



# CERTIFICATE OF ACCREDITATION

## ANSI-ASQ National Accreditation Board

500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

**Keysight Technologies, Inc. Service Center**  
**700 Lairport Avenue**  
**El Segundo, CA 90245**

has been assessed by ANAB and meets the requirements of international standard

**ISO/IEC 17025:2005**

and national standards

**ANSI/NCSL Z540-1-1994 (R2002) AND**  
**ANSI/NCSL Z540.3-2006 (R2013)**

while demonstrating technical competence in the field of

**CALIBRATION**

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations to which this accreditation applies.

AC-1498.01  
Certificate Number

  
ANAB Approval

Certificate Valid: 06/07/2018-11/16/2020  
Version No. 004 Issued: 06/07/2018



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. 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).



**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005,  
ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)**

**Keysight Technologies, Inc. Service Center**

700 Lairport Avenue  
El Segundo, CA 90245  
Scott Arrants 916-788-5540  
[Scott\\_arrants@keysight.com](mailto:Scott_arrants@keysight.com) [www.keysight.com](http://www.keysight.com)

**CALIBRATION**

Valid to: **November 16, 2020**

Certificate Number: **AC-1498.01**

**Acoustics and Vibration**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers 0.1 mV to 10 V/G or pc/g	Sinusoidal (2 to 4) Hz	2.5 % of reading	Bouche Vibration System; Endevco 2270M8 Standard Accelerometer (Reference & Check Standard)
	5 Hz to 2 kHz	1.5 % of reading	
(2 to 10) kHz	2.5 % of reading		
	Shock (20 to 10,000) g	2 % of reading	Shock System & Standard Shock Accelerometer

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source <sup>1</sup>	(10 to 220) mV	6 μV/V + 0.4 μV	Fluke 732B DC Reference Standard, HP 34420A Multimeter, Data Proof 160 Scanner Fluke 752A Reference Divider
	220 mV to 2.2 V	3.5 μV/V + 0.7 μV	
(2.2 to 11) V	2.5 μV/V + 2.5 μV		
(11 to 22) V	2.4 μV/V + 4 μV		
(22 to 220) V	3.5 μV/V + 40 μV		
	220 V to 1.1 kV	4.5 μV/V + 0.4 mV	
	(2 to 60) kV	40 μV/V	PTB Voltage Divider
DC Voltage - Source <sup>1</sup> Fixed Points	0.1 V	0.76 μV/V	Agilent 3458A Multimeter, Fluke 5720A Multi Product Calibrator
	1 V	0.5 μV/V	
	10 V	0.5 μV/V	
	100 V	0.63 μV/V	
	1 000 V	0.83 μV/V	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source <sup>1</sup>	(1 to 2) mΩ	1.4 μΩ/Ω	Guildline 6675A Bridge, 6623 Extender, L&N Standard Resistors, ESIU SR 1010, SR 1050, Hart 7009 Oil Bath, MI 9300 Air Bath
	(3 to 5) mΩ	3.4 μΩ/Ω	
	(6 to 9) mΩ	2.4 μΩ/Ω	
	(10 to 20) mΩ	1.5 μΩ/Ω	
	(3 to 5) mΩ	3.4 μΩ/Ω	
	(6 to 9) mΩ	2.4 μΩ/Ω	
	(0.3 to 0.5) Ω	1.4 μΩ/Ω	
	(0.6 to 0.9) Ω	1 μΩ/Ω	
	(1 to 13) Ω	0.17 μΩ/Ω	
	14 Ω to 1 kΩ	0.38 μΩ/Ω	
	(1.1 to 9) kΩ	0.4 μΩ/Ω	
	(11 to 100) kΩ	0.45 μΩ/Ω	
	200 kΩ to 1 MΩ	0.84 μΩ/Ω	
	(2 to 10) MΩ	1.8 μΩ/Ω	
(11 to 100) MΩ	4.1 μΩ/Ω		
(200 to 900) MΩ	12 μΩ/Ω		
Resistance – Source Fixed Points <sup>1</sup>	0.1 Ω	0.62 μΩ/Ω	Guildline 6675Av Bridge, 6623 Extender, L&N Standard Resistors, ESIU SR 1010, SR 1050, Hart 7009 Oil Bath, MI 9300 Air Bath
	0.2 Ω	0.64 μΩ/Ω	
	1 Ω	0.17 μΩ/Ω	
	10 Ω	0.17 μΩ/Ω	
	100 Ω	0.38 μΩ/Ω	
	1 kΩ	0.38 μΩ/Ω	
	10 kΩ	0.25 μΩ/Ω	
1 GΩ	12 μΩ/Ω		
High Resistance - Measure	(1 to 10) GΩ	0.8 mΩ/Ω	Guildline 6500A Terohmmeter
	(10 to 100) GΩ	1.2 mΩ/Ω	
	100 GΩ to 1 TΩ	2.3 mΩ/Ω	
	(1 to 10) TΩ	3.5 mΩ/Ω	
	(10 to 100) TΩ	5.8 mΩ/Ω	
	100 TΩ to 1 PΩ	12 mΩ/Ω	
Capacitance – Measure <sup>1</sup> 50 Hz to 20 kHz	(3, 4) pF	3.7 μF/F	Andeen Hagerling 2500A Capacitance Bridge, Andeen Hagerling 2700A Capacitance Bridge
	(5 to 9) pF	3.6 μF/F	
	(10, 20, 30) pF	3.6 μF/F	
	(40 to 100) pF	3.5 μF/F	
	(300 to 400) pF	3.5 μF/F	
	(500 to 600) pF	3.6 μF/F	
	(700 to 800) pf	3.5 μF/F	
	0.9 pF to 1 nF	3.6 μF/F	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure <sup>1</sup> 50 Hz to 20 kHz Fixed Points	1 pF 2 pF 0.2 nF	4.1 μF/F 3.8 μF/F 3.6 μF/F	Andeen Hagerling AH1100 – 10 PFD & 100 PFD Standard Capacitors, GR 1404A 1 000 PFD Standard Capacitor
Capacitance – Source <sup>1</sup> Fixed Points	10 pF 50 Hz 0.1 kHz 0.4 kHz 0.8 kHz 1 kHz 2 kHz 6 kHz 8 kHz 10 kHz 16 kHz 20 kHz	3.4 μF/F 1.6 μF/F 0.48 μF/F 0.35 μF/F 0.33 μF/F 0.32 μF/F 0.55 μF/F 0.75 μF/F 1.1 μF/F 2.3 μF/F 3.5 μF/F	Standard Capacitors
	100 pF 50 Hz 0.1 kHz 0.4 kHz 0.8 kHz 1 kHz 2 kHz 6 kHz 8 kHz 10 kHz 16 kHz 20 kHz	1.9 μF/F 1 μF/F 0.54 μF/F 0.46 μF/F 0.29 μF/F 0.28 μF/F 0.45 μF/F 0.81 μF/F 0.94 μF/F 2.1 μF/F 2.7 μF/F	
	1 000 pF 0.1 kHz 0.4 kHz 1 kHz	3.7 μF/F 2.7 μF/F 2.3 μF/F	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
Capacitance – Source <sup>1</sup> Fixed Points	1 pF		Standard Capacitors	
	1 kHz	30 μF/F		
	10 kHz	33 μF/F		
	50 kHz	55 μF/F		
	100 kHz	83 μF/F		
	500 kHz	0.35 mF/F		
	1 MHz	0.71 mF/F		
	2 MHz	1.6 mF/F		
	3 MHz	2.8 mF/F		
	4 MHz	3.8 mF/F		
	5 MHz	5.1 mF/F		
	6 MHz	6.6 mF/F		
	7 MHz	8.2 mF/F		
	8 MHz	10 mF/F		
	9 MHz	12 mF/F		
	10 MHz	14 mF/F		
	10 pF			
	1 kHz	29 μF/F		
	10 kHz	33 μF/F		
	50 kHz	33 μF/F		
	100 kHz	33 μF/F		
	500 kHz	33 μF/F		
	10 pF			
	1 MHz	33 μF/F		
	2 MHz	54 μF/F		
	3 MHz	0.1 mF/F		
	4 MHz	0.17 mF/F		
	5 MHz	0.27 mF/F		
	6 MHz	0.39 mF/F		
	7 MHz	0.53 mF/F		
8 MHz	0.7 mF/F			
9 MHz	0.9 mF/F			
10 MHz	1.1 mF/F			

