



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

KEYSIGHT TECHNOLOGIES SANTA ROSA METROLOGY SERVICES
 1400 Fountain Grove Parkway
 Santa Rosa, CA 95403
 Bob Ramirez Phone: 707 577 5020

CALIBRATION

Valid To: March 31, 2018

Certificate Number: 2079.01

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

I. Dimensional

Parameter/Equipment	Range	CMC ^{2, 3} (±)	Comments
Plain Ring Gages	(1 to 100) mm	(0.19 + 0.0011L) µm	Universal length measuring machine
Plain Plug Gages	(0.5 to 75) mm	(0.35 + 0.0007L) µm	Universal length measuring machine
	(0.5 to 75) mm	0.7 µm	Supermicrometer™ w/ laser interferometer
One Dimensional – Length	(0.01 to 300) mm	(0.9 + 0.0032L) µm	Zeiss CMM
	(0.01 to 25.4) mm	0.3 µm	Heidenhain Certo drop indicator
Pin Depth	(-50 to 50) µm	0.92 µm	Zeiss CMM
	(-50 to 50) µm	0.28 µm	Zygo white light interferometer microscope

Parameter/Equipment	Range	CMC ^{2,3} (±)	Comments
Diameter –	(1 to 16) mm	$(0.9 + 0.0026D) \mu\text{m}$	Zeiss CMM
Diameter – Outer	(0.4 to 16) mm	0.43 μm	Z-Mike 1210 gold laser micrometer
Diameter – Inner	(1.845 to 1.855) mm (2.395 to 2.405) mm (2.912 to 2.928) mm (3.495 to 3.505) mm (6.492 to 6.508) mm (6.995 to 7.005) mm	0.49 μm 0.49 μm 0.49 μm 0.49 μm 0.49 μm 0.49 μm	Ring gages w/ 1.85 mm air probe 2.4 mm air probe 2.92 mm air probe 3.5 mm air probe 6.5 mm air probe 7 mm air probe

II. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ² (±)	Comments
Resistance – Measure	(10 to 100) Ω	13 $\mu\Omega/\Omega + 740 \mu\Omega$	HP 3458A

III. Electrical – RF/Microwave

Parameter/Range	CMC ² (±)	Comments
Reflection S ₁₁ /S ₂₂ – Measure ⁴ 10 MHz to 18 GHz (0.0001 to 1.0) lin (0 to 0.01) lin (0.01 to 0.1) lin (0.1 to 0.5) lin (0.5 to 1.0) lin	(±0.00018 to ±0.0025) lin (±2.6 to ±180) deg (±0.38 to ±11) deg (±0.18 to ±1.2) deg (±0.20 to ±0.36) deg	Network analyzer, ET33733 APC 7 mm characterized device cal kit

Parameter/Range	CMC ² (\pm)	Comments
Reflection S ₁₁ /S ₂₂ – Measure ⁴ (cont)		
10 MHz to 18 GHz		
(0.0001 to 1.0) lin	(± 0.00024 to ± 0.0025) lin	Network analyzer, ET33717 type N characterized device cal kit
(0 to 0.01) lin	(± 2.7 to ± 180) deg	
(0.01 to 0.1) lin	(± 0.42 to ± 17) deg	
(0.1 to 0.5) lin	(± 0.24 to ± 2.0) deg	
(0.5 to 1.0) lin	(± 0.20 to ± 0.84) deg	
10 MHz to 33.5 GHz		
(0.0001 to 1.0) lin	(± 0.00022 to ± 0.0025) lin	Network analyzer, ET33700 3.5 mm, characterized device cal kit
(0 to 0.01) lin	(± 2.6 to ± 180) deg	
(0.01 to 0.1) lin	(± 0.38 to ± 13) deg	
(0.1 to 0.5) lin	(± 0.18 to ± 1.4) deg	
(0.5 to 1.0) lin	(± 0.20 to ± 0.43) deg	
10 MHz to 50 GHz		
(0.0001 to 1.0) lin	(± 0.00042 to ± 0.0048) lin	Network analyzer, ET33702 2.4 mm, characterized device cal kit
(0 to 0.01) lin	(± 5.1 to ± 180) deg	
(0.01 to 0.1) lin	(± 0.71 to ± 29) deg	
(0.1 to 0.5) lin	(± 0.37 to ± 3.6) deg	
(0.5 to 1.0) lin	(± 0.31 to ± 2.1) deg	
10 MHz to 70 GHz		
(0.0001 to 1.0) lin	(± 0.00011 to ± 0.010) lin	Network analyzer, ET36411 1.85 mm, multi-offset short mode, characterized device cal kit
(0 to 0.01) lin	(± 2.6 to ± 180) deg	
(0.01 to 0.1) lin	(± 0.52 to ± 180) deg	
(0.1 to 0.5) lin	(± 0.52 to ± 7.0) deg	
(0.5 to 1.0) lin	(± 0.20 to ± 3.3) deg	
10 MHz to 8.2 GHz		
(0.0001 to 1.0) lin	(± 0.00025 to ± 0.0019) lin	Network analyzer, ET51600 7-16 connector, characterized device cal kit
(0 to 0.01) lin	(± 2.9 to ± 180) deg	
(0.01 to 0.1) lin	(± 0.42 to ± 12) deg	
(0.1 to 0.5) lin	(± 0.20 to ± 1.2) deg	
(0.5 to 1.0) lin	(± 0.20 to ± 0.36) deg	

