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ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

PRIMARY STANDARDS NORTH AMERICA, INC.
EL Segundo, CA

for technical competence in the field of

Calibration

The accreditation covers the specific calibrations listed on the agreed scope of accreditation. This laboratory meets the requirements of ISO/IEC 17025 - 1999 "General Requirements for the Competence of Testing and Calibration Laboratories" Laboratories that comply with this International Standard also operate in accordance with ISO 9001 or ISO 9002 (1994). This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration.

Presented this 11th day of November 2003.

American Association for Laboratory Accreditation
Corporate SEAL 1978
District of Columbia
A2LA

President
For the Accreditation Council
Certificate Number 1964.01
Valid to October 31, 2005

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

SCOPE OF ACCREDITATION TO ISO/IEC 17025-1999
& ANSI/NCSL Z540-1-1994

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CALIBRATION

Valid To: October 31, 2005 Certificate Number: 1964.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations[1]:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
DC Voltage	0.1 V 1 V 10 V 100 V 1000 V (2 to 3) kV (4 to 60) kV	0.77 µV/V 0.24 µV/V 0.22 µV/V 0.51 µV/V 1 µV/V 0.008 % 0.007 %	Fluke 732B HP 34420A NVM HP 3458A DMM Data Proof 160 scanner Fluke 752A NIST voltage divider Agilent 3458A DMM
Resistance	(0.001, 0.01) Ω 0.1 Ω (1, 10) Ω 100 Ω, 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ	1.5 µΩ/Ω 0.71 µΩ/Ω 0.26 µΩ/Ω 0.46 µΩ/Ω 0.48 µΩ/Ω 0.6 µΩ/Ω 1.4 µΩ/Ω 2.9 µΩ/Ω 7.5 µΩ/Ω 31 µΩ/Ω	Guildline 6675A, 6623; L&N standard resistors; ESI SR1010, SR1050; Hart 7009 oil bath, MI 9300 air bath

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
High Resistance – Measure	(1 to 10) GΩ (10 to 100) GΩ 100 GΩ to 1 TΩ (1 to 10) TΩ (10 to 100) TΩ 100 TΩ to 1 PΩ (1 to 10) PΩ	0.08 % 0.12 % 0.23 % 0.35 % 0.58 % 1.2 % 12 %	Guildline 6500A Teraohmmeter
Capacitance – Measure @ 1 kHz	1 pF 2 pF (3, 4) pF (5 to 9) pF (10, 20, 30) pF (40 to 100) pF 200 pF (300 to 400) pF (500 to 600) pF (700 to 800) pF (900 to 1000) pF (1 nF) (2 to 4) nF 5 nF (6 to 10) nF 20 nF (30 to 40) nF 50 nF (60 to 100) nF 200 nF (300 to 400) nF 500 nF (600 to 1000) nF (1 µF)	4.1 µF/F 3.8 µF/F 3.7 µF/F 3.6 µF/F 3.6 µF/F 3.5 µF/F 3.6 µF/F 3.5 µF/F 3.6 µF/F 3.5 µF/F 3.6 µF/F 3.6 µF/F 3.7 µF/F 3.7 µF/F 3.9 µF/F 3.9 µF/F 4.7 µF/F 4.7 µF/F 7.4 µF/F 7.4 µF/F 15 µF/F 15 µF/F	Andeen Hagerling 2500A capacitance bridge, Andeen Hagerling 1100 – 10PFD & 100 PFD standard capacitors, GR 1404A 1000 PFD standard capacitor
Capacitance – Generate @ 1 kHz	10 pF 100 pF 1000 pF	3.6 µF/F 3.5 µF/F 3.6 µF/F	Standard capacitors
Inductance – Measure & Generate	100 µH at 1 kHz 1 mH at 100 Hz, 1 kHz 10 kHz 10 mH at 1 kHz 10 kHz	 0.12 % 0.023 % 0.058 % 0.023 % 0.061 %	HP 4274A LCR meter, GR 1482B,E,H,L,P,T standard inductors