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance - Source <sup>1</sup> Fixed Points	100 pF		Standard Capacitors
	1 kHz	29 $\mu$ F/F	
	10 kHz	33 $\mu$ F/F	
	50 kHz	33 $\mu$ F/F	
	100 kHz	33 $\mu$ F/F	
	500 kHz	33 $\mu$ F/F	
	1 MHz	37 $\mu$ F/F	
	2 MHz	59 $\mu$ F/F	
	3 MHz	0.1 mF/F	
	4 MHz	0.18 mF/F	
	5 MHz	0.27 mF/F	
	6 MHz	0.39 mF/F	
	7 MHz	0.54 mF/F	
	8 MHz	0.7 mF/F	
	9 MHz	0.9 mF/F	
	10 MHz	1.1 mF/F	
	1 000 pF		
	1 kHz	29 $\mu$ F/F	
	10 kHz	33 $\mu$ F/F	
	50 kHz	33 $\mu$ F/F	
	100 kHz	33 $\mu$ F/F	
	500 kHz	33 $\mu$ F/F	
	1 000 pF		
	1 MHz	37 $\mu$ F/F	
	2 MHz	59 $\mu$ F/F	
	3 MHz	0.1 mF/F	
	4 MHz	0.18 mF/F	
	5 MHz	0.27 mF/F	
	6 MHz	0.39 mF/F	
	7 MHz	0.53 mF/F	
8 MHz	0.7 mF/F		
9 MHz	0.9 mF/F		
10 MHz	1.1 mF/F		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouples <sup>1</sup>	Type E		Calibrator, Ice Bath
	(-270 to -265) °C	0.3 °C	
	(-264 to -240) °C	0.1 °C	
	(-239 to -212) °C	0.03 °C	
	(-211 to 1 200) °C	0.03 °C	
	Type J		
	(-210 to -197) °C	0.04 °C	
	(-196 to 1 200) °C	0.03 °C	
	Type K		
	(-270 to -263) °C	0.3 °C	
	(-262 to -251) °C	0.15 °C	
	(-250 to -234) °C	0.1 °C	
	(-233 to -195) °C	0.05 °C	
	(-194 to 1 372) °C	0.03 °C	
	Type N		
	(-270 to -253) °C	0.28 °C	
	(-252 to -239) °C	0.14 °C	
	(-238 to -226) °C	0.09 °C	
	(-225 to -201) °C	0.07 °C	
	(-200 to -73) °C	0.05 °C	
	(-72 to 1 300) °C	0.03 °C	
	Type R		
	(-50 to -17) °C	0.13 °C	
	(-16 to 10) °C	0.09 °C	
(11 to 1 768) °C	0.07 °C		
Type S			
(-50 to 37) °C	0.09 °C		
(38 to 1 768) °C	0.07 °C		
Type T			
(-270 to -266) °C	0.3 °C		
(-265 to -259) °C	0.14 °C		
(-258 to -196) °C	0.07 °C		
(-195 to -18) °C	0.03 °C		
(-17 to 400) °C	0.02 °C		





Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source and Measure <sup>1</sup>	1 $\mu$ A to 30 mA (30 to 100) mA (100 to 300) mA (300 to 400) mA (500 to 800) mA (800 to 900) mA 900 mA to 15 A (16 to 50) A (50 to 70) A (70 to 100) A (100 to 400) A	4 $\mu$ A/A 5 $\mu$ A/A 6 $\mu$ A/A 13 $\mu$ A/A 11 $\mu$ A/A 9 $\mu$ A/A 8 $\mu$ A/A 13 $\mu$ A/A 18 $\mu$ A/A 24 $\mu$ A/A 30 $\mu$ A/A	Stable DC Source, Standard Resistor, Voltmeter
Inductance – Fixed Points	100 $\mu$ H 100 Hz 1 kHz 10 kHz 1 mH 100 Hz 1 kHz 10 kHz 10 mH 1 kHz 10 kHz 100 mH 100 Hz 1 kHz 10 kHz 1 H 100, 400 Hz 1 kHz 10 H 100, 400 Hz 1 kHz	0.15 mH/H 80 $\mu$ H/H 0.15 mH/H 0.1 mH/H 70 $\mu$ H/H 0.15 mH/H 70 $\mu$ H/H 0.13 mH/H 90 $\mu$ H/H 70 $\mu$ H/H 0.2 mH/H 80 $\mu$ H/H 70 $\mu$ H/H 90 $\mu$ H/H 80 $\mu$ H/H	Quadtech 7600 Plus LCR Meter, GR 1482B,E,L,P,T Standard Inductors
AC Voltage Flatness – Measure <sup>1</sup>	0.45 V 0.3 MHz 1 MHz 3 MHz 10 MHz 30 MHz 50 MHz 80 MHz 100 MHz	0.01 % of reading 0.01 % of reading 0.01 % of reading 0.01 % of reading 0.03 % of reading 0.07 % of reading 0.18 % of reading 0.36 % of reading	Ballantine Thermal Voltage Converters 1395B-0.4-09 1395B-1-09 1395B-3-09





Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Flatness – Measure <sup>1</sup>	1 V		Ballantine Thermal Voltage Converters 1395B-0.4-09 1395B-1-09 1395B-3-09
	0.3 MHz	0.01 % of reading	
	1 MHz	0.01 % of reading	
	3 MHz	0.02 % of reading	
	10 MHz	0.02 % of reading	
	30 MHz	0.02 % of reading	
	50 MHz	0.04 % of reading	
	80 MHz	0.1 % of reading	
	100 MHz	0.3 % of reading	
	3 V		
	0.3 MHz	0.02 % of reading	
	1 MHz	0.04 % of reading	
	3 MHz	0.03 % of reading	
	10 MHz	0.04 % of reading	
	30 MHz	0.05 % of reading	
	50 MHz	0.06 % of reading	
80 MHz	0.16 % of reading		
100 MHz	0.24 % of reading		
AC Voltage – Measure, Source <sup>1</sup>	2 mV		Fluke 792A AC/DC Thermal Transfer Standard
	10 Hz	360 $\mu$ V/V	
	20 Hz	354 $\mu$ V/V	
	40 Hz	315 $\mu$ V/V	
	100 Hz	335 $\mu$ V/V	
	1 kHz	315 $\mu$ V/V	
	10 kHz	284 $\mu$ V/V	
	20 kHz	381 $\mu$ V/V	
	50 kHz	484 $\mu$ V/V	
	100 kHz	536 $\mu$ V/V	
	300 kHz	437 $\mu$ V/V	
	500 kHz	403 $\mu$ V/V	
	800 kHz	474 $\mu$ V/V	
1 MHz	458 $\mu$ V/V		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure, Source <sup>1</sup>	6 mV		Fluke 792A AC/DC Thermal Transfer Standard
	10 Hz	135 $\mu$ V/V	
	20 Hz	188 $\mu$ V/V	
	40 Hz	218 $\mu$ V/V	
	100 Hz	172 $\mu$ V/V	
	1 kHz	125 $\mu$ V/V	
	10 kHz	125 $\mu$ V/V	
	20 kHz	146 $\mu$ V/V	
	50 kHz	129 $\mu$ V/V	
	100 kHz	181 $\mu$ V/V	
	300 kHz	245 $\mu$ V/V	
	500 kHz	189 $\mu$ V/V	
	800 kHz	146 $\mu$ V/V	
	1 MHz	153 $\mu$ V/V	
	10 mV		
	10 Hz	102 $\mu$ V/V	
	20 Hz	114 $\mu$ V/V	
	40 Hz	111 $\mu$ V/V	
	100 Hz	96 $\mu$ V/V	
	1 kHz	96 $\mu$ V/V	
	10 kHz	103 $\mu$ V/V	
	20 kHz	89 $\mu$ V/V	
	50 kHz	97 $\mu$ V/V	
	100 kHz	115 $\mu$ V/V	
	300 kHz	105 $\mu$ V/V	
	500 kHz	107 $\mu$ V/V	
	800 kHz	121 $\mu$ V/V	
1 MHz	128 $\mu$ V/V		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure, Source <sup>1</sup>	20 mV		Fluke 792A AC/DC Thermal Transfer Standard
	10 Hz	61 $\mu$ V/V	
	20 Hz	66 $\mu$ V/V	
	40 Hz	57 $\mu$ V/V	
	100 Hz	59 $\mu$ V/V	
	1 kHz	56 $\mu$ V/V	
	10 kHz	52 $\mu$ V/V	
	20 kHz	57 $\mu$ V/V	
	50 kHz	53 $\mu$ V/V	
	100 kHz	51 $\mu$ V/V	
	300 kHz	64 $\mu$ V/V	
	500 kHz	59 $\mu$ V/V	
	800 kHz	67 $\mu$ V/V	
	1 MHz	97 $\mu$ V/V	
	60 mV		
	10 Hz	34 $\mu$ V/V	
	20 Hz	31 $\mu$ V/V	
	40 Hz	29 $\mu$ V/V	
	100 Hz	27 $\mu$ V/V	
	1 kHz	25 $\mu$ V/V	
	10 kHz	29 $\mu$ V/V	
	20 kHz	27 $\mu$ V/V	
	50 kHz	27 $\mu$ V/V	
	100 kHz	29 $\mu$ V/V	
	300 kHz	28 $\mu$ V/V	
	500 kHz	31 $\mu$ V/V	
	800 kHz	38 $\mu$ V/V	
	1 MHz	49 $\mu$ V/V	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
AC Voltage – Measure, Source <sup>1</sup>	100 mV		Fluke 792A AC/DC Thermal Transfer Standard	
	10 Hz	20 $\mu$ V/V		
	20 Hz	18 $\mu$ V/V		
	40 Hz	19 $\mu$ V/V		
	100 Hz	19 $\mu$ V/V		
	1 kHz	17 $\mu$ V/V		
	10 kHz	16 $\mu$ V/V		
	20 kHz	18 $\mu$ V/V		
	50 kHz	19 $\mu$ V/V		
	100 kHz	17 $\mu$ V/V		
	300 kHz	16 $\mu$ V/V		
	500 kHz	16 $\mu$ V/V		
	800 kHz	26 $\mu$ V/V		
	1 MHz	32 $\mu$ V/V		
	200 mV			
	10 Hz	18 $\mu$ V/V		
	20 Hz	12 $\mu$ V/V		
	40 Hz	13 $\mu$ V/V		
	100 Hz	12 $\mu$ V/V		
	1 kHz	13 $\mu$ V/V		
	10 kHz	12 $\mu$ V/V		
	20 kHz	12 $\mu$ V/V		
	50 kHz	12 $\mu$ V/V		
	100 kHz	13 $\mu$ V/V		
	300 kHz	14 $\mu$ V/V		
	500 kHz	15 $\mu$ V/V		
	800 kHz	20 $\mu$ V/V		
1 MHz	27 $\mu$ V/V			