Parameter/Range	CMC ² (±)	Comments
Reflection S ₁₁ /S ₂₂ – Measure ⁴ (cont)		
10 MHz to 12 GHz		
(0.0001 to 1.0) lin	(±0.00051 to ±0.0010) lin	Network analyzer, ET36409 type N 75 ohm, characterized device cal kit
(0 to 0.01) lin	(±3.3 to ±180) deg	
(0.01 to 0.1) lin	(±0.47 to ±180) deg	
(0.1 to 0.5) lin	(±0.23 to ±9.2) deg	
(0.5 to 1.0) lin	(±0.22 to ±7.1) deg	
10 MHz to 6.2 GHz		
(0.0001 to 1.0) lin	(±0.00035 to ±0.002) lin	Network analyzer, ET36442 type F 75 ohm, Characterized device cal kit
(0 to 0.01) lin	(±3.1 to ±180) deg	
(0.01 to 0.1) lin	(±0.46 to ±12) deg	
(0.1 to 0.5) lin	(±0.21 to ±1.3) deg	
(0.5 to 1.0) lin	(±0.20 to ±0.37) deg	
10 MHz to 45 GHz		
(0.0001 to 1.0) lin	(±0.002 to ±0.029) lin	Network analyzer, 85056K option H01 2.92 mm multiple offset short, open, load calibration kit
(0 to 0.01) lin	(±16.1 to ±180) deg	
(0.01 to 0.1) lin	(±0.90 to ±16.1) deg	
(0.1 to 0.5) lin	(±0.30 to ±0.90) deg	
(0.5 to 1.0) lin	(±0.20 to ±0.30) deg	
(8.2 to 12.4) GHz		
(0.0001 to 1.0) lin	(±0.0012 to ±0.0075) lin	Network analyzer, ET36405 X band, TRL cal kit
(0 to 0.01) lin	(±8.9 to ±180) deg	
(0.01 to 0.1) lin	(±2.5 to ±8.9) deg	
(0.1 to 0.5) lin	(±1.9 to ±2.5) deg	
(0.5 to 1.0) lin	(±1.9 to ±1.9) deg	
(12.4 to 18.0) GHz		
(0.0001 to 1.0) lin	(±0.00073 to ±0.0023) lin	Network analyzer, ET36406 P band, TRL cal kit
(0 to 0.01) lin	(±4.5 to ±180) deg	
(0.01 to 0.1) lin	(±0.72 to ±4.5) deg	
(0.1 to 0.5) lin	(±0.41 to ±0.72) deg	
(0.5 to 1.0) lin	(±0.73 to ±0.41) deg	

Parameter/Range	CMC ² (\pm)	Comments
Reflection S ₁₁ /S ₂₂ – Measure ⁴ (cont)		
(18.0 to 26.5) GHz		
(0.0001 to 1.0) lin	(± 0.0013 to ± 0.0028) lin	Network analyzer, ET36407 K band, TRL cal kit
(0 to 0.01) lin	(± 7.7 to ± 180) deg	
(0.01 to 0.1) lin	(± 1.1 to ± 7.8) deg	
(0.1 to 0.5) lin	(± 0.53 to ± 1.2) deg	
(0.5 to 1.0) lin	(± 0.48 to ± 0.65) deg	
(26.5 to 40) GHz		
(0.0001 to 1.0) lin	(± 0.0022 to ± 0.0077) lin	Network analyzer, ET36320 R-band, TRL cal kit
(0 to 0.01) lin	(± 13 to ± 180) deg	
(0.01 to 0.1) lin	(± 1.7 to ± 13) deg	
(0.1 to 0.5) lin	(± 0.67 to ± 1.7) deg	
(0.5 to 1.0) lin	(± 0.64 to ± 0.67) deg	
(33 to 50) GHz		
(0.0001 to 1.0) lin	(± 0.0022 to ± 0.0077) lin	Network analyzer, ET36321 Q-band, TRL cal kit
(0 to 0.01) lin	(± 13 to ± 180) deg	
(0.01 to 0.1) lin	(± 1.7 to ± 13) deg	
(0.1 to 0.5) lin	(± 0.74 to ± 1.7) deg	
(0.5 to 1.0) lin	(± 0.70 to ± 0.74) deg	
(40 to 60) GHz		
(0.0001 to 1.0) lin	(± 0.0012 to ± 0.011) lin	Network analyzer HP8510C, multiplier test set HP U85104A, HP 85105A mm wave controller RF source HP83623B Lo source HP 83651A/B, ET36322 U-band, TRL cal kit
(0 to 0.01) lin	(± 17 to ± 180) deg	
(0.01 to 0.1) lin	(± 5.0 to ± 17) deg	
(0.1 to 0.5) lin	(± 4.1 to ± 5.0) deg	
(0.5 to 1.0) lin	(± 4.1 to ± 4.2) deg	