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Inductance – Measure & Generate (cont)	100 mH 100 Hz, 1 kHz 10 kHz 1 H (100, 400) Hz 10 kHz 10 H 100 Hz 400 Hz 1 kHz	 0.023 % 0.061 % 0.031 % 0.061 % 0.03 % 0.12 % 0.23 %	HP 4274A LCR meter, GR 1482B,E,H,L,P,T standard inductors
Accelerometer	0.1 mV to 10 V/g or pc/g (2 to 4) Hz 5 Hz to 2 kHz (2 to 10) kHz	 2.5 % 1.5 % 2.5 %	Bouche vibration system; Endevco 2270M8 standard accelerometer (reference & check standard)
Pulse Transition Time – Generate Measure	 Rise Time Fall Time Risetime Fall Time	 <28 pS <28 pS <19 pS <18 pS	 Wavetek 9550 active head Tektronix 11801B, SD26
Square Wave – Generate, 50 Ω or 1 MΩ load impedance	10 Hz to 10 kHz (35.52 to 99.90) μV_{pp} (1 to 21) mV_{pp} (21.001 to 556) mV_{pp} (0.55601 to 210) V_{pp}	 1 % + 10 μV_{pp} 0.1 % + 15 μV_{pp} 0.1 % + 1 μV_{pp} 0.05 % + 1 μV_{pp}	Wavetek 9500
Time Marker – Generate	450.50 pS to 55.00 S	10 ppm of output period	Wavetek 9500
DC Voltage – Generate	±(888 µV to 222.4 V)	0.25 % + 25 µV	Wavetek 9500

Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments
AC Voltage Flatness – Measure (0.45, 1, 3, or 6) V	0.3 MHz 1 MHz 3 MHz 10 MHz 30 MHz 50 MHz 80 MHz 100 MHz	0.04 % 0.01 % 0.02 % 0.06 % 0.13 % 0.25 % 0.63 % 0.63 %	Ballantine thermal voltage converters: 1395B-0.4-09 1395B-1-09 1395B-3-09 1395B-6-09

AC Voltage – Measure			Fluke 792A AC/DC thermal transfer standard
10 mV	20 Hz	64 µV/V	
	1 kHz	58 µV/V	
	20 kHz	58 µV/V	
	50 kHz	81 µV/V	
	100 kHz	160 µV/V	
	500 kHz	320 µV/V	
	1 MHz	390 µV/V	
100 mV	20 Hz	29 µV/V	
	1 kHz	24 µV/V	
	20 kHz	24 µV/V	
	50 kHz	35 µV/V	
	100 kHz	60 µV/V	
	500 kHz	120 µV/V	
	1 MHz	200 µV/V	
700 mV	20 Hz	21 µV/V	
	1 kHz	7 µV/V	
	20 kHz	7 µV/V	
	50 kHz	9 µV/V	
	100 kHz	11 µV/V	
	500 kHz	26 µV/V	
	1 MHz	40 µV/V	
1 V	20 Hz	21 µV/V	
	1 kHz	7 µV/V	
	20 kHz	7 µV/V	
	50 kHz	9 µV/V	
	100 kHz	9 µV/V	
	500 kHz	26 µV/V	
	1 MHz	37 µV/V	
3 V	50 Hz	9 µV/V	
	1 kHz	7 µV/V	
	20 kHz	7 µV/V	
	100 kHz	9 µV/V	
	500 kHz	24 µV/V	
	1 MHz	35 µV/V	
Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments

AC Voltage – Measure & Generate			Fluke 792A AC/DC thermal transfer standard
7 V	20 Hz	21 µV/V	
	1 kHz	7 µV/V	
	50 kHz	9 µV/V	
	100 kHz	9 µV/V	
	1 MHz	36 µV/V	
10 V	20 Hz	21 µV/V	
	1 kHz	7 µV/V	
	20 kHz	7 µV/V	
	50 kHz	8 µV/V	
	100 kHz	8 µV/V	
	500 kHz	24 µV/V	
	1 MHz	35 µV/V	
70 V	20 Hz	24 µV/V	
	1 kHz	10 µV/V	
	20 kHz	9 µV/V	
	50 kHz	9 µV/V	
	100 kHz	11 µV/V	
	200 kHz	40 µV/V	
100 V	20 Hz	24 µV/V	
	1 kHz	9 µV/V	
	20 kHz	8 µV/V	
	50 kHz	9 µV/V	
	100 kHz	12 µV/V	
	200 kHz	28 µV/V	
500 V	50 Hz	24 µV/V	
	1 kHz	12 µV/V	
	30 kHz	12 µV/V	
1000 V	50 Hz	25 µV/V	
	1 kHz	20 µV/V	
	20 kHz	21 µV/V	
	30 kHz	21 µV/V	