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure, Source <sup>1</sup>	600 mV		Fluke 792A AC/DC Thermal Transfer Standard
	10 Hz	13 $\mu$ V/V	
	20 Hz	7 $\mu$ V/V	
	40 Hz	8 $\mu$ V/V	
	100 Hz	8 $\mu$ V/V	
	1 kHz	7 $\mu$ V/V	
	10 kHz	9 $\mu$ V/V	
	20 kHz	7 $\mu$ V/V	
	50 kHz	7 $\mu$ V/V	
	100 kHz	8 $\mu$ V/V	
	300 kHz	11 $\mu$ V/V	
	500 kHz	15 $\mu$ V/V	
	800 kHz	18 $\mu$ V/V	
	1 MHz	25 $\mu$ V/V	
	1V		
	10 Hz	14 $\mu$ V/V	
	20 Hz	9 $\mu$ V/V	
	40 Hz	9 $\mu$ V/V	
	100 Hz	7 $\mu$ V/V	
	1 kHz	11 $\mu$ V/V	
	10 kHz	12 $\mu$ V/V	
	20 kHz	13 $\mu$ V/V	
	50 kHz	9 $\mu$ V/V	
	100 kHz	8 $\mu$ V/V	
	300 kHz	12 $\mu$ V/V	
	500 kHz	15 $\mu$ V/V	
	800 kHz	20 $\mu$ V/V	
	1 MHz	27 $\mu$ V/V	



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
AC Voltage – Measure, Source <sup>1</sup>	2V		Fluke 792A AC/DC Thermal Transfer Standard	
	10 Hz	13 μV/V		
	20 Hz	7 μV/V		
	40 Hz	7 μV/V		
	100 Hz	7 μV/V		
	1 kHz	7 μV/V		
	10 kHz	7 μV/V		
	20 kHz	7 μV/V		
	50 kHz	8 μV/V		
	100 kHz	8 μV/V		
	300 kHz	13 μV/V		
	500 kHz	21 μV/V		
	800 kHz	27 μV/V		
	1 MHz	31 μV/V		
	6V			
	10 Hz	12 μV/V		
	20 Hz	7 μV/V		
	40 Hz	7 μV/V		
	100 Hz	7 μV/V		
	1 kHz	8 μV/V		
	10 kHz	8 μV/V		
	20 kHz	8 μV/V		
	50 kHz	8 μV/V		
	100 kHz	9 μV/V		
	300 kHz	11 μV/V		
	500 kHz	16 μV/V		
	800 kHz	19 μV/V		
1 MHz	25 μV/V			



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
AC Voltage – Measure, Source <sup>1</sup>	10V		Fluke 792A AC/DC Thermal Transfer Standard	
	10 Hz	16 $\mu$ V/V		
	20 Hz	9 $\mu$ V/V		
	40 Hz	8 $\mu$ V/V		
	100 Hz	8 $\mu$ V/V		
	1 kHz	9 $\mu$ V/V		
	10 kHz	9 $\mu$ V/V		
	20 kHz	10 $\mu$ V/V		
	50 kHz	11 $\mu$ V/V		
	100 kHz	11 $\mu$ V/V		
	300 kHz	12 $\mu$ V/V		
	500 kHz	18 $\mu$ V/V		
	800 kHz	20 $\mu$ V/V		
	1 MHz	26 $\mu$ V/V		
	20V			
	10 Hz	13 $\mu$ V/V		
	20 Hz	8 $\mu$ V/V		
	40 Hz	7 $\mu$ V/V		
	100 Hz	7 $\mu$ V/V		
	1 kHz	8 $\mu$ V/V		
	10 kHz	8 $\mu$ V/V		
	20 kHz	9 $\mu$ V/V		
	50 kHz	10 $\mu$ V/V		
	100 kHz	10 $\mu$ V/V		
	300 kHz	11 $\mu$ V/V		
	500 kHz	15 $\mu$ V/V		
	800 kHz	19 $\mu$ V/V		
	1 MHz	25 $\mu$ V/V		
	60V			
	10 Hz	14 $\mu$ V/V		
	20 Hz	10 $\mu$ V/V		
	40 Hz	9 $\mu$ V/V		
	100 Hz	9 $\mu$ V/V		
	1 kHz	9 $\mu$ V/V		
	10 kHz	9 $\mu$ V/V		
	20 kHz	10 $\mu$ V/V		
50 kHz	11 $\mu$ V/V			
100 kHz	14 $\mu$ V/V			
300 kHz	19 $\mu$ V/V			





Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure, Source <sup>1</sup>	200V 10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	23 $\mu$ V/V 13 $\mu$ V/V 11 $\mu$ V/V 10 $\mu$ V/V 10 $\mu$ V/V 11 $\mu$ V/V 10 $\mu$ V/V 10 $\mu$ V/V 13 $\mu$ V/V 15 $\mu$ V/V	Fluke 792A AC/DC Thermal Transfer Standard
	600V 10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	21 $\mu$ V/V 12 $\mu$ V/V 12 $\mu$ V/V 10 $\mu$ V/V 10 $\mu$ V/V 10 $\mu$ V/V 10 $\mu$ V/V 11 $\mu$ V/V 15 $\mu$ V/V	
AC Voltage – Measure, Source <sup>1</sup>	1 000V 10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	17 $\mu$ V/V 12 $\mu$ V/V 11 $\mu$ V/V 11 $\mu$ V/V 12 $\mu$ V/V 12 $\mu$ V/V 12 $\mu$ V/V 12 $\mu$ V/V 13 $\mu$ V/V 24 $\mu$ V/V	PTB Voltage Divider, Agilent 3458A Multimeter
	(2 to 80) kV 10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz  60 Hz	17 $\mu$ V/V 12 $\mu$ V/V 11 $\mu$ V/V 11 $\mu$ V/V 12 $\mu$ V/V 12 $\mu$ V/V 16 $\mu$ V/V 18 $\mu$ V/V 28 $\mu$ V/V  1.8 mV/V	





Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure, Source <sup>1</sup>	10 mA		Holt HCS-1 AC Shunts, Fluke 5720A Multi Product Calibrator / 5725A Amplifier, HP 3458A DMM, Wavetek 4920 Voltmeter Standard, Fluke 792A Thermal Transfer Standard
	20 Hz	31 $\mu$ A/A	
	400 Hz	18 $\mu$ A/A	
	1 kHz	18 $\mu$ A/A	
	5 kHz	18 $\mu$ A/A	
	20 kHz	18 $\mu$ A/A	
	50 kHz	29 $\mu$ A/A	
	20 mA		
	20 Hz	31 $\mu$ A/A	
	400 Hz	18 $\mu$ A/A	
	1 kHz	18 $\mu$ A/A	
	5 kHz	18 $\mu$ A/A	
	50 mA		
	20 Hz	31 $\mu$ A/A	
	400 Hz	18 $\mu$ A/A	
	1 kHz	18 $\mu$ A/A	
	5 kHz	18 $\mu$ A/A	
	100 mA		
	20 Hz	32 $\mu$ A/A	
	400 Hz	21 $\mu$ A/A	
	1 kHz	21 $\mu$ A/A	
	5 kHz	21 $\mu$ A/A	
	20 kHz	21 $\mu$ A/A	
	50 kHz	41 $\mu$ A/A	
	200 mA		
	20 Hz	34 $\mu$ A/A	
	400 Hz	22 $\mu$ A/A	
	1 kHz	22 $\mu$ A/A	
5 kHz	22 $\mu$ A/A		
500 mA			
20 Hz	36 $\mu$ A/A		
400 Hz	23 $\mu$ A/A		
1 kHz	23 $\mu$ A/A		
5 kHz	23 $\mu$ A/A		
1A			
20 Hz	38 $\mu$ A/A		
400 Hz	25 $\mu$ A/A		
1 kHz	25 $\mu$ A/A		
5 kHz	25 $\mu$ A/A		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure, Source <sup>1</sup>	2A		Holt HCS-1 AC Shunts, Fluke 5720A Multi Product Calibrator / 5725A Amplifier, HP 3458A DMM, Wavetek 4920 Voltmeter Standard, Fluke 792A Thermal Transfer Standard
	20 kHz	25 μA/A	
	50 kHz	55 μA/A	
	20 Hz	42 μA/A	
	400 Hz	27 μA/A	
	1 kHz	27 μA/A	
	5 kHz	27 μA/A	
	5A		
	20 Hz	54 μA/A	
	400 Hz	34 μA/A	
	1 kHz	34 μA/A	
	5 kHz	34 μA/A	
	10A		
	20 Hz	67 μA/A	
	400 Hz	41 μA/A	
	1 kHz	41 μA/A	
	5 kHz	41 μA/A	
	20 kHz	41 μA/A	
	20A		
	20 Hz	94 μA/A	
400 Hz	58 μA/A		
1 kHz	58 μA/A		
5 kHz	58 μA/A		
20 kHz	58 μA/A		
Ratio Transformer	400 & 1 000 Hz	0.000 051 % of Input	Gertsch 1011 Ratio Standard
Phase Angle – Source	(0 to 360) °		Clark-Hess 5500-2 Phase Standard
	@ 5V Equal Input		
	1 Hz to 6.25 kHz	0.006 °	
	(6.25 to 50) kHz	0.012 °	
	(50 to 200) kHz	0.047 °	
	(0 to 360) °		
	@50 mV to 100V		
	1 Hz to 1kHz	0.006 °	
	(1 to 6.25) kHz	0.012 °	
	(6.25 to 50) kHz	0.018 °	
	(50 to 200) kHz	0.047 °	
	(0 to 360) °		
@100V to 120V			
1 Hz to 1kHz	0.012 °		
(1 to 6.25) kHz	0.023 °		
(6.25 to 50) kHz	0.035 °		
(50 to 200) kHz	0.093 °		