Parameter/Range	CMC ² (±)	Comments
Reflection S ₁₁ /S ₂₂ – Measure ⁴ (cont)		
(50 to 75) GHz		
(0.0001 to 1.0) lin	(±0.0022 to ±0.013) lin	Network analyzer HP8510C, multiplier test set HP V85104A, HP 85105A mm wave controller, source HP 83623B, source HP 83651A/B, ET36323 V-band, TRL cal kit
(0 to 0.01) lin	(±18 to ±180) deg	
(0.01 to 0.1) lin	(±6.0 to ±18) deg	
(0.1 to 0.5) lin	(±5.1 to +6.0) deg	
(0.5 to 1.0) lin	(±5.1 to ±5.3) deg	
(75 to 110) GHz		
(0.0001 to 1.0) lin	(±0.0022 to ±0.015) lin	Network analyzer HP8510C, multiplier test set HP W85104A, HP 85105A mm wave controller, source HP 83623B, source HP 83651 A/B, ET36324 W-band, TRL cal kit
(0 to 0.01) lin	(±30 to ±180) deg	
(0.01 to 0.1) lin	(±9.1 to ±30) deg	
(0.1 to 0.5) lin	(±7.5 to ±9.1) deg	
(0.5 to 1.0) lin	(±7.5 to ±7.6) deg	
9 kHz to 8.5 GHz		
(0.0001 to 1.0) lin	(±0.004 to ±0.014) lin (±1.1 to ±180) deg	Network analyzer E5071C, cal kit 85032F
9 kHz to 8.5 GHz		
(0.0001 to 1.0) lin	(±0.0051 to ±0.016) lin (±0.91 to ±180) deg	Network analyzer E5071C, cal kit 85033E

Parameter/Range	CMC ² (±)	Comments
Transmission S_{12}/S_{21} – Measure ⁵		
9 kHz to 8.5 GHz		
(0 to 20) dB	(±0.046 to ±0.15) dB (±0.48 to ±1.0) deg	Network analyzer E5071C, cal kit 85032F
(20 to 40) dB	(±0.072 to ±0.18) dB (±0.48 to ±1.3) deg	
(40 to 60) dB	(±0.10 to ±0.24) dB (±0.69 to ±1.7) deg	
9 kHz to 8.5 GHz		
(0 to 20) dB	(±0.04 to ±0.14) dB (±0.27 to ±0.90) deg	Network analyzer E5071C, cal kit 85033E
(20 to 40) dB	(±0.067 to ±0.17) dB (±0.44 to ±1.2) deg	
(40 to 60) dB	(±0.098 to ±0.23) dB (±0.65 to ±1.6) deg	
10 MHz to 18 GHz		
(0 to 20) dB	(±0.012 to ±0.042) dB (±0.12 to ±0.34) deg	Network analyzer, ET33733 APC 7 mm, characterized device cal kit
(20 to 40) dB	(±0.024 to ±0.025) dB (±0.22 to ±1.8) deg	
(40 to 60) dB	(±0.036 to ±2.2) dB (±0.36 to ±17) deg	
10 MHz to 18 GHz		
(0 to 20) dB	(±0.012 to ±0.042) dB (±0.12 to ±0.34) deg	Network analyzer, ET33717 type N, characterized device cal kit
(20 to 40) dB	(±0.024 to ±0.025) dB (±0.22 to ±1.8) deg	
(40 to 60) dB	(±0.037 to ±2.2) dB (±0.36 to ±17) deg	

Parameter/Range	CMC ² (\pm)	Comments
Transmission S_{12}/S_{21} – Measure ⁵ (cont)		
10 MHz to 33.5 GHz		
(0 to 20) dB	(± 0.012 to ± 0.042) dB (± 0.12 to ± 0.34) deg	Network analyzer, ET33700 3.5 mm, characterized device cal kit
(20 to 40) dB	(± 0.024 to ± 0.025) dB (± 0.22 to ± 1.8) deg	
(40 to 60) dB	(± 0.036 to ± 2.2) dB (± 0.36 to ± 17) deg	
10 MHz to 45 GHz		
(0 to 20) dB	(± 0.06 to ± 0.07) dB (± 0.40 to ± 2.7) deg	Network Analyzer, 85056K option H01 2.92 mm multiple offset short, open, load calibration kit
(20 to 40) dB	(± 0.06 to ± 0.07) dB (± 0.50 to ± 2.7) deg	
(40 to 60) dB	(± 0.06 to ± 0.13) dB (± 0.50 to ± 2.8) deg	
10 MHz to 50 GHz		
(0 to 20) dB	(± 0.012 to ± 0.051) dB (± 0.12 to ± 0.43) deg	Network analyzer, ET33702 2.4 mm, characterized device cal kit
(20 to 40) dB	(± 0.023 to ± 0.027) dB (± 0.23 to ± 2.0) deg	
(40 to 60) dB	(± 0.034 to ± 2.3) dB (± 0.36 to ± 18) deg	
10 MHz to 70 GHz		
(0 to 20) dB	(± 0.012 to ± 0.088) dB (± 0.12 to ± 0.65) deg	Network analyzer, ET36411 1.85 mm, multi offset short mode characterized device cal kit
(20 to 40) dB	(± 0.024 to ± 0.56) dB (± 0.22 to ± 3.9) deg	
(40 to 60) dB	(± 0.036 to ± 4.4) dB (± 0.40 to ± 42) deg	