Parameter/Range	Frequency	Best Uncertainty[2] (±)	Comments

AC Current – Measure & Generate			Holt HCS-1 AC shunts, Fluke 5720A/5725A, HP 3458A DMM, Wavetek 4920, Fluke 792A
10 mA	400 Hz 5 kHz 20 kHz 50 kHz	60 µA/A 60 µA/A 60 µA/A 93 µA/A	
20 mA	400 Hz 5 kHz	60 µA/A 60 µA/A	
100 mA	400 Hz 5 kHz 20 kHz 50 kHz	60 µA/A 60 µA/A 60 µA/A 82 µA/A	
200 mA	400 Hz 5 kHz	60 µA/A 60 µA/A	
500 A	400 Hz 5 kHz	61 µA/A 61 µA/A	
1 A	400 Hz 5 kHz 20 kHz 50 kHz	60 µA/A 60 µA/A 60 µA/A 82 µA/A	
2 A	400 Hz 5 kHz	60 µA/A 60 µA/A	
5 A	400 Hz 5 kHz	120 µA/A 120 µA/A	
10 A	400 Hz 5 kHz 20 kHz	120 µA/A 120 µA/A 60 µA/A	
20 A	400 Hz 5 kHz 20 kHz	120 µA/A 120 µA/A 61 µA/A	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments

DC Current (Measure ≤ 400A) (Generate ≤ 100A)	(1 to 99) µA 100 µA to 30 mA (31 to 100) mA (101 to 300) mA (301 to 400) mA (401 to 500) mA (501 to 799) mA (800 to 900) mA 901 mA to 15 A (16 to 50) A (51 to 70) A (71 to 100) A (101 to 400) A	5 µA/A 4 µA/A 5 µA/A 6 µA/A 13 µA/A 11 µA/A 10 µA/A 9 µA/A 8 µA/A 15 µA/A 21 µA/A 26 µA/A 62 µA/A	Stable DC source standard resistor, voltmeter

II. Electrical – RF/Microwave

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Sine Wave – Absolute Level			HP 3325A/B
0.001 Hz to 100 kHz 100 kHz to 20 MHz	(13.52 to 23.98) dBm	0.1 dB 0.4 dB	
0.001 Hz to 100 kHz 100 kHz to 20 MHz	(-16.02 to 13.52) dBm	0.2 dB 0.6 dB	
0.001 Hz to 100 kHz 100 kHz to 10 MHz (10 to 20) MHz	(-56.02 to -16.02) dBm	0.2 dB 0.6 dB 0.9 dB	
Flatness –			HP 3335A
(50, 75Ω)	1 kHz to 25 MHz 200 Hz to 80 MHz	0.07 dB 0.15 dB	
Absolute Level (50 Ω ref to 100 kHz)	(0 to 18) dB (20 to 58) dB (60 to 98) dB	0.04 dB 0.09 dB 0.2 dB	
Absolute Level (75 Ω ref to 100 kHz)	(0 to 18) dB (20 to 58) dB (60 to 98) dB	0.04 dB 0.09 dB 0.2 dB	
Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments

Leveled Sine Wave – Generate	100 mHz to 100 MHz (100 to 550) MHz 550 MHz to 1.1 GHz (1.1 to 2.5) GHz (2.5 to 3.2) GHz	1.5 % 3 % 4 % 5 % 5 %	Wavetek 9500; Flatness is relative to 50 kHz.
RF/mW Absolute Power – Measure			Hewlett Packard 8482A, 8481H opt H70, 8481A, 8481D, 8485A opt 033, 8485D opt 033, 8487A, 8487D, Q8486A, V8486A, W8486A, R486A, Hughes thermistor mounts
Type N	100 kHz to 100 MHz 100 MHz to 10 GHz (10 to 13) GHz (13 to 16) GHz (16 to 18) GHz	0.3 % 0.4 % 0.5 % 0.6 % 0.8 %	
3.5mm	50 MHz to 9 GHz (9 to 16) GHz (16 to 33) GHz	1.8 % 1.9 % 2.3 %	
2.92mm	50 MHz to 1 GHz (1 to 10) GHz (10 to 20) GHz (20 to 25) GHz (25 to 40) GHz	0.4 % 1.1 % 1.6 % 1.7 % 2.2 %	
2.4mm	50 Hz to 500 MHz 500 MHz to 8 GHz (8 to 18) GHz (18 to 26) GHz (26 to 47) GHz 48 GHz 49 GHz 50 GHz	0.4 % 1.3 % 1.6 % 1.7 % 2 % 2.1 % 3.2 % 3.6 %	
WR-42 WR-28 WR-22 WR-15 WR-10	(18 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	1 % 1.1 % 1.5 % 1.7 % 2.5 %	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Tune RF Level – Measure, (0 to -127) dB (0 to 10) dB (0 to 20) dB (0 to 30) dB (0 to 40) dB (0 to 50) dB (0 to 60) dB (0 to 70) dB (0 to 80) dB (0 to 90) dB (0 to 100) dB (0 to 110) dB (0 to 120) dB	2.5 MHz to 110 GHz	0.02 dB 0.02 dB 0.03 dB 0.04 dB 0.06 dB 0.08 dB 0.08 dB 0.11 dB 0.12 dB 0.13 dB 0.12 dB 0.15 dB	Hewlett Packard 8902A measuring receiver with Hewlett Packard 11793A microwave converter or 11970 series harmonic mixer
Modulation – Measure Phase Frequency Amplitude	 (0.15 to 10) MHz (10 to 1300) MHz 10 MHz to 26.5 GHz (0.25 to 10) MHz (10 to 1300) MHz 50 MHz to 26.5 GHz (0.15 to 10) MHz (10 to 1300) MHz 1300 MHz to 26.5 GHz	 4 % of reading 3 % of reading 3 % of reading 2 % + 1 digit 1 % + 1 digit 1 % + 1 digit 2 % + 1 digit 1 % + 1 digit 1.1 % + digit	Hewlett Packard 8902A measuring receiver with Hewlett Packard 11793A microwave converter
Antenna Gain	(1 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	0.15 dB 0.2 dB 0.2 dB 0.25 dB 0.3 dB	HP 8510C, 8517B, V85104A, W85104A; Scientific Atlanta 12-2.9, 12-5.8, 12-8.2, 12-12, 12-18, 12-26, 12-33; Narda 642, 643, 645; TRG 861B/383, AB90; FXR M638A; Hughes 45826H-1020
Phase Noise – Measure	10 MHz to 18 GHz	1.6 dB (1 Hz to 100 kHz offset)	Hewlett Packard 3048A system w/8662A and 11729C

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Phase Noise – (cont) Generate	10 MHz 9.75 GHz	1 dB (1 Hz to 1 MHz offset) 2 dB (10 Hz offset) 1 dB (20 Hz to 2 MHz offset)	Datum 8040A oscillator Techtrol-Cyclonetic model MX415 oscillator
50 MHz Reference Source	1.000 mW @ 50 MHz	0.3 %	PSNA reference source
Power Sensor/ Thermistor Mount Characterization – Coaxial/Waveguide (1 to 26.5) GHz NOTE: Following are the uncertainties to develop a standard power. The device under test may contribute other unknown sources of error.	0.0001 GHz 0.0003 GHz (0.001, 0.003) GHz (0.005,0.01) GHz 0.02 GHz 0.03 GHz 0.04 GHz 0.05 GHz (0.06, 0.07, 0.08) GHz 0.09 GHz (0.1, 0.2, 0.3, 0.4) GHz 0.5 GHz (0.6, 0.7, 0.8) GHz 0.9 GHz 1.0 GHz 2.0 GHz 3.0 GHz 4.0 GHz 5.0 GHz 6.0 GHz 7.0 GHz 8.0 GHz 9.0 GHz 10 GHz 11 GHz 12 GHz 13 GHz 14 GHz 15 GHz	0.63 % 0.5 % 0.4 % 0.4 % 0.63 % 0.52 % 0.64 % 0.6 % 0.63 % 0.63 % 0.5 % 0.5 % 0.6 % 0.5 % 0.4 % 0.38 % 0.4 % 0.42 % 0.43 % 0.47 % 0.48 % 0.49 % 0.51 % 0.55 % 0.57 % 0.59 % 0.62 % 0.65 % 0.71 %	HP 3456A, 432A, 8510C, 8517B 478A opt H63; Weinschel 1120 Bolometer; HP 8478B, P486A, R486A; V85104A, W85104A, Millitech THM-22-RF000, THM-15-RF000, THM-10-RF000

