 V	(0.010 to 5) kHz (5 to 50) kHz (50 to 75) kHz (75 to 100) kHz	0.056° 0.60° 0.1° 0.15°	Clarke Hess 6000, current transformer
Phase – Generate Sinewave Voltage to Voltage	(10 to 65) Hz (65 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz	0.67° 0.17° 0.33° 1.7°	Fluke 5520A

Parameter/Equipment	Range	CMC ^{2,8} (±)	Comments
Resistance – Generate and Measure Fixed Points ⁴	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ	7.6 μΩ/Ω 14 μΩ/Ω 3.1 μΩ/Ω 3.8 μΩ/Ω 3.6 μΩ/Ω	Guildline 9334A

Parameter/Equipment	Range	CMC ^{2,8} (\pm)	Comments
Resistance – Generate and Measure (cont)			
Measure Only ⁵	100 k Ω 1 M Ω 10 M Ω 100 M Ω 1000 M Ω	5.0 $\mu\Omega/\Omega$ 6.6 $\mu\Omega/\Omega$ 27 $\mu\Omega/\Omega$ 39 $\mu\Omega/\Omega$ 99 $\mu\Omega/\Omega$	Guildline 9334A
	(0.01 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) k Ω (10 to 100) k Ω (100 to 1000) k Ω (1 to 10) M Ω (10 to 100) M Ω	14 $\mu\Omega/\Omega$ + 84 $\mu\Omega$ 14 $\mu\Omega/\Omega$ + 84 $\mu\Omega$ 12 $\mu\Omega/\Omega$ + 800 $\mu\Omega$ 11 $\mu\Omega/\Omega$ + 2.5 m Ω 11 $\mu\Omega/\Omega$ + 25 m Ω 11 $\mu\Omega/\Omega$ + 250 m Ω 11 $\mu\Omega/\Omega$ + 7 Ω 44 $\mu\Omega/\Omega$ + 150 Ω 0.036 % + 1.5 k Ω	Keysight 3458A
	(0.01 to 1.9999) Ω (0.1 to 19.999) Ω (1 to 199.99) Ω (10 to 199.99) Ω (0.1 to 19.999) k Ω (1 to 199.99) k Ω (10 to 19999) k Ω (0.1 to 19.999) M Ω (1 to 199.99) M Ω (10 to 1999.9) M Ω	4.3 $\mu\Omega/\Omega$ + 9.5 $\mu\Omega$ 4.1 $\mu\Omega/\Omega$ + 31 $\mu\Omega$ 4.4 $\mu\Omega/\Omega$ + 230 $\mu\Omega$ 4.6 $\mu\Omega/\Omega$ + 1.8 m Ω 4.8 $\mu\Omega/\Omega$ + 14 m Ω 4.3 $\mu\Omega/\Omega$ + 240 m Ω 3.7 $\mu\Omega/\Omega$ + 4.3 Ω 3.3 $\mu\Omega/\Omega$ + 120 Ω 6.5 $\mu\Omega/\Omega$ + 7.8 k Ω 0.016 % + 840 k Ω	Fluke 8508A
Oscilloscope –			
Generate, Amplitude Volt	0 V (0.9 to 80) mV (0.08 to 2) V (2 to 20) V (20 to 200) V	25 μ V 0.049 % + 25 μ V 0.069 % + 64 μ V 0.069 % + 1.4 mV 0.069 % + 14 mV	Tektronix 9500B oscilloscope calibrator
Measure, Resistance	50 Ω 1 M Ω	1.4 m Ω 19 Ω	Keysight 3458A

Parameter/Equipment	Range	CMC ^{2, 8, 11} (\pm)	Comments
Oscilloscope – (cont)			
AC Voltage Bandwidth – Generate and Measure	50 kHz to 550 MHz	3.3 %	9500B
	50 kHz to 3.2 GHz	3.7 %	9500B and 9560
	50 MHz to 33 GHz	3.0 %	8487A sensor E8257 generator
Pulse – Generate & Measure			
Transition Time (Generate)	(70, 500) ps	6.4 ps + (-0.12 + 30t) ps	9500B, 9560 t = transition time in ps
Measure	20 ps to 20 ns	6.4 ps + (0.12 + 30t) ps	SD24/11801C
Generate Only – Transition Time	< 20 ps	5.3 ps	Tek 067-1338-00

II. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2, 8, 11} (\pm)	Comments
Milliwatt Reference –			
Power – Measure 1 mW @ 50 Ω	50 MHz	0.21 %	432A w/478AH76, 3458A
Power – Generate 1 mW @ 50 Ω	50 MHz	2.1 μ W	E44xX series
Power – Measure ⁹			
(-10 to 20) dBm	(9 to 100) kHz	0.10 dB	Agilent E9304A- H19 w/ E4419B
(-20 to -10) dBm	(9 to 100) kHz	0.26 dB	
(20 to 30) dBm	9 kHz to 20 GHz SWR < 1.2	0.16 dB	E9304A-H19 E9300A-H25

Parameter/Equipment	Frequency	CMC ^{2,8} (±)	Comments
Power – Measure ⁹ (cont) (10 to 20) dBm	(100 to 300) kHz SWR < 1.6:1	0.14 dB	Agilent 8482A- H84 w/ E4419B
	300 kHz to 1 MHz SWR < 1.2:1	0.13 dB	
	1 MHz to 2 GHz SWR < 1.1:1	0.13 dB	
	(2 to 4.2) GHz SWR < 1.3:1	0.14 dB	
(-20 to 10) dBm	(100 to 300) kHz SWR < 1.6:1	0.057 dB	Agilent 8487A- H84 w/ E4419B
	300 kHz to 1 MHz SWR < 1.2:1	0.052 dB	
	1 MHz to 2 GHz SWR < 1.1:1	0.054 dB	
	(2 to 4.2) GHz SWR < 1.3:1	0.055 dB	
(10 to 20) dBm	(50 to 100) MHz SWR < 1.15:1	0.15 dB	Agilent 8487D w/ E4419B
	(0.1 to 2) GHz SWR < 1.1:1	0.15 dB	
	(2 to 12.4) GHz SWR < 1.15:1	0.15 dB	
	(12.4 to 18) GHz SWR < 1.2:1	0.15 dB	
	(18 to 26.5) GHz SWR < 1.25:1	0.16 dB	
	(26.5 to 40) GHz SWR < 1.4:1	0.16 dB	
	(40 to 50) GHz SWR < 1.5:1	0.2 dB	

Parameter/Range	Frequency	CMC ^{2,8} (\pm)	Comments	
Power – Measure ⁹ (cont) (-20 to 10) dBm	(50 to 100) MHz SWR < 1.15:1	0.076 dB	Agilent 8487D w/ E4419B	
	(0.1 to 2) GHz SWR < 1.1:1	0.077 dB		
	(2 to 12.4) GHz SWR < 1.15:1	0.081 dB		
	(12.4 to 18) GHz SWR < 1.2:1	0.082 dB		
	(18 to 26.5) GHz SWR < 1.25:1	0.09 dB		
	(26.5 to 40) GHz SWR < 1.4:1	0.11 dB		
	(40 to 50) GHz SWR < 1.5:1	0.16 dB		
	(-60 to -20) dBm	(50 to 100) MHz SWR < 1.15:1		0.18 dB
		(0.1 to 2) GHz SWR < 1.1:1		0.18 dB
		(2 to 12.4) GHz SWR < 1.15:1		0.19 dB
		(12.4 to 18) GHz SWR < 1.2:1		0.19 dB
		(18 to 26.5) GHz SWR < 1.25:1		0.19 dB
		(26.5 to 40) GHz SWR < 1.4:1		0.20 dB
		(40 to 50) GHz SWR < 1.5:1		0.23 dB
(-20 to 10) dBm	(50 to 67) GHz	0.23 dB	KT-V8486A E4419B	

Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
Power – Measure ⁹ (cont)			
(10 to 20) dBm SWR < 1.2:1	(0.01 to 2) GHz (2 to 26.5) GHz (26.5 to 50) GHz (50 to 67) GHz	0.21 dB 0.21 dB 0.21 dB 0.21 dB	KT-N8488A E4419B
(-20 to 10) dBm SWR < 1.2:1	(0.01 to 2) GHz (2 to 26.5) GHz (26.5 to 50) GHz (50 to 67) GHz	0.21 dB 0.21 dB 0.21 dB 0.21 dB	
(-30 to -20) dBm SWR < 1.2:1	(0.01 to 2) GHz (2 to 26.5) GHz (26.5 to 50) GHz (50 to 67) GHz	0.34 dB 0.34 dB 0.34 dB 0.34 dB	
Power – Generate (Includes DUT Mismatch 1.4 VSWR)			
(-10 to 20) dBm	(9 to 100) kHz	0.10 dB	Measure transfer
(-20 to -10) dBm	(9 to 100) kHz	0.26 dB	33250A, E4419B, E9304H19
(10 to 20) dBm	(100 to 300) kHz 300 kHz to 1 MHz 1 MHz to 2 GHz (2 to 4.2) GHz	0.14 dB 0.13 dB 0.21 dB 0.35 dB	33250A, E4419B, 8482A-H84
(-20 to 10) dBm	(100 to 300) kHz 300 kHz to 1 MHz 1 MHz to 2 GHz (2 to 4.2) GHz	0.05 dB 0.06 dB 0.18 dB 0.33 dB	E8257D, E4419B, 8482A-H84
(10 to 20) dBm	(50 to 100) MHz (0.1 to 2) GHz (2 to 12.4) GHz (12.4 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	0.22 dB 0.22 dB 0.35 dB 0.35 dB 0.44 dB 0.60 dB 0.61 dB	E8257D, E4419B, 8487A-H84
(-20 to 10) dBm	(50 to 100) MHz (0.1 to 2) GHz (2 to 12.4) GHz	0.18 dB 0.19 dB 0.33 dB	

Parameter/Range	Frequency	CMC ^{2, 8, 11} (\pm)	Comments
Power – Generate (Includes DUT Mismatch 1.4 VSWR) –(cont)			
(-20 to 10) dBm	(12.4 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	0.33 dB 0.43 dB 0.59 dB 0.60 dB	E8257D, E4419B, 8487A-H84
(-60 to -20) dBm	(50 to 100) MHz (0.1 to 2) GHz (2 to 12.4) GHz (12.4 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	0.24 dB 0.24 dB 0.37 dB 0.37 dB 0.46 dB 0.61 dB 0.62 dB	E8257D, E4419B, 8487D-H84
(-20 to 10) dBm	(50 to 67) GHz	0.23 dB + <i>M</i>	<i>M</i> = Mismatch error E8257D, KT- E8361A V8486A
Power Generate –			
(-20 to 10) dBm	50 MHz	0.054 dB + <i>R</i>	Substitution/transf er using CMC measurement to set initial reference on UUT as limited by <i>R</i>
Ratio Steps –			
(-1 to -11) dB		0.012 dB + 0.000 31 dB/dB + <i>R</i>	
(-10 to -50) dB		0.011 dB + 0.000 62 dB/dB + <i>R</i>	Characterized step attenuators Note: CMC shown at 50MHz Type N, other frequency and connectors will be greater magnitude
(-50 to -110) dB		0.015 dB + 0.000 98 dB/dB + <i>R</i>	
Network Analyzer Dynamic Accuracy Test –	5 dBm change	0.002 lin	KT 8482A 4419B
dB Steps	(0 to 5) dB (-1 to -10) dB	(0.0012 to 0.0014) lin (0.0011 to 0.000 78) lin	Two CW signals offset and phase locked (in dB steps)