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ /S ₂₁ – Measure ⁵ (cont)		
10 MHz to 8.2 GHz		
(0 to 20) dB	(±0.012 to ±0.042) dB (±0.12 to ±0.34) deg	Network analyzer, ET51600 7-16 connector, characterized device cal kit
(20 to 40) dB	(±0.024 to ±0.25) dB (±0.22 to ±1.8) deg	
(40 to 60) dB	(±0.038 to ±2.2) dB (±0.34 to ±17) deg	
10 MHz to 12 GHz		
(0 to 20) dB	(±0.012 to ±0.053) dB (±0.12 to ±0.39) deg	Network analyzer, ET36409 type N 75 ohm, characterized device cal kit
(20 to 40) dB	(±0.024 to ±0.25) dB (±0.22 to ±1.8) deg	
(40 to 60) dB	(±0.038 to ±2.2) dB (±0.37 to ±17) deg	
10 MHz to 6.2 GHz		
(0 to 20) dB	(±0.013 to ±0.048) dB (±0.12 to ±0.43) deg	Network analyzer, ET36442 type F 75 ohm, characterized device cal kit
(20 to 40) dB	(±0.024 to ±0.27) dB (±0.22 to ±2.0) deg	
(40 to 60) dB	(±0.039 to ±2.3) dB (±0.37 to ±18) deg	
(8.2 to 12.4) GHz		
(0 to 20) dB	(±0.0046 to ±0.0047) dB (±1.7 to ±1.8) deg	Network analyzer, ET36405 X-band, TRL cal kit
(20 to 40) dB	(±0.047 to ±0.051) dB (±1.8 to ±1.9) deg	
(40 to 60) dB	(±0.051 to ±0.13) dB (±1.9 to ±2.5) deg	

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ /S ₂₁ – Measure ⁵ (cont)		
(12.4 to 18.0) GHz		
(0 to 20) dB	(±0.046 to ±0.046) dB (±2.6 to ±2.6) deg	Network analyzer, ET36406 P-band, TRL cal kit
(20 to 40) dB	(±0.046 to ±0.051) dB (±2.6 to ±2.7) deg	
(40 to 60) dB	(±0.051 to ±0.17) dB (±2.6 to ±3.7) deg	
(18.0 to 26.5) GHz		
(0 to 20) dB	(±0.046 to ±0.047) dB (±4.0 to ±5.9) deg	Network analyzer, ET36408 K-band, TRL cal kit
(20 to 40) dB	(±0.047 to ±0.078) dB (±4.1 to ±6.2) deg	
(40 to 60) dB	(±0.053 to ±0.57) dB (±4.2 to ±9.7) deg	
(26.5 to 40) GHz		
(0 to 20) dB	(±0.051 to ±0.052) dB (±2.5 to ±2.6) deg	Network analyzer, ET36320 R-band, TRL cal kit
(20 to 40) dB	(±0.052 to ±0.073) dB (±2.6 to ±2.8) deg	
(40 to 60) dB	(±0.073 to ±0.45) dB (±2.8 to ±5.5) deg	
(33 to 50) GHz		
(0 to 20) dB	(±0.051 to ±0.053) dB (±3.1 to ±3.2) deg	Network analyzer HP8510C, ET36321 Q-band, TRL cal kit
(20 to 40) dB	(±0.052 to ±0.081) dB (±3.2 to ±3.5) deg	
(40 to 60) dB	(±0.081 to ±0.56) dB (±3.5 to ±6.9) deg	

Parameter/Range	CMC ² (±)	Comments
Transmission S ₁₂ /S ₂₁ – Measure ⁵ (cont)		
(40 to 60) GHz		
(0 to 20) dB	(±0.051 to ±0.053) dB (±3.75 to ±3.8) deg	Network analyzer HP8510C, multiplier test set HP
(20 to 40) dB	(±0.053 to ±0.082) dB (±3.8 to ±4.1) deg	U85104A, HP 85105A mm wave controller
(40 to 60) dB	(±0.082 to ±0.60) dB (±4.1 to ±7.5) deg	RF source HP83623B, Lo source HP 83651A/B, ET36322 U-band, TRL cal kit
(50 to 75) GHz		
(0 to 20) dB	(±0.034 to ±0.040) dB (±4.7 to ±5.1) deg	Network analyzer HP8510C, multiplier test set HP
(20 to 40) dB	(±0.040 to ±0.34) dB (±5.1 to ±9.4) deg	V85104A, HP 85105A mm wave controller,
(40 to 60) dB	(±0.34 to ±16) dB (±9.4 to ±62) deg	source HP 83623B, source HP 83651 A/B ET36323 V-band, TRL cal kit
(75 to 110) GHz		
(0 to 20) dB	(±0.038 to ±0.065) dB (±6.9 to ±7.2) deg	Network analyzer HP8510C, multiplier test set HP
(20 to 40) dB	(±0.065 to ±0.33) dB (±7.1 to ±9.9) deg	W85104A, HP 85105A mm wave controller,
(40 to 60) dB	(±0.33 to ±6.5) dB (±9.9 to ±39) deg	source HP 83623B, source HP 83651 A/B, ET36324 W-band, TRL cal kit