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Power Sensor/ Thermistor Mount Characterization –			HP 3456A, 432A, 8510C, 8517B 478A opt H63; Weinschel 1120 Bolometer; HP 8478B, P486A, R486A; V85104A, W85104A, Millitech THM-22-RF000, THM-15-RF000, THM-10-RF000
Coaxial/Waveguide (1 to 26.5) GHz (cont)	16 GHz	0.68 %	
	17 GHz	0.78 %	
	18 GHz	0.81 %	
	19 GHz	0.91 %	
	20 GHz	1.4 %	
	(21, 22) GHz	1.3 %	
	(23, 24, 25) GHz	1.4 %	
	(26, 26.5) GHz	1.3 %	
Coaxial/Waveguide (26.5 to 40) GHz	26.5 GHz	1.3 %	
	27 GHz	2 %	
	28 GHz	1.8 %	
	29 GHz	1.9 %	
	30 GHz	2.3 %	
	31 GHz	1.9 %	
	32 GHz	2.5 %	
	33 GHz	2.7 %	
	34 GHz	2.4 %	
	(35, 36) GHz	2.9 %	
	37 GHz	2.4 %	
	38 GHz	1.9 %	
	39 GHz	2.2 %	
	40 GHz	2.4 %	
Coaxial/Waveguide (33 to 50) GHz	33 GHz	2.7 %	
	34 GHz	2.4 %	
	(35, 36) GHz	2.9 %	
	37 GHz	2.4 %	
	38 GHz	1.9 %	
	39 GHz	2.2 %	
	40 GHz	2.4 %	
	41 GHz	2.3 %	
	42 GHz	2.5 %	
	43 GHz	2.6 %	
	44 GHz	2.5 %	
	45 GHz	2.3 %	
	46 GHz	2.2 %	
	47 GHz	2.3 %	
	48 GHz	2.4 %	
	49 GHz	2.2 %	
	50 GHz	2.5 %	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Power Sensor/ Thermistor Mount Characterization – (cont)			HP 3456A, 432A, 8510C, 478A opt H63; Weinschel 1120 Bolometer; HP 8478B, P486A, R486A; Millitech THM-22-RF000, THM-15-RF000, THM-10-RF000
Coaxial (50 to 65) GHz	50 GHz	2.5 %	
	51 GHz	2.4 %	
	52 GHz	2.5 %	
	(53, 54, 55, 56) GHz	2.4 %	
	57 GHz	2.6 %	
	58 GHz	2.7 %	
	(59, 60, 61) GHz	2.5 %	
	62 GHz	2.6 %	
	63 GHz	2.7 %	
	64 GHz	2.6 %	
Waveguide (50 to 75) GHz	50 GHz	2.5 %	
	51 GHz	2.4 %	
	52 GHz	2.5 %	
	(53, 54, 55, 56) GHz	2.4 %	
	57 GHz	2.6 %	
	58 GHz	2.7 %	
	(59, 60, 61) GHz	2.5 %	
	62 GHz	2.6 %	
	63 GHz	2.7 %	
	64 GHz	2.6 %	
	(65, 66, 67, 68, 69) GHz	2 %	
	(70, 71, 72, 73, 74) GHz	2 %	
	75 GHz	2 %	
Waveguide (75 to 110) GHz	75 GHz	2 %	
	76 GHz	4 %	
	77 GHz	3.6 %	
	78 GHz	3.3 %	
	(79, 80) GHz	3.1 %	
	81 GHz	4.6 %	
	82 GHz	3.2 %	
	(83, 84, 85, 86) GHz	3.1 %	
	87 GHz	3.2 %	
	(88, 89, 90, 91, 92) GHz	3.1 %	
	93 GHz	3.2 %	
	(94, 95, 96) GHz	3.1 %	
	(97, 98) GHz	3.2 %	
	(99, 100, 101) GHz	3.1 %	
	(102, 103, 104) GHz	3.1 %	
	(105, 106, 107) GHz	3.1 %	
	(108, 109) GHz	3.1 %	
	110 GHz	3.2 %	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Thermal Noise			
Coaxial (0.01 to 26.5) GHz (5 to 30) dB ENR	0.01 GHz 0.03 GHz 0.06 GHz 0.10 GHz 0.30 GHz 0.60 GHz 1 GHz 1.5 GHz 2 GHz 3 GHz 4 GHz 5 GHz (6, 7) GHz 8 GHz (9, 10, 11) GHz 12 GHz 13 GHz 14 GHz 15 GHz	0.1 dB 0.13 dB 0.1 dB 0.15 dB 0.1 dB 0.11 dB 0.13 dB 0.09 dB 0.11 dB 0.08 dB 0.13 dB 0.13 dB 0.08 dB 0.09 dB 0.07 dB 0.09 dB 0.08 dB 0.1 dB 0.08 dB	HP 8970B, 8971C, 346A, 346B, 346C, 8510C, 8517B, V85104A, W85104A; Clare TN162 WR-28, TN172 WR-22, TN164 WR-15, TN165 WR-10
Coaxial (0.01 to 26.5) GHz (5 to 30) dB ENR	16 GHz 17 GHz 18 GHz (19, 20) GHz 21 GHz 22 GHz 23 GHz 24 GHz (25, 26) GHz 26.5 GHz	0.09 dB 0.08 dB 0.12 dB 0.2 dB 0.21 dB 0.2 dB 0.15 dB 0.23 dB 0.2 dB 0.26 dB	HP 8970B, 8971C, 346A, 346B, 346C, 8510C, 8517B, V85104A, W85104A; Clare TN162 WR-28, TN172 WR-22, TN164 WR-15, TN165 WR-10
Coaxial/Waveguide (26.5 to 40) GHz (5 to 30) dB ENR	(26.5, 27, 28) GHz (29, 30) GHz 31 GHz 32 GHz (33, 34) GHz 35 GHz 36 GHz 37 GHz 38 GHz 39 GHz 40 GHz	0.1 dB 0.08 dB 0.07 dB 0.09 dB 0.08 dB 0.09 dB 0.08 dB 0.09 dB 0.1 dB 0.09 dB 0.12 dB	HP 8970B, 8971C, 346A, 346B; Clare TN162 WR-28, TN172 WR-22, TN164 WR-15, TN165 WR-10