Parameter/Equipment	Frequency	CMC ^{2,8} (\pm)	Comments
Network Analyzer Dynamic Accuracy Test –	5 dBm change	0.002 lin	KT 8482A 4419B
dB Steps	(-11 to -19) dB (-21 to -30) dB (-31 to -40) dB (-41 to -50) dB (-51 to -60) dB	(0.000 69 to 0.000 095) lin (0.000 091 to 0.000 71) lin (0.000 75 to 0.0011) lin (0.0011 to 0.0015) lin (0.0015 to 0.0018) lin	Two CW signals offset and phase locked (in dB steps)
Network Analyzer Calibration Comparison 3.5 mm			
Rho 0.999	10 MHz (0.125 to 2) GHz (2.125 to 8) GHz (8.125 to 20) GHz (20.125 to 26.5) GHz	0.0060 lin 0.0045 lin 0.0061 lin (0.012 + 6.7 $\times 10^{-6}$ <i>f</i>) lin (0.015 - 5.6 $\times 10^{-6}$ <i>f</i>) lin	E8361A w/ data- based SOL cal kit <i>f</i> = frequency in GHz
Rho 0.001	10 MHz (0.125 to 2) GHz (2.125 to 8) GHz (8.125 to 20) GHz (20.125 to 26.5) GHz	0.000 99 lin 0.000 90 lin 0.0011 lin (0.0019 + 2.9 $\times 10^{-6}$ <i>f</i>) lin (0.0025 + 4.5 $\times 10^{-6}$ <i>f</i>) lin	
Phase Noise for Analyzers – (Offset Frequency)			
10 Hz 100 Hz 1 kHz 10 kHz 30 kHz 100 kHz 1000 kHz 3000 kHz 6000 kHz 9990 kHz	1 GHz	2.6 dB @ 89 dbc/Hz 2.6 dB @ 115 dbc/Hz 1.3 dB @ 135 dbc/Hz 1.0 dB @ 147 dbc/Hz 1.0 dB @ 149 dbc/Hz 1.0 dB @ 151 dbc/Hz 1.0 dB @ 160 dbc/Hz 1.0 dB @ 160 dbc/Hz 1.0 dB @ 165 dbc/Hz 1.0 dB @ 167 dbc/Hz	Low noise oscillator

Parameter/Equipment	Frequency	CMC ² (±)	Comments
Phase Noise for Signal Sources – (Offset Frequency)	Carrier:		
≤ 100 kHz	≤ 100 MHz	2.3 dB	(LREF - LDUT) ≥ 10dB, f = frequency E5500A
≤ 100 kHz	0.1 GHz < f ≤ 26.5GHz	2.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	2.3 dB	
Cal Factor & Effective Efficiency ⁶ @ 50 Ω –			
Nominal 1 μW, 1 mW (-30 to +5) dBm	(0.009 to 0.05) MHz (0.1 to 4200) MHz (4.2 to 12.4) GHz (12.4 to 15) GHz (15 to 26) GHz (26 to 40) GHz (40 to 50) GHz	1.2 % cal factor 1.2 % cal factor 1.4 % cal factor 1.5 % cal factor 2.5 % cal factor 2.7 % cal factor 2.7 % cal factor	RF power transfer & DC substitution

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
S-Parameters –			
S ₁₁₍₂₂₎ Measure – @ 50 Ω			
2.4 mm			
45 MHz to 2 GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.019 to 0.028) lin (0.017 to 0.018) lin 0.017 lin	E8361A, 85056A
	(0.3 to 1) lin (0.01 to 0.3) lin	(3.5 to 1.6)° (180 to 3.5)°	
(2 to 20) GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.023 to 0.034) lin (0.018 to 0.023) lin 0.018 lin	
	(0.3 to 1) lin (0.01 to 0.3) lin	(5 to 2)° (180 to 5)°	