Parameter/Range	CMC ² (±)	Comments
RF / μ -Wave power Power Sensor Calibration Factor – Measure		8648C/D signal generator, 11667A power splitter, 11051A thermal converter, 478A-H75 thermistor mount, 3458A DVM, 34970 + 34901A data acquisition switch w/ DMM, 50 MHz 1mW ref oscillator
9 kHz to 18.0 GHz		
(0.009 to 10) MHz	0.0040	
(0.01 to 0.03) GHz	0.0050	E8257D signal generator,
0.050 GHz	0.0033	8648C/D signal generator,
0.10 GHz	0.0031	11667A power splitter,
(0.20 to 2.6) GHz	0.0032	CN mount,
(2.7 to 4.5) GHz	0.0033	34420A DVM,
(4.6 to 5.7) GHz	0.0034	Arbiter Type IV power meter
(5.8 to 7.2) GHz	0.0035	50 MHz 1mW ref oscillator
(7.3 to 7.9) GHz	0.0036	
(8.0 to 8.6) GHz	0.0037	CMC based on 8478B thermistor mount
(8.7 to 10.1) GHz	0.0038	
(10.2 to 10.6) GHz	0.0039	
(10.7 to 11.2) GHz	0.0040	
(11.3 to 12.4) GHz	0.0041	
(12.5 to 12.8) GHz	0.0042	
(12.9 to 13.8) GHz	0.0043	
(13.9 to 14.2) GHz	0.0044	
(14.3 to 14.7) GHz	0.0045	
(14.8 to 15.6) GHz	0.0046	
(15.7 to 16.0) GHz	0.0047	
(16.1 to 16.7) GHz	0.0046	
(16.8 to 16.9) GHz	0.0047	
(17.0 to 17.1) GHz	0.0048	
(17.2 to 17.3) GHz	0.0049	
(17.4 to 18.0) GHz	0.0050	
10 MHz to 50 GHz		
(0.01 to 3.9) GHz	0.011	E8257D signal generator,
(4.0 to 16.3) GHz	0.012	11667C power splitter,
(16.4 to 23.5) GHz	0.013	NIST type IV power meter,
(23.6 to 24.3) GHz	0.014	E4419B power meter,
(24.4 to 24.7) GHz	0.015	34420A micro-ohm meter,
(24.8 to 27.5) GHz	0.016	C24P platinum mount
27.6 GHz	0.017	
(27.8 to 28.5) GHz	0.016	CMC based on 8487A power sensor
(28.6 to 30.5) GHz	0.017	
(30.6 to 31.5) GHz	0.018	
(31.6 to 32.1) GHz	0.017	
(32.2 to 32.5) GHz	0.018	
(32.6 to 33.5) GHz	0.019	

Parameter/Range	CMC ² (±)	Comments
RF / μ -Wave power Power Sensor Calibration Factor – Measure (cont.)		
10 MHz to 50 GHz		
(33.6 to 33.9) GHz	0.018	E8257D signal generator, 11667C power splitter, NIST type IV power meter, E4419B power meter, 34420A micro-ohm meter, C24P platinum mount CMC based on 8487A power sensor
(34.0 to 34.5) GHz	0.019	
(34.6 to 35.3) GHz	0.020	
(35.4 to 35.9) GHz	0.019	
(36.0 to 38.3) GHz	0.020	
(38.4 to 38.7) GHz	0.021	
(38.8 to 39.5) GHz	0.020	
(39.6 to 40.1) GHz	0.021	
(40.2 to 40.5) GHz	0.022	
(40.6 to 41.1) GHz	0.021	
(41.2 to 41.5) GHz	0.022	
(41.6 to 42.9) GHz	0.023	
(43.0 to 43.5) GHz	0.024	
(43.6 to 44.1) GHz	0.025	
44.2 GHz	0.024	
(44.4 to 44.7) GHz	0.023	
44.8 GHz	0.024	
45.0 GHz	0.025	
(45.2 to 45.7) GHz	0.026	
45.8 GHz	0.027	
46.0 GHz	0.026	
(46.2 to 46.5) GHz	0.025	
46.6 GHz	0.026	
(46.8 to 47.7) GHz	0.027	
(47.8 to 48.1) GHz	0.026	
48.2 GHz	0.027	
48.4 GHz	0.028	
(48.6 to 49.3) GHz	0.029	
49.4 GHz	0.028	
49.6 GHz	0.027	
49.8 GHz	0.028	
50.0 GHz	0.030	

Parameter/Range	CMC ² (±)	Comments
RF / μ -Wave power Power Sensor Calibration Factor – Measure (cont.)		
(33 to 50) GHz		
(33.0 to 34.1) GHz	0.024	Q8486A power sensor, 83650A/B signal generator, 83555A multiplier head, CMC based on Q8486A power sensor
(34.2 to 36.2) GHz	0.026	
(36.3 to 37.8) GHz	0.024	
(37.9 to 48.0) GHz	0.023	
(48.1 to 48,8) GHz	0.024	
(48.9 to 50.0) GHz	0.027	
(50 to 75) GHz		
(50.0 to 54.0) GHz	0.050	45774H power sensor, 83650A/B source, 83557A multiplier head, CMC based on V8486A power sensor
(55.0) GHz	0.041	
(56.00 to 67.0) GHz	0.055	
(67.5 to 75.0) GHz	0.054	
(75 to 110) GHz		
75 GHz	0.055	Hughes 45786H -1000 calorimeter 45776H power sensor, 83650A/B source, 83558A multiplier head
76 GHz	0.055	
78 GHz	0.053	
80 GHz	0.054	
82 GHz	0.050	
84 GHz	0.052	
86 GHz	0.048	
88 GHz	0.047	
90 GHz	0.045	
92 GHz	0.045	
94 GHz	0.044	
95 GHz	0.044	
96 GHz	0.043	
98 GHz	0.044	
100 GHz	0.046	
102 GHz	0.047	
104 GHz	0.048	
108 GHz	0.050	
110 GHz	0.053	

