



THE AMERICAN ASSOCIATION FOR  
LABORATORY ACCREDITATION

## ACCREDITED LABORATORY

A2LA has accredited

# AGILENT 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/NCSL 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 18 June 2005*).

Presented this 26<sup>th</sup> day of March 2008.

A handwritten signature in cursive script, reading "Peter Abney".

President  
For the Accreditation Council  
Certificate Number 2079.01  
Valid to April 30, 2010  
REVISED March 16, 2010



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

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

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

CALIBRATION

Valid To: April 30, 2010

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 calibrations<sup>1</sup>:

I. Dimensional

Parameter/Equipment	Range	Best Uncertainty <sup>2</sup> (±)	Comments
Plain Ring Gages	(1 to 25) mm	0.21 µm	OD/ID comparator
Plain Plug Gages	(0.5 to 75) mm	0.8 µm	Supermicrometer w/ laser interferometer
Coaxial Airline –			
Uncompressed Outer Conductor Length	(10 to 300) mm	3.8 µm	Zeiss UPMC550 CMM
Uncompressed Pin Depth	(-10 to +10) µm	0.27 µm	Zygo white light interferometer microscope
Inner Conductor Diameter	(0.4 to 7) mm	0.3 µm	Z-Mike 1210 gold laser micrometer
Outer Conductor Diameter	(1 to 16) mm (1.845 to 1.855) mm (2.395 to 2.405) mm (3.495 to 3.505) mm (6.995 to 7.005) mm	0.9 µm 0.6 µm 0.6 µm 0.6 µm 0.6 µm	Ring gages w/ Zeiss UPMC550 CMM 1.85 mm air probe 2.4 mm air probe 3.5 mm air probe 7 mm air probe

Parameter/Equipment	Range	Best Uncertainty <sup>2</sup> (±)	Comments
Coaxial Short Circuit –			
Outer Conductor Diameter	(1 to 16) mm	0.9 μm	Zeiss UPMC550 CMM and ring gages
Inner Conductor Length	(0 to 25.4) mm	0.61 μm	Heidenhain Certo drop indicator
Uncompressed Pin Depth (Type N)	(-10 to +10) mm	0.92 μm	Zeiss UPMC550 CMM (5.2578 mm nominal offset)
Uncompressed Pin Depth (Type 7-16)	(-10 to +10) mm	0.91 μm	Zeiss UPMC550 CMM (1.77038 mm nominal offset)
Uncompressed Pin Depth (All Other Connectors)	(-10 to +10) mm	0.27 μm	Zygo white light interferometer microscope
Inner Conductor Diameter	(1 to 16) mm	0.3 μm	Z-Mike 1210 gold laser micrometer

## II. Electrical – RF/Microwave

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Reflection S <sub>11</sub> /S <sub>22</sub> – Measure <sup>3</sup>		
45 MHz to 18 GHz		
(0.0001 to 1.0) lin	(±0.00072 to ±0.0048) lin	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E APC 7mm, thru reflection line (TRL) cal kit
(0 to 0.01) lin	(±4.2 to ±180) deg	
(0.01 to 0.1) lin	(±0.54 to ±11) deg	
(0.1 to 0.5) lin	(±0.24 to ±1.4) deg	
(0.5 to 1.0) lin	(±0.18 to ±0.59) deg	

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Reflection S <sub>11</sub> /S <sub>22</sub> – Measure <sup>3</sup> (cont.)		
45 MHz to 18 GHz		
(0.0001 to 1.0) lin	(±0.0008 to ±0.0053) lin	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E Type N, TRL cal kit
(0 to 0.01) lin	(±4.7 to ±180) deg	
(0.01 to 0.1) lin	(±0.59 to ±12) deg	
(0.1 to 0.5) lin	(±0.27 to ±1.5) deg	
(0.5 to 1.0) lin	(±0.22 to ±0.63) deg	
45 MHz to 33.5 GHz		
(0.0001 to 1.0) lin	(±0.00090 to ±0.0082) lin	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E 3.5 mm, TRL cal kit
(0 to 0.01) lin	(±5.3 to ±180) deg	
(0.01 to 0.1) lin	(±0.64 to ±15) deg	
(0.1 to 0.5) lin	(±0.26 to ±1.8) deg	
(0.5 to 1.0) lin	(±0.19 to ±0.88) deg	
45 MHz to 50 GHz		
(0.0001 to 1.0) lin	(0.0014 to ±0.012) lin	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85133E 2.4 mm, TRL cal kit
(0 to 0.01) lin	(±8.4 to ±180) deg	
(0.01 to 0.1) lin	(±0.96 to ±21) deg	
(0.1 to 0.5) lin	(±0.32 to ±2.9) deg	
(0.5 to 1.0) lin	(±0.27 to ±1.5) deg	
45 MHz to 8.2 GHz		
(0.0001 to 1.0) lin	(±0.00073 to ±0.0019) lin	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83631 A/B, cable HP 85133E 7-16 connector, TRL cal kit
(0 to 0.01) lin	(±4.3 to ±180) deg	
(0.01 to 0.1) lin	(±0.54 to ±4.4) deg	
(0.1 to 0.5) lin	(±0.24 to ±0.61) deg	
(0.5 to 1.0) lin	(±0.18 to ±0.30) deg	