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Angle – Measure @10 mV to 350V	(0 to 360) °		Clark-Hess 6000A Phase Meter
	(5 to 10) Hz	0.23 °	
	10 Hz to 50 kHz	0.06 °	
	(50 to 57) kHz	0.12 °	
	(57 to 66) kHz	0.13 °	
	(66 to 75) kHz	0.14 °	
	(75 to 83) kHz	0.15 °	
	(83 to 92) kHz	0.16 °	
	(92 to 100) kHz	0.17 °	
	101 kHz	0.57 °	
	110 kHz	0.62 °	
	115 kHz	0.64 °	
	120 kHz	0.67 °	
	125 kHz	0.69 °	
	130 kHz	0.72 °	
	135 kHz	0.74 °	
	140 kHz	0.77 °	
	145 kHz	0.79 °	
150 kHz	0.82 °		
200 kHz	1.1 °		
250 kHz	1.4 °		
300 kHz	1.6 °		
350 kHz	1.9 °		
400 kHz	2.1 °		
450 kHz	2.4 °		
500 kHz	2.6 °		
<b>Oscilloscopes<sup>1</sup></b> Rise/ Fall Time	< 100 ps	1.6 ps	Wavetek 9550 pulse head
<b>Oscilloscopes<sup>1</sup></b> Square Wave 50 Ω or 1 MΩ load impedance – < 10 kHz	40 μV p-p to 1 mV p-p 1 mV p-p to 5 V p-p	2.5 % of reading 0.13 % of reading	Wavetek 9500B-3200 Oscilloscope Calibrator
Horizontal/Cursor Accuracy	180.19 ps to 55.00 s	0.4 parts in 10 <sup>6</sup> s	
<b>Oscilloscopes<sup>1</sup></b> Vertical/Cursor Accuracy	± (1 mV to 200 V)	0.05 % of reading	Wavetek 9500B-3200 Oscilloscope Calibrator, Agilent/HP 3458A Multimeter



Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes <sup>1</sup> Bandwidth	100 mHz to 300 MHz (300 to 500) MHz 550 MHz to 3 GHz (3 to 6) GHz (6 to 26.5) GHz (26.5 to 50) GHz (50 to 75) GHz (75 to 110) GHz	2.4 % of reading 3 % of reading 4.1 % of reading 5.8 % of reading 4.2 % of reading 7 % of reading 7.7 % of reading 7.7 % of reading	Wavetek 9500B-3200 Oscilloscope Calibrator, Wavetek 9560 Test Head Agilent/HP 8485A, 8487A, V8486A, W8486A Power Sensors

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Probe - Transfer Impedance	(-100 to +20) dB 10 Hz to 200 MHz	1.4 dB	HP 3577A Network Analyzer AH System CPF-530 Current Probe
Antenna Gain	(5 to 25) dB		Agilent 8510C Network Analyzer, 8530A Receiver, 8517B S-Parameter Test Set, V85104A, W85104A Modules
On Axis Gain, Antenna factor	(0.2 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz (140 to 220) GHz	0.15 dB 0.2 dB 0.2 dB 0.25 dB 0.3 dB 0.5 dB	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
Dish Antenna	(5 to 45) dB (12.4 to 110) GHz	0.31 dB	Hughes 45826H-1020 TRG/Custom Microwave Wr-5 Gain Horns, X, Ku, K, Ka, Q, V, W Probes Leica LT300 Laser Tracker



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Directional/ SWR Bridge <sup>1</sup> Reflections/ Directivity	(0 to 60) dB 5 Hz to 110 GHz	0.03 $\Gamma$ 1 dB	Agilent/HP 8757D Network Analyzer, 355C/D Step Attenuators, 85054B Calibration Kit, 8481D Opt H70, 8487A, VA8486A, W8486 Power Sensors, E8361C Network Analyzer, V85104A, W85104A Modules
Insertion Loss/Linearity	(0 to 60) dB 5 Hz to 67 GHz (67 to 110) GHz	0.1 dB 0.1 dB	
Directional Coupler <sup>1</sup> Main Line Loss	5 Hz to 67 GHz (67 to 110) GHz	0.1 dB 0.2 dB	Agilent/HP E8361A Network Analyzer, 8510C Network Analyzer, 8517B S-Parameter Test Set V85104A, W85104A Modules, E8361C Network Analyzer, 85054B Calibration Kit, TRL Calibration Kit
Coupling Loss	5 Hz to 67 GHz (67 to 110) GHz	0.1 dB 0.2 dB	
Reflection Directivity	5 Hz to 110 GHz 5 Hz to 110 GHz	0.03 $\Gamma$ 1 dB	
Gaussian Noise <sup>1</sup> Noise Output Power	(-100 to +20) dBm 100 kHz to 18 GHz (18 to 40) GHz	0.05 dB 0.11 dB	Agilent/HP 8482A/D, 8481A/D, 8485A/D, 8487 A/D Power Sensors Agilent/HP 8565E Spectrum Analyzer
Signal Path Response	(-60 to +20) dB 9 kHz to 3 GHz (3 to 22) GHz (22 to 50) GHz	1 dB 2.6 dB 3.5 dB	
Gaussian Noise Attenuation	(0 to 10) dB (10 to 30) dB (40 to 50) dB	0.1 dB 0.2 dB 0.3 dB	Agilent E4448A Spectrum Analyzer
Function/Pulse Generator <sup>1</sup> Frequency Accuracy Frequency Stability	1.0 $\mu$ Hz to 1 GHz 10 MHz	$5 \times 10^{-8}$ Hz $5 \times 10^{-8}$ Hz	Agilent/HP 53132A Counter Datum 4310 Frequency Standard
Function/Pulse Generator <sup>1</sup> AC Output Amplitude	1 mV to 50 V (p-p)	0.11 mV/V	Agilent/HP 3458A Multimeter, 8902 Measuring Receiver
Function/Pulse Generator <sup>1</sup> Output Flatness	DC to 100 MHz 100 MHz to 1 GHz	0.3 % of reading 0.5 % of reading	Ballantine 1395B-1/M75 Thermal Voltage Converter



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Function/Pulse Generator <sup>1</sup> DC Offset	(-20 to 20) VDC	Greater of (24 μV/V or 24μV)	Agilent/HP 8482A Power Sensor Agilent 11050A Converter
Function/Pulse Generator <sup>1</sup> Harmonic Content Harmonic Distortion Non Harmonic THD	(-30 to +15) dB 9 kHz to 1 GHz 9 kHz to 1 GHz 5 Hz to 600 kHz	1.5 dB 1.5 dB 0.6 dB	Agilent/HP 3458A Multimeter
Function/Pulse Generator <sup>1</sup> Rise-Fall Time (10 to 90) %	(10 to 1 000) ps	9.3 ps	Agilent/HP 8563E Spectrum Analyzer, 8903A Audio Analyzer, 334A, 339A Distortion Analyzers E4448A Spectrum Analyzer
Function/Pulse Generator <sup>1</sup> Pulse Width/Symmetry	1 ns to 5 s	1 ns	Agilent 86100C Mainframe, 83484A Module
Function/Pulse Generator <sup>1</sup> Phase Offset  AM Modulation DC to 100 kHz	(0 to 180) °  (0 to 90) % Depth	1.7 °  2.5 % Depth	Agilent 53132A/5335A Counters Agilent/HP 5335A Counter, 8903B Audio Analyzer Agilent/HP 8902 Measuring Receiver, E4448A Spectrum Analyzer





Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Generators – Signal <sup>1</sup>	100 kHz to 50 GHz		Agilent/HP 8902A Measuring Receiver with Agilent/HP 11793A Microwave Converter or 11970 series Harmonic Mixer, Agilent N5531S Measuring Receiver
Attenuation	(0 to 10) dB	0.015 dB	
	(0 to 20) dB	0.015 dB	
	(0 to 30) dB	0.015 dB	
	(0 to 40) dB	0.015 dB	
	(0 to 50) dB	0.015 dB	
	(0 to 60) dB	0.015 dB	
	(0 to 70) dB	0.015 dB	
	(0 to 80) dB	0.015 dB	
	(0 to 90) dB	0.015 dB	
	(0 to 100) dB	0.02 dB	
(0 to 110) dB	0.06 dB		
(0 to 120) dB	0.19 dB		
Phase Modulation	0.1 kHz to 50 GHz	1.2 % of reading	
Residual PM	100 kHz to 6.6 GHz	0.002 Rad	
	(6.6 to 13.2) GHz	0.003 9 Rad	
	(13.2 to 31.5) GHz	0.007 7 Rad	
	(31.5 to 50) GHz	0.015 Rad	
FM Deviation	100 kHz to 50 GHz	1.2 % Deviation	
Generators – Signal <sup>1</sup> Residual FM	100 kHz to 6.6 GHz (6.6 to 13.2) GHz (13.2 to 31) GHz (31 to 50) GHz	1.7 Hz rms 3.5 Hz rms 7 Hz rms 14 Hz	Agilent/HP 8902, N5531S Measuring Receivers
Generators – Signal <sup>1</sup> AM Depth	(0.15 to 10) MHz 10 MHz to 3 GHz (3 to 26.5) GHz (26.5 to 31) GHz (31 to 50) GHz	0.9 % Depth 0.6 % Depth 1.8 % Depth 2.2 % Depth 7 % Depth	HP 8902, Agilent 5531S Measuring Receivers
Generators – Signal <sup>1</sup> Residual AM	150 kHz to 50 GHz	0.03 % Depth	HP 8902, Agilent N5531S Measuring Receivers
Generators – Signal <sup>1</sup> Pulse Modulation On Off Ratio Rise Fall Time Pulse Width	(-80 to 0) dB 100 kHz to 67 GHz (10 to 90) % 50 ps to 1 s	0.6 dB 10 ps 10 ps	Agilent E4448A Spectrum Analyzer, Agilent 86100C Mainframe, Agilent 83484A Module