Parameter/Range	CMC ² (±)	Comments
RF / μ -Wave Power Absolute Power – Measure 50 MHz 1000 μ W (0 dBm) 3.2 μ W (-25 dBm) 1.0 μ W (-30 dBm)	 4.0 μ W 15 nW 20 nW	 478A-H75 thermistor mount, 34970 + 34901A data acquisition switch w/DMM, E9304A power sensor, 50 MHz 1-mW ref oscillator, E4419B power meter
RF / μ -Wave Thermal Noise ENR – Measure 10 MHz to 18.0 GHz (4.5 to 6.5) dB 10 MHz 100 MHz 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz 7 GHz 8 GHz 9 GHz 10 GHz 11 GHz 12 GHz 13 GHz 14 GHz 15 GHz 16 GHz 17 GHz 18 GHz (14 to 16) dB 10 MHz 100 MHz 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz	 0.085 dB 0.092 dB 0.079 dB 0.080 dB 0.082 dB 0.081 dB 0.10 dB 0.081 dB 0.087 dB 0.085 dB 0.079 dB 0.079 dB 0.085 dB 0.11 dB 0.089 dB 0.11 dB 0.092 dB 0.11 dB 0.11 dB 0.16 dB 0.083 dB 0.087 dB 0.074 dB 0.075 dB 0.078 dB 0.076 dB 0.096 dB	 83631A/B source, N4000A noise source standard, N8973A noise figure analyzer (NFA) 83631A/B source, N4001A noise source standard, N8973A noise figure analyzer (NFA)

Parameter/Range	CMC ² (±)	Comments
RF / μ -Wave Thermal Noise ENR – Measure (cont)		
(14 to 16) dB		
6 GHz	0.078 dB	83631A/B source, N4001A noise source standard, N8973A noise figure analyzer (NFA)
7 GHz	0.083 dB	
8 GHz	0.082 dB	
9 GHz	0.074 dB	
10 GHz	0.073 dB	
11 GHz	0.078 dB	
12 GHz	0.11 dB	
13 GHz	0.086 dB	
14 GHz	0.11 dB	
15 GHz	0.086 dB	
16 GHz	0.098 dB	
17 GHz	0.094 dB	
18 GHz	0.14 dB	
10 MHz to 26.5 GHz (12 to 17) dB		
10 MHz	0.085 dB	83631A/B source, N4002A noise source standard, N8973A noise figure analyzer (NFA)
100 MHz	0.089 dB	
1 GHz	0.075 dB	
2 GHz	0.073 dB	
3 GHz	0.077 dB	
4 GHz	0.074 dB	
5 GHz	0.095 dB	
6 GHz	0.078 dB	
7 GHz	0.082 dB	
8 GHz	0.080 dB	
9 GHz	0.073 dB	
10 GHz	0.072 dB	
11 GHz	0.078 dB	
12 GHz	0.12 dB	
13 GHz	0.083 dB	
14 GHz	0.11 dB	
15 GHz	0.088 dB	
16 GHz	0.11 dB	
17 GHz	0.087 dB	
18 GHz	0.099 dB	
19 GHz	0.096 dB	
20 GHz	0.11 dB	
21 GHz	0.097 dB	
22 GHz	0.096 dB	
23 GHz	0.11 dB	
24 GHz	0.11 dB	
25 GHz	0.098 dB	
26 GHz	0.11 dB	
26.5 GHz	0.12 dB	

Parameter/Range	CMC ² (±)	Comments
Complex Impulse Response – Measure		
DC to 10 GHz	±0.17 dB ±0.87 deg	Oscilloscope sampling head excited by 110 GHz photodiode
(10 to 20) GHz	±0.17 dB ±1.1 deg	Keysight 86100D mainframe
(20 to 30) GHz	±0.20 dB ±1.3 deg	Keysight 86118A sampling head
(30 to 40) GHz	±0.23 dB ±1.6 deg	
(40 to 50) GHz	±0.26 dB ±1.6 deg	
(50 to 60) GHz	±0.33 dB ±2.0 deg	
(60 to 70) GHz	±0.50 dB ±2.8 deg	