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
S-Parameters – S ₁₁₍₂₂₎ Measure – @ 50 Ω 2.4 mm (20 to 40) GHz	(0.3 to 1) lin (0.01 to 0.3) lin	(5 to 2)° (180 to 5)°	E8361A, 85056A
(40 to 50) GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.037 to 0.056) lin (0.03 to 0.037) lin 0.03 lin	
	(0.3 to 1) lin (0.01 to 0.3) lin	(9 to 3.2)° (180 to 9)°	
	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.044 to 0.07) lin (0.034 to 0.044) lin 0.034 lin	
	(0.3 to 1) lin (0.01 to 0.3) lin	(11 to 4)° (180 to 11)°	
S ₁₂₍₂₁₎ Measure – 2.4 mm 45 MHz to 50 GHz	(0 to -60) dB	(0.08 to 0.6) dB (0.5 to 5.8)°	E8361A, 85056A
S ₁₁₍₂₂₎ Measure – @ 50 Ω 3.5 mm 45 MHz to 2 GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.01 to 0.022) lin (0.009 to 0.01) lin 0.009 lin	E8361A, 85052C
	(0.3 to 1) lin (0.01 to 0.3) lin	(2 to 1.3)° (54 to 2)°	
(2 to 20) GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.012 to 0.015) lin (0.008 to 0.013) lin 0.008 lin	
	(0.3 to 1) lin (0.01 to 0.3) lin	(2.6 to 0.82)° (0.0045 to 2.6)°	

Parameter/Equipment	Range	CMC ^{2, 8} (\pm)	Comments
S-Parameters – (cont)			
S₁₁₍₂₂₎ Measure – @ 50 Ω			
3.5 mm			
(20 to 26) GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(0.013 to 0.017) lin (0.008 to 0.014) lin 0.009 lin	E8361A, 85052C
	(0.3 to 1) lin (0.01 to 0.3) lin	(2.8 to 1) $^{\circ}$ (53 to 2.8) $^{\circ}$	
S₁₂₍₂₁₎ Measure –			
3.5 mm			
45 MHz to 26 GHz	(0 to -60) dB	(0.05 to 0.27) dB (0.3 to 1.9) $^{\circ}$	
S₁₁₍₂₂₎ Measure – @ 50 Ω	(0.01 to 1) lin	(0.003 to 0.01) lin	
7 mm, Type N ⁶			
1 MHz to 2 GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(1 to 0.6) $^{\circ}$ (6 to 1) $^{\circ}$ (16 to 6) $^{\circ}$	E8361A, 85050C
	(0.01 to 1) lin	(0.002 to 0.007) lin	
(2 to 18) GHz	(0.3 to 1) lin (0.03 to 0.3) lin (0.01 to 0.03) lin	(1.6 to 0.4) $^{\circ}$ (5 to 1.6) $^{\circ}$ (11 to 5) $^{\circ}$	
S₁₂₍₂₁₎ Measure –			
7 mm, Type N ⁶			
1 MHz to 18 GHz	(0 to -60) dB	(0.05 to 0.27) dB (0.3 to 1.9) $^{\circ}$	
S₁₁₍₂₂₎ Measure – @ 50 Ω			
1.85 mm			
(1 to 67) GHz	(0.1 to 1) lin	(0.0089 to 0.027) lin (0.65 to 180) $^{\circ}$	E8361A, 85050C
	(0.001 to 0.1) lin	(0.0089 to 0.020) lin (5.1 to 180) $^{\circ}$	

Parameter/Equipment	Range	CMC ^{2, 8, 11} (\pm)	Comments
S-Parameters (cont) – S ₁₂₍₂₁₎ Measure – @ 50 Ω 1.85 mm (1 to 67) GHz	(0 to -60) dB	(0.09 to 0.37) dB (0.45 to 4.5) ^o	E8361A, 85058B
RF Power – Measure Relative Level Insertion Loss	100 kHz to 50 GHz 100 kHz to 50 GHz	0.013 dB + 0.004 dB/10 dB 0.026 dB + 0.004 dB/10 dB	E4448A/233
Amplitude Modulation – Measure 200 MHz to 3 GHz 0.010 kHz to 50 GHz	(30 to 90) % ratio; 1 kHz rate 5 % ratio; 50 Hz to 5 kHz rate 30 % ratio; 50 Hz to 5 kHz rate 99 % ratio; 50 Hz to 5 kHz rate 5 % ratio; (5 to 100) kHz rate 30 % ratio; (5 to 100) kHz rate 99 % ratio; (5 to 100) kHz rate	0.43 % AM 2.4 % AM 1.2 % AM 0.42 % AM 2.4 % AM 0.88 % AM 0.32 % AM	E4448A/233