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Generators – Signal <sup>1</sup> Digital Modulation Magnitude EVM For: MSK GMSK, BPSK DQPSK, n/4DQPSK 8 PSK, 16 QAM QPSK, OQPSK	Frequency Span < 100 kHz ≤ 1 MHz > 1 MHz	0.6 % rms 0.7 % rms 1.3 % rms	Agilent/HP 89441A Vector Signal Analyzer
Generators – Signal <sup>1</sup> Phase Phase Error for: MSK GMSK, BPSK, DQPSK, n/4DQPSK, 8 PSK, 16 QAM & 32 QAM QPSK, OQPSK	Frequency Span <100 kHz ≤1 MHz >1 MHz	0.6° rms 0.7° rms 0.7° rms	Agilent/HP 89441A Vector Signal Analyzer
Generators – Signal <sup>1</sup> Digital Modulation – Measure EVM for FSK	Symbol Rate 3.2 kHz 1.152 MHz	1.1 % rms 1.8 % rms	Agilent/HP 89441A Vector Signal Analyzer
Generators – Signal <sup>1</sup> Harmonic Content Harmonics Non-Harmonics Sub Harmonics	(-60 to +15) dB 3 Hz to 3 GHz (3 to 6.6) GHz (6.6 to 22) GHz (22 to 26.8) GHz (26.4 to 31.15) GHz (31.15 to 50) GHz (50 to 75) GHz (75 to 110) GHz	1.1 dB 2 dB 2.5 dB 3.1 dB 2.2 dB 3.1 dB 4.5 dB 4.5 dB	Agilent/HP 8565E Spectrum Analyzer, Agilent/HP 11970 series Harmonic Converter, Oleson Microwave Harmonic Mixer
Generators – Signal <sup>1</sup> Phase Noise	(-140 to -70) dBc/Hz 1 kHz to 1 MHz offset	2.4 dB	Agilent/HP E5052 Signal Analyzer, 3048A Phase Noise System, Symmetricon 5120A Phase Noise Test Set
Generators – Signal <sup>1</sup> Total Harmonic Distortion	(40 to 90) dB 5 Hz to 100 kHz (100 to 600) kHz	1.2 dB 2 dB	Agilent/HP 334A, HP 339A Distortion Analyzers, HP 8903A Audio Analyzer, E4448A Spectrum Analyzer



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Generators – Signal <sup>1</sup> Frequency/Response Power Accuracy	(-120 to +13) dB (0.001 to 18) GHz (18 to 33) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	0.1 dB 0.1 dB 0.1 dB 0.12 dB 0.14 dB	Agilent/HP 8482A, 8481A, 8485A, 8487A, V8486A, W8486A, E4413A, N8487A, E9304A Power Sensors
Generators – Signal <sup>1</sup> Time Base Aging	(5 to 10) MHz	2.5 x 10 <sup>-10</sup> Hz	Agilent 53132A Counter, NIST FMAS
Harmonic Mixer Conversion Loss	(0 to 50) dB (18 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	1.8 dB 1.8 dB 1.8 dB 1.8 dB 1.8 dB	Agilent/HP 8563E Spectrum Analyzer, 8485A, 8487A, V8486A, W8486A Power Sensors Hughes/HP/Millitech Thermistor mounts
Noise Figure Meter/Analyzer <sup>1</sup> Noise Figure Ranging	(0 to 30) dB	0.06 dB	Agilent/HP 346A/B/C, 346C Opt K01, Agilent/HP 346A/B/C, 346C Opt K01 Noise Sources,
Noise Figure Gain Ranging	(-20 to +40) dB	0.07 dB	Avantek Amplifier, NIST FMAS, NIST TMAS, Agilent 83650B Signal Generator,
Time Base	(1, 5, 10) MHz	2.5 x 10 <sup>-10</sup> Hz	NIST FMAS, NIST TMAS, Agilent 83650B Signal Generator,
Frequency Accuracy	10 MHz to 110 GHz	1.5 x 10 <sup>-6</sup> Hz	NIST FMAS, NIST TMAS, Agilent 83650B Signal Generator,
Noise Figure	(0 to 30) dB 10 MHz to 110 GHz	0.12 dB	Agilent/HP 346A/B/C, 346C Opt K01, C.P. Clare TN-172, C.P. Clare TN- 164, C.P. Clare TN-165 Noise Sources
Reflection Coefficient	10 MHz to 110 GHz	± 0.04 Γ	Agilent/HP 8753ES, 8510C Network Analyzer, 8517B S-Parameter Test Set, V85104A, W85104A Modules



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Network Analyzer <sup>1</sup> (Scalar/Vector) Time Base Accuracy Source Absolute Accuracy Source Linearity/Dynamic Accuracy	(1, 5, 10) MHz (-140 to +30) dBm 5 Hz to 110 GHz (-140 to +30) dB 5 Hz to 110 GHz	1 x 10 <sup>-8</sup> Hz 0.04 dB 0.03 dB	Agilent/HP 5370A Counter, 3458A Multimeter, 8482A, 8485A, 8487A, V8487A, W8487, E4413A, N8487A, E9304A Power Sensors
Network Analyzer <sup>1</sup> Source Harmonic Content	(-140 to -80) dB 5 Hz to 3 GHz (3 to 6.6) GHz (6.6 to 22) GHz (22 to 26.8) GHz (26.8 to 31.15) GHz (31.15 to 50) GHz (50 to 75) GHz (75 to 110) GHz	1.1 dB 2 dB 2.5 dB 3.1 dB 2.2 dB 3.1 dB 4.5 dB 4.5 dB	HP 8565E Spectrum Analyzer, Agilent E4448A Spectrum Analyzer, Agilent 11970 Series Harmonic Mixer
Network Analyzer <sup>1</sup> Receiver Absolute Accuracy Receiver Dynamic Accuracy & Linearity	(-140 to +30) dBm 5 Hz to 110 GHz (-140 to +30) dBm 5 Hz to 110 GHz	0.04 dB 0.04 dB	Agilent/HP 8482A, 8487A, V8486A Power Sensors, 3458A Multimeter, W8486 Power Sensor, E4419B Power Meter Agilent/HP 355C/D Step Attenuators
Network Analyzer <sup>1</sup> Corrected Performance Transmission Tracking Reflection Tracking Directivity	(-140 to +30) dB 5 Hz to 110 GHz	0.05 dB 0.02 dB 1.5 dB	Agilent/HP 85052D, 85051A, 85056A, PSNA TRL, 85058V, 85059A Calibration Kits
Phase Noise <sup>1</sup> Measure	(-120 to -20) dBc/Hz 1 MHz to 18 GHz	1.5 dBc 1 Hz to 100 kHz Offset	HP 3048A Phase Noise System with 8662A Signal Generator and 11729C Carrier Noise Test Set, Symmetricom 5120A Opt 1 Phase Noise Test Set



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise <sup>1</sup> Measure	(-140 to -80) dBc/Hz 10 MHz to 26.5 GHz	2.4 dBc 1 kHz to 1 MHz Offset	Agilent E5052A Signal Analyzer /E5053A Converter Signal Source Analyzer
Phase Noise <sup>1</sup> Source	(-150 to -90) dBc/Hz 10 MHz	2.5 dBc 1 Hz to 100 kHz Offset	Datum 8040A Oscillator
Power Divider/Splitter <sup>1</sup> Insertion Loss	(0 to 60) dB 5 Hz to 67 GHz (67 to 110) GHz	0.08 dB 0.2 dB	Agilent/HP E8361A Network Analyzer, 8510C Network Analyzer, 8517B S-Parameter Test Set, 85052C, V85104A, W85104A Modules, 85056A, TRL Calibration Kit
Insertion Phase	(-180 to +180) □ 5 Hz to 67 GHz (67 to 110) GHz	0.6 ° 5 °	
Reflection Coefficient	5 Hz to 67 GHz (67 to 110) GHz	0.03 Γ 0.03 Γ	
Insertion Loss Tracking	(0 to 60) dB 5 Hz to 67 GHz (67 to 110) GHz	0.1 dB 0.3 dB	
Phase Tracking	(-180 to +180) □ 5 Hz to 110 GHz (67 to 110) GHz	0.8 ° 6.5 °	
Power Meters <sup>1</sup> Range	(20 to -35) dBm (-35 to -60) dBm	0.07 dB 0.11 dB	Boonton 2520 RF Calibrator, Agilent/HP 11683A Range Calibrator
Power Meters <sup>1</sup> Reference Source	1 000 mW @ 50 MHz	0.35 % of reading	PSNA Reference Source
Power Meters Reference Source Linearity	(20 to -30) dBm (-30 to -60) dBm	0.01 dB 0.03 dB	Agilent/HP 8902 Measuring Receiver, N5531S, 355C/D Step Attenuators
RF Power – Absolute <sup>1</sup> Type N	(0.1 to 100) MHz (0.1 to 14) GHz (14 to 18 GHz)	0.31 % of reading 0.43 % of reading 0.51 % of reading	Rohde & Schwarz NR VS/NrV-5, NIST CN Mount
RF Power – Absolute <sup>1</sup> 3.5 mm	(0.5 to 18) GHz (18 to 26.5) GHz (26.5 to 33) GHz	0.4 % of reading 1.2 % of reading 2.2 % of reading	Hughes/Agilent/HP Thermistor Mounts with Cx Adapter





Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Absolute <sup>1</sup> 2.92 mm	(0.05 to 1) GHz (1 to 10) GHz (10 to 20) GHz (20 to 25) GHz (25 to 40) GHz	0.43 % of reading 1.1 % of reading 1.6 % of reading 1.7 % of reading 2.2 % of reading	Agilent/HP 8487A Power Sensors with K Cx Adapter
RF Power – Absolute <sup>1</sup> 2.4 mm	(0.05 to 0.5) GHz (1 to 8) GHz (8 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (40 to 50) GHz	0.43 % of reading 1.3 % of reading 1.6 % of reading 1.7 % of reading 1.9 % of reading 2.2 % of reading	Hughes/Agilent/HP Thermistor Mounts with Cx Adapter, Agilent 8487A, 8487D, 8482A Power Sensors
RF Power – Absolute <sup>1</sup> WR-42 WR-28 WR-22 WR-15 WR-10	(-30 to +20) dBm (10 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	0.047 dB 0.047 dB 0.064 dB 0.086 dB 0.11 dB	Hughes/Millitech/Agilent/HP Thermistor Mounts, V8486A, W8486A, E4419B Power Meter
Scalar Detector <sup>1</sup> Reflections	10 MHz to 26.5 GHz (26.5 to 110) GHz	0.03 $\Gamma$ 0.05 $\Gamma$	Hughes/Agilent/HP Thermistor Mounts with Cx Adapter, Agilent/HP 8487A, V8486A, W8486A, E4418B, 8510
Frequency Response	(0 to 60) dB 10 MHz to 40 GHz (40 to 75) GHz (75 to 110) GHz	0.15 dB 0.3 dB 0.3 dB	
Amplitude Accuracy	(-50 to +10) dB 10 MHz to 40 GHz (40 to 75) GHz (75 to 110) GHz	0.1 dB 0.2 dB 0.2 dB	
Dynamic Accuracy	(20 to 10) dBm 0 dBm (-10 to -55) dBm	0.11 dB 0.1 dB 0.25 dB	
Power Sensor Characterization <sup>1</sup> (50 $\Omega$ ) Coaxial	(9 to 100) kHz (100 to 300) kHz 300 kHz to 10 GHz 10 GHz to 18 GHz 19 GHz to 26 GHz 26.5 GHz 26.5 GHz to 40 GHz 40 GHz to 50 GHz 50 GHz to 56 GHz 56 GHz to 65 GHz	0.6 % of reading 0.4 % of reading 0.4 % of reading 0.6 % of reading 1.4 % of reading 1.3 % of reading 1.5 % of reading 2 % of reading 2.5 % of reading 2.7 % of reading	Coaxial Thermistor/ Thermocouple



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Sensor Characterization <sup>1</sup> Waveguide S Band G Band H Band X Band Ku band K Band Ka Band Q Band	(2.6 to 3.95) GHz (3.95 to 5.85) GHz (7.05 to 10) GHz (8.2 to 12.4) GHz (12.4 to 18) GHz (18 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz	1.2 % of reading 1.2 % of reading 1.2 % of reading 1.3 % of reading 1.3 % of reading 1.4 % of reading 1.4 % of reading 2 % of reading	Waveguide Thermistor/ Thermocouple or Diode Power Sensors
Power Sensor Characterization <sup>1</sup> V Band	(50 to 52) GHz (52 to 56) GHz (56 to 64) GHz (65 to 75) GHz	2.5 % of reading 2.4 % of reading 2.7 % of reading 2.4 % of reading	Waveguide Thermistor/ Thermocouple or Diode Power Sensors
Power Sensor Characterization <sup>1</sup> W Band	(75 to 76) GHz (76 to 77) GHz (77 to 80) GHz (80 to 81) GHz (81 to 110) GHz	4 % of reading 3.6 % of reading 3.3 % of reading 4.6 % of reading 3.2 % of reading	Waveguide Thermistor/ Thermocouple or Diode Power Sensors
Power Sensor Characterization <sup>1</sup> (75 Ω)	100 kHz to 2 GHz (2 to 4.2) GHz	1.3 % of reading 1.5 % of reading	Tegam F1119, Tegam 1804 Power Standards, NIST CN Mount, Agilent 11852B
Spectrum Analyzers <sup>1</sup> Residual Response Display Avg Noise Time Base Accuracy Spurious Response	(-100 to +30) dBm 9 kHz to 50 GHz (-15 to 0) dBm 9 kHz to 50 GHz 10 MHz (-15 to 0) dB 9 kHz to 50 GHz	0.5 dB 1.3 dB 1 x 10 <sup>-8</sup> Hz 1 dB	Agilent/HP 53132A Counter, 8565E Spectrum Analyzer, 83650 Signal Generator, Datum 4310A Frequency Standard, Agilent 53131A Counter





Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Spectrum Analyzers <sup>1</sup> Third Order Intermodulation Distortion	(-82 to 0) dB 100 kHz to 5 GHz	1 dB	Agilent/HP 83650 Signal Generator, 3335A, 355C/D Step Attenuators, 438A, 8482A, 8485A, 8487A Power Sensors, 5335A, 53132A Counter, 8665B, Agilent E8752D Signal Generators
Second Harmonic Distortion	(-79 to 0) dB 100 kHz to 5 GHz	0.5 dB	
Resolution Bandwidth	(0 to 88) dB	0.05 dB	
Display Scale Fidelity (50 Ω ref to 100 kHz)	(0 to 18) dB	0.07 dB	
(75 Ω ref to 100 kHz)	(20 to 58) dB (60 to 98) dB	0.12 dB 0.24 dB	
Spectrum Analyzers Amplitude Accuracy and Frequency Response <sup>1</sup>	(-100 to +30) dB		Agilent/HP 83650 Signal Generator, 3335A, 355C/D Step Attenuators, 438A, 8482A, 8485A, 8487A Power Sensors, 5335A, 53132A Counter, 8665B, E8257D Signal Generators
50 Ω	1 MHz to 200 Hz	0.12 dB	
	200 Hz to 100 kHz	0.08 dB	
	100 kHz to 18 GHz	0.06 dB	
	(18 to 50) GHz	0.17 dB	
75 Ω	(50 to 75) GHz	0.2 dB	
	(75 to 110) GHz	0.25 dB	
	(-100 to +30) dB		
	200 Hz to 1 kHz	0.18 dB	
1 kHz to 25 MHz	1 kHz to 25 MHz	0.09 dB	
	(25 to 80) MHz	0.18 dB	
Spectrum Analyzers <sup>1</sup> Sweep Time	(-3 to +3) dB 100 kHz to 6 GHz	1 dB	Agilent/HP 83650 Signal Generator, 3335A, 355C/D Step Attenuators, 438A, 8482A, 8485A, 8487A Power Sensors, 5335A, 53132A Counter, 8665B, E8257D Signal Generators
Span	0.1 μs to 100 s	2.3 μs/s	
Input Attenuator	1 Hz to 2 GHz	4 μHz/Hz	
Noise Sidebands	(-117 to 0) dB 50 MHz	0.08 dB	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameters Reflection: S11 and S22 Reflection Coefficient <sup>1</sup> 0 to 1  Coaxial (50/75) Ω	(0.005 to 30) kHz	0.001 (lin) 0.1 °	Agilent/HP3577A Network Analyzer, 87512A Transmission/Reflection Test Set, 8753ES, 8510C Network Analyzers, 8517B S-Parameter Test Set, E8361A Network Analyzer, 85052C, 85054B, 85056A, 85036B, 85038B, 85039B, 85059A Calibration Kits Type N S-Parameter Ref Standards 7mm S-Parameter Standards 3.5mm S-Parameter Ref Standards 2.92mm S-Parameter Ref Standards 1.85mm S-Parameter Ref Standards
	(0.03 to 45) MHz	0.002 (lin) 0.1 °	
	(0.045 to 0.3) GHz	0.002 (lin) 0.1 °	
	(0.3 to 17) GHz	0.004 (lin) 0.2 °	
	(17 to 18) GHz	0.005 (lin) 0.3 °	
	(18 to 40) GHz	0.015 (lin) 0.8 °	
	(41 to 50) GHz	0.018 (lin) 1.1 °	
	(50 to 67) GHz	0.23 (lin) 1.3 °	
Scattering Parameters Waveguide Reflection: S11 and S22 Reflection Coefficient <sup>1</sup> (0 to 1)	(2.6 to 12.4) GHz	0.009 (lin) 0.5 °	Agilent/HP 8510C Network Analyzer, 8517B S-Parameter Test Set, E8361A Network Analyzer, V85104A, W85104A Modules. PSNA TRL Calibration Kit, Oleson V05 VNA1-T/R WR28 S-Parameter Ref Standards WR22 S-Parameter Ref Standards WR15 S-Parameter Ref Standards WR10 S-Parameter Ref Standards
	(12.4 to 26.5) GHz	0.01 (lin) 0.5 °	
	(26.5 to 50) GHz	0.006 (lin) 0.3 °	
	(50 to 75) GHz	0.018 (lin) 1.1 °	
	(75 to 110) GHz	0.024 (lin) 1.4 °	
	(140 to 220) GHz	0.048 (lin) 10 °	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameters Transmission: S <sub>21</sub> and S <sub>12</sub> <sup>1</sup> Coaxial – (50/75) Ω (0.005 to <30) kHz  (0.03 to 45) MHz  (0.045 to 67) GHz	(0 to 70) dB	0.01 dB 0.2 °	Agilent/HP 3577A Network Analyzer, 87512A, 8753ES, 8510C Network Analyzer, 8517B S-Parameter Test Set, 85052C, 85054B, 85056A, 85036B, 85038B, 85039B Calibration Kits, E8361A Network Analyzer, 85058E Type N S-Parameter Ref Standards 7mm S-Parameter Standards 3.5mm S-Parameter Ref Standards 2.92mm S-Parameter Ref Standards 1.85mm S-Parameter Ref Standards
	(0 to 70) dB	0.01 dB 0.02 °	
	(0 to 10) dB	0.01 dB 0.2 °	
	(10 to 20) dB	0.02 dB 0.2 °	
	(20 to 30) dB	0.03 dB 0.21 °	
	(30 to 50) dB	0.11 dB 0.57 °	
	(50 to 70) dB	0.2 dB 1.3 °	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameters Waveguide <sup>1</sup> (2.6 to 12.4) GHz	(0 to 30) dB	0.02 dB 0.6 °	Agilent/HP 8510C Network Analyzer, 8517B S-Parameter Test Set, E8361A Network Analyzer, V85104A, W85104A Modules, PSNA TRL Calibration Kit, Oleson V05 VNA1-T/R WR28 S-Parameter Ref Standards WR22 S-Parameter Ref Standards WR15 S-Parameter Ref Standards WR10 S-Parameter Ref Standards
	(30 to 50) dB	0.08 dB 0.7 °	
(12.4 to 18) GHz	(0 to 30) dB	0.02 dB 0.7 °	
	(30 to 50) dB	0.09 dB 0.7 °	
(18 to 26.5) GHz	(0 to 30) dB	0.05 dB 1.8 °	
	(30 to 50) dB	0.08 dB 1.8 °	
(26.5 to 40) GHz	(0 to 30) dB	0.03 dB 1.2 °	
	(30 to 50) dB	0.09 dB 1.4 °	
(40.0 to 50.0) GHz	(0 to 30) dB	0.03 dB 1.8 °	
	(30 to 50) dB	0.09 dB 2.1 °	
(50 to 75.0) GHz	(0 to 30) dB	0.05 dB 3.3 °	
	(30 to 50) dB	0.1 dB 3.4 °	
(75 to 110) GHz	(0 to 30) dB	0.06 dB 4.6 °	
	(30 to 50) dB	0.11 dB 5.4 °	
(140 to 220) GHz	(0 to 30) dB	0.7 dB 9.3 °	
	(30 to 40) dB	1 dB 14 °	