Parameter/Range	CMC (±)	Comments

Parameter/Range	CMC (±)	Comments
Spectrum Analyzer –		N7800A test environment manager, N7814A X-series signal analyzer application
Absolute amplitude @ 50 MHz (-81 to -11) dBm	0.072 dB	8494G, 8496G step attenuator 8482A, 8485A, 8487A, N8487A power sensors, E4419B power meter, E8257D signal generator, 83650B synthesized sweeper, 11677B, 11667C power splitter, 3458A DVM, 33120A function generator
Frequency response relative to 50 MHz		
100 kHz to 300 kHz	0.048 dB	
300 kHz to 2 GHz	0.046 dB	
(2 to 3.6) GHz	0.047 dB	
(3.6 to 50) GHz	0.25 dB	
Display Scale Fidelity @ 50 MHz (-85 to -16) dBm	0.006 dB	
Gain Compression		
(50, 200, 500, 2000, 3000, 3500, 6000, 11000, 15300, 19900) MHz	0.14 dB	
Third Order Intercept Two tone 1 MHz offset		
50.01 MHz	0.31 dB	
1700.21 MHz	0.38 dB	
2800.21 MHz	0.46 dB	
5000.21 MHz	0.45 dB	
13000.21 MHz	0.47 dB	
19500.21 MHz	0.48 dB	
23500.21 MHz	0.49 dB	

Parameter/Range	CMC ² (±)	Comments
Spectrum Analyzer – (cont)		N7800A test environment manager, N7814A X-series signal analyzer application
Second Harmonic Intercept Two tone 1 MHz offset		8494G, 8496G step attenuator 8482A, 8485A, 8487A, N8487A power sensors E4419B power meter E8257D signal generator 83650B synthesized sweeper 11677B, 11667C power splitter 3458A DVM 33120A function generator
50 MHz	0.86 dB	
290.10 MHz	0.86 dB	
1748.10 MHz	0.86 dB	
3900.10 MHz	0.87 dB	
8200.10 MHz	0.89 dB	
11750.10 MHz	0.89 dB	
DANL 3 Hz to 50 GHz	0.27 dB	500-13438D ultra low phase noise source
LO Phase Noise @ 1GHz Frequency offset: (0.10, 0.99, 10, 100, 1000, 9900) kHz	0.35 dB	

Parameter/Range	Frequency ⁶	CMC ² (±)	Comments
RF Absolute Power – Measure			
(-10 to 0) dBm	9 kHz ≤ f < 5 MHz	0.054 dB	Power sensor E9304A_H19, power meter E4419B, CMC based on E8257D signal source
	5 MHz ≤ f < 30 MHz	0.056 dB	
	(30 ≤ f < 50) MHz	0.044 dB	
	50 MHz ≤ f < 1 GHz	0.054 dB	
	(1 ≤ f < 2) GHz	0.055 dB	
	(2 ≤ f < 9) GHz	0.056 dB	
	(9 ≤ f < 10) GHz	0.070 dB	
	(10 ≤ f < 15) GHz	0.080 dB	
	(15 ≤ f < 17) GHz	0.074 dB	
	(17 ≤ f < 19) GHz	0.080 dB	

Parameter/Range	Frequency ⁶	CMC ² (±)	Comments
RF Absolute Power – Measure (cont)			
(0 to +30) dBm	9 kHz ≤ f < 30 MHz (30 ≤ f < 50) MHz (50 ≤ f < 500) MHz 500 MHz ≤ f < 1 GHz (1 ≤ f < 9) GHz (9 ≤ f < 10) GHz (10 ≤ f < 12) GHz (12 ≤ f < 15) GHz (15 ≤ f < 17) GHz (17 ≤ f < 18) GHz	0.063 dB 0.046 dB 0.060 dB 0.061 dB 0.065 dB 0.077 dB 0.086 dB 0.089 dB 0.082 dB 0.084 dB	Power sensor E9304A_H19, power meter E4419B, CMC based on E8257D signal source
(-10 to 10) dBm	50 MHz ≤ f < 2 GHz (2 ≤ f < 12) GHz (12 ≤ f < 18) GHz (18 ≤ f < 25) GHz (25 ≤ f < 26) GHz (26 ≤ f < 37) GHz (37 ≤ f < 40) GHz (40 ≤ f < 43) GHz (43 ≤ f < 48) GHz (48 ≤ f < 49) GHz (49 ≤ f < 50) GHz	0.09 dB 0.10 dB 0.12 dB 0.14 dB 0.15 dB 0.16 dB 0.17 dB 0.22 dB 0.23 dB 0.24 dB 0.25 dB	Power sensor 8487A, power meter E4419B, CMC based on E8257D signal source
(10 to 20 dBm)	50 MHz ≤ f < 100 MHz 100 MHz ≤ f < 2 GHz (2 ≤ f < 12) GHz (12 ≤ f < 18) GHz (18 ≤ f < 25) GHz (25 ≤ f < 26) GHz (26 ≤ f < 37) GHz (37 ≤ f < 40) GHz (40 ≤ f < 43) GHz (43 ≤ f < 48) GHz (48 ≤ f < 49) GHz (49 ≤ f < 50) GHz	0.18 dB 0.17 dB 0.18 dB 0.19 dB 0.20 dB 0.21 dB 0.21 dB 0.22 dB 0.26 dB 0.27 dB 0.28 dB 0.29 dB	Power sensor 8487A, power meter E4419B, CMC based on E8257D signal source