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Reflection S <sub>11</sub> /S <sub>22</sub> – Measure <sup>3</sup> (cont.)		
500 MHz to 12 GHz		
(0.0001 to 1.0) lin	(±0.0010 to ±0.012) lin	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E Type N 75 ohm, TRL cal kit
(0 to 0.01) lin	(±5.7 to ±180) deg	
(0.01 to 0.1) lin	(±0.68 to ±35) deg	
(0.1 to 0.5) lin	(±0.28 to ±3.6) deg	
(0.5 to 1.0) lin	(±0.22 to ±1.0) deg	
200 MHz to 6.2 GHz		
(0.0001 to 1.0) lin	(±0.0011 to ±0.018) lin	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E Type F 75 ohm, TRL cal kit
(0 to 0.01) lin	(±6.2 to ±180) deg	
(0.01 to 0.1) lin	(±0.73 to ±19) deg	
(0.1 to 0.5) lin	(±0.28 to ±2.0) deg	
(0.5 to 1.0) lin	(±0.22 to ±1.2) deg	
(8.2 to 12.4) GHz		
(0.0001 to 1.0) lin	(±0.0012 to ±0.0075) lin	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85132E X-band waveguide HP X11644A, 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 ±0.00225) lin	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85132E P-band waveguide HP P11644A, 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	(±0.37 to ±0.41) deg	

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Reflection S <sub>11</sub> /S <sub>22</sub> – Measure <sup>3</sup> (cont.)		
(18.0 to 26.5) GHz		
(0.0001 to 1.0) lin	(±0.0013 to ±0.0028) lin	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85132E K-band waveguide HP K11644A, 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 HP8510C, source module HP 83554A, HP 85100A mm wave system RF source HP8340A, source HP 83651 A/B, R-band HP R11644A, 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 HP8510C, source module HP 83555A, HP 85100A mm wave system RF source HP8340A, source HP 83651 A/B, Q-band HP Q11644A, 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 83651 A/B, U-band HP U11644A, 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	Best Uncertainty <sup>2</sup> ( $\pm$ )	Comments
Reflection $S_{11}/S_{22}$ – Measure <sup>3</sup> (cont.)  (50 to 75) 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  (75 to 110) 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	   ( $\pm 0.0022$ to $\pm 0.013$ ) lin  ( $\pm 18$ to $\pm 180$ ) deg ( $\pm 6.0$ to $\pm 18$ ) deg ( $\pm 5.1$ to $\pm 6.0$ ) deg ( $\pm 5.1$ to $\pm 5.3$ ) deg  ( $\pm 0.0022$ to $\pm 0.015$ ) lin  ( $\pm 30$ to $\pm 180$ ) deg ( $\pm 9.1$ to $\pm 30$ ) deg ( $\pm 7.5$ to $\pm 9.1$ ) deg ( $\pm 7.5$ to $\pm 7.6$ ) deg	   Network analyzer HP8510C, multiplier test set HP V85104A, HP 85105A mm wave controller, source HP 83623B, source HP 83651 A/B, V-band HP V11644A, TRL cal kit  Network analyzer HP8510C, multiplier test set HP W85104A, HP 85105A mm wave controller, source HP 83623B, source HP 83651 A/B, W-band HP W11644A, TRL cal kit
Transmission $S_{12}/S_{21}$ – Measure <sup>4</sup>  45 MHz to 18 GHz  (0 to 20) dB  (20 to 40) dB  (40 to 60) dB  45 MHz to 18 GHz  (0 to 20) dB  (20 to 40) dB  (40 to 60) dB	   ( $\pm 0.016$ to $\pm 0.018$ ) dB ( $\pm 0.15$ to $\pm 2.0$ ) deg  ( $\pm 0.018$ to $\pm 0.028$ ) dB ( $\pm 0.23$ to $\pm 2.2$ ) deg  ( $\pm 0.028$ to $\pm 0.13$ ) dB ( $\pm 0.32$ to $\pm 4.5$ ) deg  ( $\pm 0.018$ to $\pm 0.019$ ) dB ( $\pm 0.17$ to $\pm 2.0$ ) deg  ( $\pm 0.019$ to $\pm 0.058$ ) dB ( $\pm 0.24$ to $\pm 2.2$ ) deg  ( $\pm 0.045$ to $\pm 0.13$ ) dB ( $\pm 0.32$ to $\pm 4.5$ ) deg	   Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E, APC 7mm, thru reflection line (TRL) cal kit  Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E Type N, TRL cal kit