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameters – Electrical/Group Delay <sup>1</sup>	30 kHz to 45 MHz 45 MHz to 67 GHz (67 to 110) GHz	240 ps 78 ps 1 ns	Agilent/HP 8510C Network Analyzer, 8517B S-Parameter Test Set, 85104A, W85104A, 85052C, 85054B, 85056A, 8503B, 85038B, 85039B Calibration Kits, E8361A Network Analyzer, 85058E, PSNA TRL Calibration Kit, Oleson V05 VNA1-T/R
Tuned RF Level <sup>1</sup> 2 MHz to 110 GHz	(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	0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.01 dB 0.02 dB 0.07 dB	Agilent 355C/D Step Attenuator, Agilent/HP N5531S/E4448A Spectrum Analyzer, Agilent/HP 8902A Measuring Receiver with Agilent/HP 11793A Microwave Converter or 11970 series Harmonic Mixer or Oleson Microwave Lab Mixers
Watt Meters	450 kHz to 2.7 GHz	1.5 % of reading	Agilent/HP E4418A/B, 8482A Power Sensor, Amplifier Research DC3002, Agilent E9304A, E4412A
Thermal Noise <sup>1</sup> Coaxial (0.01 to 50) GHz	(5 to 40) dB ENR (0.1 to 1.0) GHz (1.0 to 11) GHz (11 to 18) GHz (18 to 26.5) GHz (26.5 to 35) GHz (35 to 50) GHz	0.08 dB 0.09 dB 0.13 dB 0.07 dB 0.15 dB 0.16 dB	Agilent 8970B, 8971B, N8975A, 6A, 346B, 346C Noise Sources, 8510C Network Analyzer, 8517B S-Parameter Test Set, Clare TN162 (WR-28), TN172 (WR-22) Noise Sources



Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thermal Noise <sup>1</sup> Waveguide (26.5 to 50) GHz	(5 to 30) dB ENR (26.5 to 27) GHz (27 to 31) GHz (31 to 39) GHz 40 GHz (40 to 50) GHz	0.07 dB 0.06 dB 0.08 dB 0.1 dB 0.13 dB	Agilent 8970B, 8971C, N8975A, 346C Noise Source, 8510C Network Analyzer, 8517B S-Parameter Test Set, Clare TN162 (WR-28), TN 172 (WR-22), TN164 (WR-15), TN165 (WR-10) Noise Sources
Thermal Noise <sup>1</sup> Waveguide (50 to 75) GHz	(5 to 30) dB ENR (50 to 54) GHz 55 GHz (55 to 63) GHz (63 to 65) GHz 66 GHz 67 GHz 68 GHz 69 GHz 70 GHz 71 GHz 72 GHz 73 GHz 74 GHz 75 GHz	0.15 dB 0.14 dB 0.16 dB 0.19 dB 0.21 dB 0.23 dB 0.25 dB 0.26 dB 0.28 dB 0.31 dB 0.33 dB 0.34 dB 0.34 dB 0.36 dB	Agilent 8970B, 8971C, N8975A, 346C Noise Sources, 8510C Network Analyzer, 8517B S-Parameter Test Set, Clare TN162 (WR-28), TN 172 (WR-22), TN164 (WR-15), TN165 (WR-10) Noise Sources
Thermal Noise <sup>1</sup> Waveguide (75 to 110) GHz	(3 to 30) dB ENR (75 to 77) GHz (77 to 80) GHz (80 to 89) GHz (89 to 94) GHz (94 to 100) GHz 101 GHz 102 GHz 103 GHz 104 GHz 105 GHz 106 GHz 107 GHz 108 GHz 109 GHz 110 GHz	0.3 dB 0.31 dB 0.44 dB 0.31 dB 0.43 dB 0.78 dB 0.77 dB 0.77 dB 0.76 dB 0.75 dB 0.94 dB 1.1 dB 1.3 dB 1.5 dB 1.7 dB	Agilent 8970B, N8975A, Clare TN164 (WR-15), TN 165 (WR-10) Noise Sources



**Length – Dimensional metrology**

<b>Parameter/Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Calipers	Up to 60 in	$(320 + 6L) \mu\text{in}$	Gage Blocks, Ring Gage
Connector Gage Masters	Up to 0.35 in Up to 0.50 $\mu\text{in}$	200 $\mu\text{in}$ 16 $\mu\text{in}$	Dial Indicator, Optical Flat
Cylindrical Plug Gages	Up to 2 in	$(26 + 6L) \mu\text{in}$	Gage Blocks
Cylindrical Ring Gages	Up to 4 in	$(6 + 12L) \mu\text{in}$	Gage Blocks, Internal Comparison
Dial/Digital Indicators	Up to 1 in (1 to 2) in (2 to 6) in	33 $\mu\text{in}$ 64 $\mu\text{in}$ 0.000 14 in	Gage Blocks
Electronic Gage Amplifiers	Up to 0.1 in	10 $\mu\text{in}$	Gage Blocks
Gage Blocks	(0.01 to 4) in (0.50 to 100.00) mm	$(2 + L) \mu\text{in}$ $(0.05 + 0.001 5L) \mu\text{m}$	Electromechanical Comparison
Height Gages	Up to 60 in	$(320 + 6L) \mu\text{in}$	Gage Blocks
Length – Non-Contact Measurement	Up to 12 in (12 to 60) in	$(10 + 10L) \mu\text{in}$ $(150 + 12L) \mu\text{in}$	Laser Interferometer
Micrometers – Outside	Up to 12 in	$(35 + 6L) \mu\text{in}$	Gage Blocks
Depth	Up to 12 in	$(40 + 6L) \mu\text{in}$	
Inside	Up to 12 in	$(25 + 6L) \mu\text{in}$	
Thread Measuring Wires	(4 to 80) TPI	15 $\mu\text{in}$	Mechanical Comparison
Torque Moment Arms and Wheels	Up to 30 in	$(150 + 50L) \mu\text{in}$	Gage Blocks, Electronic Amplifier
Alignment Collimator	2 ft to Infinity Focus	1.3 arc s	Optical Wedge
Autocollimators	Up to 1 000 arc s	0.3 % of reading + 0.4 arc s	Laser Interferometer
Angle Generator	Up to 1 000 arc s	0.3 % of reading + 0.4 arc s	Laser Interferometer
Angle Gage Blocks	1 arc s to 45 degrees	1 arc s	Angle Gage Blocks; Autocollimator
Levels	Up to 200 arc s Up to 1 000 arc s	0.8 arc s 2.9 arc s	Laser Interferometer



**Length – Dimensional metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Bars & Plates Angle Parallelism	Up to 45 degrees 0.10 in	2.3 arc s 33 μin	Angle Gage Blocks, Gaging Amplifier
Squares and Angle Plates	90 <sup>0</sup>	6.5 arc s	Cylindrical Square
Protractor	Up to 90 <sup>0</sup>	40 arc s	Sine Plate, Cylindrical Square
Optical Wedge	Up to 30 arc s	0.29 arc s	Laser Interferometer
Theodolite/Transmit/ Alignment Telescope Collimation	Infinity Focus	1.1 arc s	Alignment Collimator
Line of Sight	2 ft to Infinity focus	1.6 arc s	
Trunnion Axis	(60 to 135) <sup>0</sup>	1.2 arc s	
V-Blocks Parallelism	Up to 6 in	37 μin	Gaging Amplifier
Perpendicularity	Up to 6 in	6.5 arc s	Cylindrical Square
Surface Plate <sup>1</sup>	(60 x 96) in	12 √D μin	Electronic Level
Thread Plug Gages Pitch Diameter	Up to 1 in	60 μin	3 Wire Method
Major Diameter	Up to 1 in	50 μin	Gage Blocks
Thread Ring Gages Pitch Diameter	Up to 1 in	160 μin	Thread Setting Plug

**Mass**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gas Flow <sup>1</sup>	10 sccm to 30 slpm (30 to 100) slpm	0.5 % of reading 0.7 % of reading	Nitrogen, Air, Argon Mass Flow Standards
Helium Leak Rate	(10 <sup>-09</sup> to 10 <sup>-03</sup> ) sccs	10 % of reading	Standard Comparison