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Absolute Power – Measure (cont)			
(-10 to 0) dBm	50 GHz	0.20 dB	Power sensor V8486A, power meter E4419B, CMC based on E8257D signal source
	51 GHz	0.20 dB	
	52 GHz	0.19 dB	
	53 GHz	0.18 dB	
	54 GHz	0.17 dB	
	55 GHz	0.16 dB	
	56 GHz	0.17 dB	
	57 GHz	0.18 dB	
	58 GHz	0.19 dB	
	59 GHz	0.20 dB	
	60 GHz	0.20 dB	
	61 GHz	0.19 dB	
	62 GHz	0.19 dB	
	63 GHz	0.18 dB	
64 GHz	0.17 dB		
65 GHz	0.18 dB		
66 GHz	0.20 dB		
67 GHz	0.19 dB		
(0 to +20) dBm	50 GHz	0.25 dB	Power sensor V8486A, Power meter E4419B, CMC based on E8257D signal source
	51 GHz	0.24 dB	
	52 GHz	0.24 dB	
	53 GHz	0.23 dB	
	54 GHz	0.22 dB	
	55 GHz	0.22 dB	
	56 GHz	0.22 dB	
	57 GHz	0.23 dB	
	58 GHz	0.23 dB	
	59 GHz	0.25 dB	
	60 GHz	0.25 dB	
	61 GHz	0.24 dB	
	62 GHz	0.23 dB	
	63 GHz	0.23 dB	
64 GHz	0.22 dB		
65 GHz	0.23 dB		
66 GHz	0.24 dB		
67 GHz	0.23 dB		

Parameter/Range	Frequency ⁶	CMC ² (±)	Comments
Signal Generator –			N7800A test environment manager
SSB phase noise			
At (1, 10, 100, 1k, 10k, 100k) Hz offset	$0.10 \leq f \leq 26.5$	2.3 dB ^[1]	E5505A phase noise system PNRS_E8257D reference source
Digital modulation			
EVM (16, 64, 256) QAM, BPSK, QPSK	$0.50 \leq f \leq 50$	(+0 to -0.82) % reading	89441A vector signal analyzer
RF Absolute power - measure			
(>20 to 30) dBm	9 kHz to <10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz	0.16 dB 0.16 dB 0.16 dB 0.17 dB	
(>14 to 20) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.11 dB 0.05 dB 0.06 dB 0.08 dB 0.07 dB 0.07 dB	
(>-10 to +14) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.11dB 0.04 dB 0.05 dB 0.07 dB 0.05 dB 0.06 dB	

Parameter/Range	Frequency	CMC ² (±)	Comments
Signal Generator – (cont)			
RF Absolute power - measure			
(1 to -1) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.04 dB 0.04 dB 0.05 dB 0.07 dB 0.05 dB 0.06 dB	N7800A test environment manager
(-10 to -30) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.13 dB 0.04 dB 0.05 dB 0.07 dB 0.05 dB 0.06 dB	
(>-30 to -90) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.12 dB 0.05 dB 0.06 dB 0.07 dB 0.06 dB 0.06 dB	
(<-90 to -110) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.12 dB 0.06 dB 0.07 dB 0.08 dB 0.08 dB 0.08 dB	

Parameter/Range	Frequency	CMC ² (±)	Comments
Signal Generator – (cont)			
RF Absolute Power – Measure			
(<-110 to -130) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.13 dB 0.08 dB 0.08 dB 0.10 dB 0.09 dB 0.09 dB	N7800A test environment manager
(<-130 to -140) dBm	9 kHz to < 10 MHz 10 MHz to < 13 GHz (13 to <19) GHz (19 to 26.5) GHz (>26.5 to 40) GHz (>40 to 50) GHz	0.15 dB 0.09 dB 0.09 dB 0.10 dB 0.10 dB 0.12 dB	

IV. Mechanical

Parameter/Equipment	Range	CMC ² (±)	Comments
Torque	(1 to 50) in·ozf (2.5 to 250) in·lbf	1.8 % of reading 2.2 % of reading	Torque transducers

V. Time & Frequency

Parameter/Equipment	Range	CMC ² (±)	Comments
Frequency – Measuring Equipment	10 MHz	worst case $\sigma_y(2,24\text{hr}) = 1 \times 10^{-13}$ Hz/Hz	Allen deviation worst case HP 5071A cesium beam; CBT S/N 3839A00594 HP 58503B GPS-disciplined oscillator

¹ These laboratories offer commercial 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 In the statement of CMC, L is the numerical value of the nominal length in mm and D is the numerical value of the nominal diameter in mm.

⁴ S_{11}/S_{22} reflection CMCs are a function of actual measured reflection and transmission magnitude. The CMC statements assume $S_{21}=S_{12}=0$.

⁵ S_{21}/S_{12} transmission CMCs are a function of actual measured transmission and reflection magnitudes. These CMC statements assume $S_{11}=S_{22}=0$.

⁶ In the frequency column, f is the frequency.



Accredited Laboratory

A2LA has accredited

KEYSIGHT TECHNOLOGIES SANTA ROSA METROLOGY SERVICES

Santa Rosa, CA

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 any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).



Presented this 4th day of March 2016.

A handwritten signature in blue ink, appearing to read "J. C. Bunt".

Senior Director, Quality and Communications
For the Accreditation Council
Certificate Number 2079.01
Valid to March 31, 2018

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