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Transmission $S_{12}/S_{21}$ – Measure <sup>4</sup> (cont.)		
45 MHz to 26.5 GHz		
(0 to 20) dB	(±0.017 to ±0.019) dB (±0.15 to ±2.9) deg	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E 3.5 mm, TRL cal kit
(20 to 40) dB	(±0.019 to ±0.028) dB (±0.24 to ±3.7) deg	
(40 to 60) dB	(±0.028 to ±0.13) dB (±0.32 to ±12) deg	
45 MHz to 50 GHz		
(0 to 20) dB	(±0.017 to ±0.023) dB (±0.15 to ±2.6) deg	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85133E, 2.4 mm, TRL cal kit
(20 to 40) dB	(±0.023 to ±0.037) dB (±0.34 to ±3.5) deg	
(40 to 60) dB	(±0.037 to ±0.26) dB (±0.32 to ±13) deg	
45 MHz to 8.2 GHz		
(0 to 20) dB	(±0.033 to ±0.038) dB (±0.15 to ±1.0) deg	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83631 A/B, cable HP 85133E, 7-16 connector, TRL cal kit
(20 to 40) dB	(±0.035 to ±0.046) dB (±0.24 to ±1.1) deg	
(40 to 60) dB	(±0.045 to ±0.29) dB (±0.32 to ±2.6) deg	
500 MHz to 6.2 GHz		
(0 to 20) dB	(±0.033 to ±0.042) dB (±0.17 to ±2.1) deg	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E, Type N 75 ohm, TRL cal kit
(20 to 40) dB	(±0.035 to ±0.062) dB (±0.24 to ±2.3) deg	
(40 to 60) dB	(±0.045 to ±0.39) dB (±0.32 to ±4.5) deg	

Parameter/Range	Best Uncertainty <sup>2</sup> ( $\pm$ )	Comments
Transmission $S_{12}/S_{21}$ – Measure <sup>4</sup> (cont.)		
200 MHz to 12 GHz		
(0 to 20) dB	( $\pm 0.033$ to $\pm 0.042$ ) dB ( $\pm 0.17$ to $\pm 2.1$ ) deg	Network analyzer HP8510C, S Parameter test set HP8515A, source HP 83651 A/B, cable HP 85133E, Type F 75 ohm, TRL cal kit
(20 to 40) dB	( $\pm 0.035$ to $\pm 0.062$ ) dB $\pm 0.24$ to $\pm 2.3$ deg	
(40 to 60) dB	( $\pm 0.045$ to $\pm 0.39$ ) dB ( $\pm 0.32$ to $\pm 4.5$ ) deg	
(8.2 to 12.4) GHz		
(0 to 20) dB	( $\pm 0.046$ to $\pm 0.047$ ) dB ( $\pm 1.7$ to $\pm 1.8$ ) deg	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85132E X-band waveguide HP X11644A, TRL cal kit
(20 to 40) dB	( $\pm 0.047$ to $\pm 0.051$ ) dB ( $\pm 1.8$ to $\pm 1.9$ ) deg	
(40 to 60) dB	( $\pm 0.051$ to $\pm 0.13$ ) dB ( $\pm 1.9$ to $\pm 2.5$ ) deg	
(12.4 to 18.0) GHz		
(0 to 20) dB	( $\pm 0.046$ to $\pm 0.046$ ) dB ( $\pm 2.57$ to $\pm 2.60$ ) deg	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85132E P-band waveguide HP P11644A, TRL cal kit
(20 to 40) dB	( $\pm 0.046$ to $\pm 0.051$ ) dB ( $\pm 2.6$ to $\pm 2.7$ ) deg	
(40 to 60) dB	( $\pm 0.051$ to $\pm 0.17$ ) dB ( $\pm 2.6$ to $\pm 3.7$ ) deg	
(18.0 to 26.5) GHz		
(0 to 20) dB	( $\pm 0.046$ to $\pm 0.047$ ) dB ( $\pm 4.0$ to $\pm 5.9$ ) deg	Network analyzer HP8510C, S Parameter test set HP8517A, source HP 83651 A/B, cable HP 85132E K-band waveguide HP K11644A, TRL cal kit
(20 to 40) dB	( $\pm 0.047$ to $\pm 0.078$ ) dB ( $\pm 4.1$ to $\pm 6.2$ ) deg	
(40 to 60) dB	( $\pm 0.053$ to $\pm 0.57$ ) dB ( $\pm 4.2$ to $\pm 9.7$ ) deg	