Parameter/Equipment	Range	CMC ^{2, 8, 11} (\pm)	Comments
Angular (Frequency) Modulation – Measure 200 MHz to 20 GHz	(100 to 240) kHz peak deviation modulation index > 1	0.80 kHz	AT-E4448A AT-33250A AT-34401A rubidium oscillator
Angular (Phase) Modulation – Measure 200 MHz to 20 GHz	(1 to 10) radian modulation index	0.78 % + 0.0025 radian	AT-E4448A rubidium oscillator
Angular and Amplitude Modulation (Digital Signal) – Measure 16 QAM 256 QAM 64 QAM, B PSK QPSK	(0.5 to 44) GHz	0.83 % EVM	AT 89441A EVM=error vector magnitude

III. Time & Frequency

Parameter/Range	Range	CMC ^{2, 14} (\pm)	Comments
Frequency – Measure	5, 10 MHz 1 Hz to 120 MHz	2.5 pHz/Hz 10 pHz/Hz	NIST FMAS, GPS receiver (1 Hz Steps)
	250 kHz to 50 GHz	10 nHz/Hz + 0.10 Hz	E4448A/233 ext lock
Frequency – Measuring Equipment	10 MHz distribution	10 pHz/Hz	Rubidium, 58503B distribution amplifiers
	1 Hz to 10 MHz	2.3 μ Hz/Hz	AT 33250 waveform generator
	250 kHz to 67 GHz	10 nHz/Hz + 1.2 mHz	E8257D-550 ext lock

Parameter/Range	Range	CMC ^{2, 14} (\pm)	Comments
Time Interval – Measuring Equipment and Measure	1 ns to 10 s	0.92 ns + $TI/0.04$ μ s/s	33250A/ 53132A/12 TI = Time interval in seconds

¹ This laboratory does not normally offer commercial calibration services.

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 Agilent 3458A with Option 2, settings DCV, 100PLC, ACAL within prior 24 Hrs, 1 year cal cycle.

⁴ Transfer using Agilent 3458A.

⁵ Agilent 3458A four wire ohms, ACAL within prior 24 Hrs, NPLC 100 < 100E6 Ohm > NPLC 10

⁶ Calibration Factor 100 kHz to 10 MHz is effective efficiency only.

⁷ Measure and Generate is limited to below 5 kHz; Measure only above 5 kHz.

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. 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.

⁹ The statement of CMC does not include the effects of mismatch error.

¹⁰ Add $(12 \mu\text{V}/\text{V}) * (\text{V}_{\text{input}} / 1000)^2$ for voltage > 100 V unless used as a characterized transfer.

¹¹ In the statement of CMC, the value is defined as the percentage of reading unless otherwise noted, and R is the resolution contribution from the unit under test.

¹² Points identified in the Parameter/Range reflect the reference standard range for which the CMC applies.

¹³ The 5790A/3 may be used to characterize the 5720A/3 and 5725A to generate CMC values.

¹⁴ 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.

¹⁵ This scope meets A2LA's *P112 Flexible Scope Policy*.



Accredited Laboratory

A2LA has accredited

ELECTRO RENT CORPORATION

Van Nuys, 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 Z540.3-2006 and R205 – Specific Requirements: Calibration Laboratory Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 27th day of April 2021.

A handwritten signature in blue ink, positioned above a horizontal line.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2562.01
Valid to June 30, 2023

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