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Thermal Noise (cont)			
Coaxial/Waveguide (33 to 50) GHz (5 to 30) dB ENR	33 GHz	0.13 dB	HP 8970B, 8971C, 346A, 346B; Clare TN162 WR-28, TN172 WR-22, TN164 WR-15, TN165 WR-10
	(34, 35) GHz	0.14 dB	
	36 GHz	0.12 dB	
	37 GHz	0.14 dB	
	38 GHz	0.08 dB	
	(39, 40, 41.5) GHz	0.13 dB	
	42 GHz	0.14 dB	
	43 GHz	0.12 dB	
	43.5 GHz	0.14 dB	
	44 GHz	0.15 dB	
	44.5 GHz	0.12 dB	
	45 GHz	0.13 dB	
	(45.5, 46, 47) GHz	0.11 dB	
	48 GHz	0.13 dB	
	49 GHz	0.11 dB	
	50 GHz	0.13 dB	
Waveguide (50 to 75) GHz (5 to 30) dB ENR	50 GHz	0.21 dB	HP 8970B, 8971C, 346A, 346B; Clare TN162 WR-28, TN172 WR-22, TN164 WR-15, TN165 WR-10
	51 GHz	0.19 dB	
	52 GHz	0.18 dB	
	53 GHz	0.15 dB	
	54 GHz	0.14 dB	
	(55, 56) GHz	0.12 dB	
	57 GHz	0.13 dB	
	(58, 59) GHz	0.15 dB	
	60 GHz	0.17 dB	
	61 GHz	0.14 dB	
	62 GHz	0.13 dB	
	63 GHz	0.12 dB	
	64 GHz	0.09 dB	
	65 GHz	0.1 dB	
	66 GHz	0.13 dB	
	67 GHz	0.17 dB	
	68 GHz	0.2 dB	
	69 GHz	0.24 dB	
	70 GHz	0.28 dB	
	71 GHz	0.31 dB	
	72 GHz	0.35 dB	
	73 GHz	0.39 dB	
	74 GHz	0.42 dB	
	75 GHz	0.46 dB	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Thermal Noise (cont) Waveguide (75 to 110) GHz (5 to 30) dB ENR	75 GHz 76 GHz 77 GHz 78 GHz 78.5 GHz 79 GHz 80 GHz 81 GHz 82 GHz 83 GHz 84 GHz 85 GHz 86 GHz 87 GHz 88 GHz 89 GHz 90 GHz 91 GHz 92 GHz 93 GHz 94 GHz 95 GHz 96 GHz 97 GHz 98 GHz 99 GHz 100 GHz (101, 102, 103, 104) GHz (105, 106, 107, 108) GHz (109, 110) GHz	0.39 dB 0.34 dB 0.29 dB 0.25 dB 0.24 dB 0.29 dB 0.37 dB 0.43 dB 0.49 dB 0.55 dB 0.62 dB 0.68 dB 0.64 dB 0.6 dB 0.57 dB 0.53 dB 0.5 dB 0.48 dB 0.46 dB 0.44 dB 0.41 dB 0.44 dB 0.46 dB 0.48 dB 0.5 dB 0.52 dB 0.55 dB 0.6 dB 0.6 dB 0.6 dB	HP 8970B, 8971C, 346A, 346B; Clare TN162 WR-28, TN172 WR-22, TN164 WR-15, TN165 WR-10
Scattering Parameters – Reflection: S_{11} and S_{22} Reflection Coefficient 0 to 1 Coaxial Waveguide	(0.0001 to 0.045) GHz (0.045 to 50) GHz (26.5 to 40) GHz (WR28) (33 to 50) GHz (WR22) (50 to 75) GHz (WR15) (75 to 110) GHz (WR10)	0.02 (lin) 0.03 (lin) 0.01 (lin) 0.015 (lin) 0.015 (lin) 0.02 (lin)	HP 8510C, 8517B, V85104A, W85104A, 85052C, 85054B, 85056A, 3577A, 3458A, 355D, 8482A, 4419B; Fluke 5720A; PSNA KA-TRL, Q-TRL, V-TRL, W-TRL calibration kits, NIST 2.4 mm airline, NIST V-Band, and NIST W-Band attenuation standards