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Transmission $S_{12}/S_{21}$ – Measure <sup>4</sup> (cont.)		
(26.5 to 40) GHz		
(0 to 20) dB	(±0.051 to ±0.052) dB (±2.5 to ±2.6) deg	Network analyzer HP8510C, source module HP 83554A, HP 85100A mm wave system, RF source HP8340A, source HP 83651 A/B, R-band HP R11644A, 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 ±0.052) dB (±3.1 to ±3.2) deg	Network analyzer HP8510C, source module HP 83555A, HP 85100A mm wave system, RF source HP8340A, source HP 83651 A/B, Q-band HP Q11644A, 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	
(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 U85104A, HP 85105A mm wave controller RF source HP83623B, Lo source HP 83651 A/B, U-band HP U11644A, TRL cal kit
(20 to 40) dB	(±0.053 to ±0.082) dB (±3.8 to ±4.1) deg	
(40 to 60) dB	(±0.082 to ±0.60) dB (±4.1 to ±7.5) deg	
(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 V85104A, HP 85105A mm wave controller, source HP 83623B, source HP 83651 A/B V-band HP V11644A, TRL cal kit
(20 to 40) dB	(±0.040 to ±0.34) dB (±5.1 to ±9.4) deg	
(40 to 60) dB	(±0.34 to ±16) dB (±9.4 to ±62) deg	

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
Transmission S <sub>21</sub> /S <sub>12</sub> – measure <sup>4</sup> (cont.)  (75 to 110) GHz  (0 to 20) dB  (20 to 40) dB  (40 to 60) dB	   (±0.038 to ±0.065) dB (±6.9 to ±7.2) deg  (±0.065 to ±0.33) dB (±7.1 to ±9.9) deg  (±0.33 to ±6.5) dB (±9.9 to ±39) deg	   Network analyzer HP8510C, multiplier test set HP W85104A, HP 85105A mm wave controller, source HP 83623B, source HP 83651 A/B, W-band HP W11644A, TRL cal kit
RF / μ-Wave power Power Sensor Calibration Factor – Measure  9 kHz to 18.0 GHz  (0.009 to 10) MHz (0.01 to 0.03) GHz 0.050 GHz (0.050 to 1.0) GHz (1.0 to 1.6) GHz (1.8 to 2.0) GHz 2.2 GHz (2.4 to 3.6) GHz (3.8 to 4.6) GHz (4.8 to 5.2) GHz (5.4 to 5.6) GHz (5.8 to 6.4) GHz 6.6 GHz 7.6 GHz	   0.0040 0.0050 0.0030 0.0024 0.0025 0.0026 0.0027 0.0028 0.0029 0.0030 0.0031 0.0032 0.0033 0.0034	   83650A/B signal generator, 8648C/D signal generator, 11667A power splitter, 11051A thermal converter, 478A-H75 thermistor mount, 8478B thermistor mount, 3458A DVM, 34970 + 34901A data acquisition switch w/ DMM, 50 MHz 1mW ref oscillator  uncertainty based on 8481 or E9304A power sensor

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments	
RF / $\mu$ -Wave power Power Sensor Calibration Factor – Measure (cont.)			
9 kHz to 18.0 GHz			
7.8 GHz	0.0036	83650A/B signal generator, 8648C/D signal generator, 11667A power splitter, 11051A thermal converter, 478A-H75 thermistor mount, 8478B thermistor mount, 3458A DVM, 34970 + 34901A data acquisition switch w/ DMM, 50 MHz 1mW ref oscillator	
8.0 GHz	0.0037		
(8.2 to 9.6) GHz	0.0039		
(9.8 to 10.8) GHz	0.0041		
(11.0 to 11.4) GHz	0.0043		
(11.6 to 11.8.0) GHz	0.0045		
(12.00 to 12.5) GHz	0.0048		
(12.75 to 13.00) GHz	0.0051		
(13.25 to 13.75) GHz	0.0052		
(14.00 to 14.25) GHz	0.0054		
(14.50 to 14.75) GHz	0.0056		
(15.00 to 15.50) GHz	0.0062		
(15.75 to 16.00) GHz	0.0067		
16.25 GHz	0.0069		
(16.50 to 17.00) GHz	0.0073		
17.25 GHz	0.0082	uncertainty based on 8481 or E9304A power sensor	
17.50 GHz	0.0078		
17.75 GHz	0.0089		
18.00 GHz	0.0081		
10 MHz to 50 GHz			
(0.01 to 9.0) GHz	0.015		83650A/B source, 11667C power splitter, 8487A power sensor
(10.0 to 17.0) GHz	0.016		
(18.0 to 20.0) GHz	0.017		
(21.0 to 31.0) GHz	0.017		
(31.5 to 33.0) GHz	0.020		
(33.5 to 38.0) GHz	0.019		
(38.5 to 42.0) GHz	0.022		
43.0 GHz	0.023		
44.0 GHz	0.026		
(45.0, 49.0) GHz	0.027		
50.0 GHz	0.034		

Parameter/Range	Best Uncertainty <sup>2</sup> (±)	Comments
RF / $\mu$ -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,  uncertainty 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 53.5) GHz	0.049	45774H power sensor, 83650A/B source, 83557A multiplier head, uncertainty based on V8486A power sensor
(54.00 to 67.0) GHz	0.041	
(67.5 to 75.0) GHz	0.047	
(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	Best Uncertainty <sup>2</sup> (±)	Comments
RF / $\mu$ -Wave Power Absolute Power – Measure  50 MHz  1000 $\mu$ W (0 dBm)  3.2 $\mu$ W (-25 dBm)  1.0 $\mu$ W (-30 dBm)	   4.0 $\mu$ 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 / $\mu$ -Wave Thermal Noise ENR – Measure  10 MHz to 18.0 GHz  (4.5 to 6.5) dB  10 MHz to 1 GHz 2 GHz to 17 GHz 18 GHz  (14 to 16) dB  10 MHz to 11 GHz 12 GHz to 17 GHz 18 GHz  10 MHz to 26.5 GHz  (12 to 17) dB  10 MHz to 13 GHz 14 GHz to 17 GHz 18 GHz to 23 GHz 24 GHz to 26 GHz 26.5 GHz	   0.10 dB 0.12 dB 0.16 dB    0.10 dB 0.12 dB 0.15 dB    0.10 dB 0.12 dB 0.15 dB 0.23 dB 0.27 dB	   83631 A/B source, N4000A noise source standard, N8973A noise figure analyzer (NFA)    83631 A/B source, N4001A noise source standard, N8973A noise figure analyzer (NFA)    83631 A/B source, N4002A noise source standard, N8973A noise figure analyzer (NFA)

### III. Mechanical

Parameter/Equipment	Range	Best Uncertainty <sup>2</sup> (±)	Comments
Torque	(5 to 10) in·lbf (10 to 50) in·lbf (25 to 50) in·lbf	1.7 % of reading 1.1 % of reading 1.1 % of reading	Mountz ETA MK5 BMX-50i

<sup>1</sup> These laboratories offer commercial calibration service.

<sup>2</sup> “Best Uncertainty” 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 of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of  $k = 2$ . The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer’s device and to influences from the circumstances of the specific calibration.

<sup>3</sup>  $S_{11}/S_{22}$  reflection uncertainties are a function of actual measured reflection and transmission magnitude. These uncertainty statements assume  $S_{21}=S_{12}=0$ .

<sup>4</sup>  $S_{21}/S_{12}$  transmission uncertainties are a function of actual measured transmission and reflection magnitudes. These uncertainty statements assume  $S_{11}=S_{22}=0$ .