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Scattering Parameters – Transmission: S_{21} and S_{12}			HP 8510C, 8517B, V85104A, W85104A, 85052C, 85054B, 85056A, 3577A, 3458A, 355D, 8482A, 4419B; Fluke 5720A; PSNA KA-TRL, Q-TRL, V-TRL, W-TRL calibration kits, NIST 2.4 mm airline
Coaxial			
(0.0001 to 0.045) GHz	(0 to 1) dB (1 to 10) dB 30 dB (10 to 60) dB (60 to 70) dB	0.015 dB 0.05 dB 0.01 dB 0.12 dB 0.15 dB	
(0.045 to 50) GHz	(0 to 40) dB (40 to 50) dB	0.14 dB 0.27 dB	
Waveguide			
(26.5 to 40) GHz (WR-28)	(0 to 10) dB (10 to 30) dB (30 to 40) dB (40 to 50) dB	0.05 dB 0.04 dB 0.08 dB 0.25 dB	NIST WR-28 attenuation standards
(33 to 50) GHz (WR-22)	(0 to 10) dB (10 to 30) dB (30 to 40) dB (40 to 50) dB	0.04 dB 0.03 dB 0.15 dB 0.30 dB	NIST WR-22 attenuation standards
(50 to 75) GHz (WR-15)	(0 to 30) dB (30 to 40) dB	0.14 dB 0.18 dB	NIST WR-15 attenuation standards
(75 to 110) GHz (WR-10)	(0 to 30) dB (30 to 40) dB	0.15 dB 0.22 dB	NIST WR-10 attenuation standards

III. Time and Frequency

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments

Frequency – Generate	5 MHz 10 MHz 0.001 Hz to 110 GHz	4 parts in 10^{13} 4 parts in 10^{13} (Using External Ref)	Datum 4310 Cesium standard HP 3325A HP 83650 Olsen V-Band source Olsen W-Band source

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Frequency –Measure	(1, 5, 10) MHz DC to 110 GHz	2 parts in 10^{13} (24Hr) 4 parts in 10^{13} + 1 LSD	NIST frequency measurement and analysis system (FMAS) HP 5335A HP 53152A EIP 548 with external sensor

IV. Dimensional

Parameter/Equipment	Range	Best Uncertainty[2, 3] (±)	Comments
Gage Blocks	(0.01 to 4) in	(2 + *L*) µin	Electromechanical comparison
Cylindrical Ring Gages	(0 to 4) in	(6 + 12*L*) µin	Gage blocks, internal comparator
Cylindrical Plug Gages	(0 to 2) in	(26 + 6*L*) µin	Gage blocks
Micrometers (Outside)	(0 to 12) in	(40 + 6*L*) µin	Gage blocks
Calipers	(0 to 24) in	(380 + 5*L*) µin	Gage blocks, ring gage
Dial/Digital Indicators	(0 to 0.2) in (0 to 1) in	20 µin 40 µin	Gage blocks

Torque Moment Arms	(0 to 24) in	(250 + 50*L*) µin	Gage blocks, dial indicator

V. Mechanical

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Force	(15 to 300) lbf (300 to 1000) lbf (1000 to 2000) lbf (2000 to 5000) lbf (5000 to 10 000) lbf (10 000 to 50 000) lbf	0.045 % 0.6 lbf 1 lbf 2.2 lbf 4.1 lbf 20 lbf	Dead weight Proving ring
Pressure	(0.2 to 1000) psi (gauge and absolute pressure) (1000 to 15 000) psig	0.0036 % 0.0043 %	Ruska 2465 Ruska 2475
Vacuum – Ionization Gauge	 2.0 E-07 torr 5.0 E-07 torr 9.0 E-07 torr 2.0 E-06 torr 5.0 E-06 torr 9.0 E-06 torr 2.0 E-05 torr 5.0 E-05 torr 9.0 E-05 torr 2.0 E-04 torr 4.0 E-04 torr	 7.4 % 3 % 2.2 % 5.9 % 2.5 % 1.6 % 6 % 2.5 % 1.6 % 6.2 % 2.8 %	 Spinning rotor gauge
Thermocouple Vacuum Gauge/ Capacitance Manometer	(0.01 to 0.05) torr (0.05 to 0.1) torr (0.1 to 10) torr (10 to 1000) torr	0.7 % 0.3 % 0.2 % 0.2 %	Capacitance diaphragm gauge
Torque Transducers	(20 to 320) in·oz (9 to 100) in·lb (10 to 100) ft·lb	0.03 % 0.03 % 0.03 %	Standard weights, torque moment arms

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
	(100 to 1000) ft·lb	0.03 %	
Torque Wrench and Torque Screwdriver	(20 to 320) in·oz (9 to 100) in·lb (10 to 100) ft·lb (100 to 1000) ft·lb	0.8 % 0.8 % 0.8 % 0.8 %	AKO TSD6000

VI. Thermodynamics

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Temperature – Generate & Measure	-195.5 °C -80 °C to 0 °C 0.01 °C (TPW) 1 °C to 125 °C 126 °C to 300 °C 301 °C to 660 °C 661 °C to 1000 °C	0.006 °C 0.004 °C 0.0004 °C 0.002 °C 0.004 °C 0.1 °C 0.16 °C	Super thermometer SPRT TPW Cell Oil Bath, LN_2 Nanovoltmeter Type S thermocouple Furnace
Temperature Simulation –			Fluke 5440B, ice bath
Type E	-270 °C to -265 °C -264 °C to -240 °C -239 °C to -212 °C -211 °C to 1000 °C	0.36 °C 0.12 °C 0.04 °C 0.03 °C	
Type J	-210 °C to -197 °C -196 °C to 1200 °C	0.04 °C 0.03 °C	
Type K	-270 °C to -263 °C -262 °C to -251 °C -250 °C to -234 °C -233 °C to -172 °C -171 °C to 1344 °C 1345 °C to 1372 °C	0.35 °C 0.17 °C 0.12 °C 0.06 °C 0.03 °C 0.04 °C	
Type N	-270 °C to -253 °C -252 °C to -239 °C -238 °C to -226 °C -225 °C to -201 °C -200 °C to -73 °C -72 °C to 1300 °C	0.34 °C 0.17 °C 0.11 °C 0.09 °C 0.06 °C 0.03 °C	

Type R	-50 °C to -17 °C -16 °C to 10 °C 11 °C to 1768 °C	0.16 °C 0.11 °C 0.08 °C	
Type S	-50 °C to 38 °C 37 °C to 1768 °C	0.11 °C 0.08 °C	
Type T	-270 °C to -266 °C -265 °C to -259 °C -258 °C to -196 °C -195 °C to -18 °C -17 °C to 400 °C	0.32 °C 0.16 °C 0.08 °C 0.04 °C 0.02 °C	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Relative Humidity Indicators	20 % to 85 %	0.9 %	Humidity chamber

[1] This laboratory offers commercial calibration service.

[2] Best Uncertainties represent expanded using a coverage factor of k=2 which provides a level of confidence of approximately 95 %. All uncertainties in this Scope of Accreditation were derived using NIST calibrated artifacts.

[3] L is the length in inches.