Mass

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Durometers Type A, B, C, D, DO, E, O, OO, OOO, OOO-S Spring Calibration Force	(0 to 100) durometer units	0.7 durometer units	Durocalibrator, balance
Durometers Extension Indenter Display	(0.096 to 0.200) in (0 to 100) durometer units	0.000 2 in 0.7 durometer units	Gage Blocks
Durometers Indenter Extension and Shape Diameter Radius Angle	(0.004 to 0.500) in (0.004 to 0.500) in (29 to 36) °	0.000 25 in 0.000 25 in 0.07 °	Optical Comparator
Force <sup>1</sup>	(0.000 44 to 500) lbf (500 to 1 000) lbf (1 000 to 2 000) lbf (2 000 to 5 000) lbf (5 000 to 10 000) lbf (10 000 to 25 000) lbf (25 000 to 50 000) lbf (50 000 to 100 000) lbf	0.045 % of reading 0.6 lbf 1 lbf 2.4 lbf 3.7 lbf 8.7 lbf 22 lbf 220 lbf	Dead Weight, Proving Ring, Load Cell
Mass	(1 to 500) mg 500 mg to 2 g (2 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g 500 g to 1 kg (1 to 2) kg (2 to 5) kg  (5 to 10) lb (10 to 20) lb (20 to 50) lb	0.012 mg 0.04 mg 0.043 mg 0.075 mg 0.12 mg 0.23 mg 0.46 mg 0.91 mg 2.3 mg 5.2 mg 26 mg 33 mg  0.000 063 lb 0.000 55 lb 0.000 59 lb	Class 1 Weights and Electronic Balances
Pressure <sup>1</sup>	(0.2 to 100) psia/psig (100 to 1 000) psia/psig	0.003 6 % of reading 0.004 % of reading	Ruska 2465 Deadweight Tester, Heise PTE-1 Calibrator
Pressure <sup>1</sup>	(1 000 to 15 000) psig	0.004 4 % of reading	Ruska 2475, 2485 Deadweight Testers Heise PTE-1 Calibrator



Mass

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales and Balances <sup>1</sup>	(5 to 500) mg (0.5 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g (500 to 1000) g (1 to 2) kg (2 to 5) kg (5 to 20) kg	0.012 mg 0.044 mg 0.064 mg 0.093 mg 0.14 mg 0.3 mg 0.59 mg 1.5 mg 3.2 mg 13 mg 19 mg 0.1 g	Class 1 Weights
	(50 to 2 000) lb (2 000 to 5 000) lb	0.025 % of reading 0.06 % of reading	Class F Weights
Vacuum Ionization Gages, Inverted Magnetron Gages, Cold Cathode Gages, Residual Drag Gages	2.0 x 10 <sup>-7</sup> torr 5.0 x 10 <sup>-7</sup> torr 9.0 x 10 <sup>-7</sup> torr	8.3 % of reading 5 % of reading 4.4 % of reading	Ionization Gage
	2.0 x 10 <sup>-6</sup> torr 5.0 x 10 <sup>-6</sup> torr 9.0 x 10 <sup>-6</sup> torr 2.0 x 10 <sup>-5</sup> torr 5.0 x 10 <sup>-5</sup> torr 9.0 x 10 <sup>-5</sup> torr 2.0 x 10 <sup>-4</sup> torr 5.0 x 10 <sup>-4</sup> torr 9.0 x 10 <sup>-4</sup> torr	6.3 % of reading 3.5 % of reading 2.8 % of reading 6.3 % of reading 3.4 % of reading 2.7 % of reading 6.3 % of reading 3.4 % of reading 2.7 % of reading	Spinning Rotor Gage
Thermocouple Vacuum Gage/Capacitance Manometer	(0.01 to 0.1) torr (0.1 to 10) torr (10 to 1 000) torr	0.6 % + 0.3 mtorr 0.6 % + 2 mtorr 0.006 6 % of reading	Capacitance Diaphragm Gage Ruska 2465 Deadweight Tester
Torque Transducers	10 ozf·in to 2 000 lbf·ft	0.03 % of reading	Standard Weights, Torque Moment Arms
Torque Wrench and Torque Screwdriver	20 ozf·in to 2 000 lbf·ft	0.7 % of reading	AKO TSD6000 Torque Tester



Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Fiber Optic Attenuation Single Mode 1 310, 1 550 nm	(0 to 60) dB	0.021 dB	EXFO 1502 Power Meter
Multi Mode 850, 1 300 nm	(0 to 60) dB	0.021 dB	
Fiber Optic Optical Time Domain Reflectometer Single Mode 1 310, 1 550 nm	2.3 km 13.1 km	1.8 m 3.0 m	NPL Optical Length Reference
Fiber Optic Optical Time Domain Reflectometer Multi Mode 850, 1300 nm	(1.1 + 4.5N) km	(2 + N) m	NPL Recirculating Loop Optical Length Reference
Fiber Optic Power Single Mode 1 310, 1 550 nm	(-60 to 5) dBm	0.047 dB	EXFO 1502 Power Meter
Multi Mode 850, 1 300 nm	(-60 to 5) dBm	0.047 dB	
Fiber Optic Wavelength Wavelength Meter	(1 528 to 1 563) nm	0.001 4 nm	NIST SRM 2519
Fiber Optic Wavelength Measure (Single Mode)	(700 to 1 700) nm	0.002 1 nm	Burleigh WA-1650 Wavelength Meter
Fiber Optic Wavelength Measure (Multi Mode)	(550 to 2 000) nm	2.9 nm	Newport 77250 Monochromator
Laser Energy	1.06 μm 100 μJ to 150 mJ	3.8 % of reading	Calorimeter
Laser Power	1.06 μm, 2W	1.7 % of reading	Calorimeter
Luminous Intensity	(20 to 500) fc	0.8 % of reading	NIST Luminous Intensity Lamp



Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Pyrometer	(800 to 849) °C	3.3 °C	NIST Tungsten Strip Lamp
	(850 to 949) °C	3 °C	
	(950 to 1 049) °C	2.6 °C	
	(1 050 to 1 149) °C	3.1 °C	
	(1 150 to 1 249) °C	2.4 °C	
	(1 250 to 1 349) °C	2.5 °C	
	(1 350 to 1 449) °C	2.8 °C	
	(1 450 to 1 549) °C	2.8 °C	
	(1 550 to 1 649) °C	3.1 °C	
	(1 650 to 1 749) °C	2.9 °C	
	(1 750 to 1 849) °C	3.1 °C	
	(1 850 to 1 949) °C	3.2 °C	
(1 950 to 2 049) °C	4.1 °C		
(2 050 to 2 149) °C	5 °C		
(2 150 to 2 249) °C	4.5 °C		
(2 250 to 2 300) °C	3.8 °C		
Dewpoint / Frostpoint Indicators	(-80 to 10) °C	0.35 °C	Thunder Scientific 3900 Low Humidity Generator
Infrared Thermometers	(-15 to 0) °C	1.3 °C	Infrared Calibrator
	(0 to 100) °C	1.2 °C	
	(100 to 200) °C	1.4 °C	
	(200 to 350) °C	1.9 °C	
	(350 to 500) °C	2.4 °C	
Relative Humidity <sup>1</sup>	(20 to 85) %RH	0.9 %RH	Thunder Scientific 2500ST Humidity Generator
Resistance Thermometry, Fixed Points	-195.5 °C	0.002 3 °C	DCC Resistance Bridge, Standard Resistors, NIST SPRT LN2 Comparator
	-38.8344 °C	0.001 4 °C	DCC Resistance Bridge, Standard Resistors, NIST SPRT, TP Mercury Cell
	0.0100 °C	0.000 4 °C	DCC Resistance Bridge, Standard Resistors, NIST SPRT, TPW Cell
	231.9280 °C	0.002 5 °C	DCC Resistance Bridge, Standard Resistors, NIST SPRT, FP Tin Cell
	419.527 °C	0.002 8 °C	DCC Resistance Bridge, Standard Resistors, NIST SPRT, FP Zinc Cell



**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature <sup>1</sup>	(-80 to 0) °C (1 to 125) °C (126 to 300) °C (301 to 660) °C (661 to 1 000) °C	0.005 °C 0.003 °C 0.005 °C 0.3 °C 0.3 °C	Super Thermometer, SPRT, TPW Cell, Oil Bath, LN <sub>2</sub> Nanovoltmeter, Type S Thermocouple, Furnace

**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Counters <sup>1</sup> Time Base Accuracy Time Base Aging  Sensitivity	(1, 5, 10) MHz (1, 5, 10) MHz  (0 to -20) dBm (<-20 to -30) dBm (<-30 to -40) dBm (<-40 to -50) dBm	5 x 10 <sup>-10</sup> Hz 5 x 10 <sup>-10</sup> Hz  0.1 dB 0.15 dB 0.2 dB 0.26 dB	NIST, FMAS, TMAS, Agilent/HP 5370A Counter, 33120A, 83650 Signal Generator, 3558A, 8482A, 8385A, 8485A, 8487A, V8486A, W8486A Power Sensors, Datum 4310A Frequency Standard, HP 8355A Spectrum Analyzer
Frequency Measure Frequency Offset Frequency Stability	(1, 5, 10) MHz (1, 5, 10) MHz	5.8 parts in 10 <sup>14</sup> Hz 5.8 parts in 10 <sup>14</sup> Hz	NIST TMAS System
Allan Variance	(1, 5, 10) MHz	7.8 x 10 <sup>-14</sup> Hz	HP 5370B Counter, Symmetricon 5120A Opt 001 Phase Noise Test Set
Stop Watches – Timers With Human Interaction	24 hrs	0.6 s/24 hours	HP 5326A Counter, NIST TMAS System Agilent 53131A Counter
Stop Watches – Timers Without Human Interaction	24 hrs	0.23 s/24 hours	

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 (*k*=2), corresponding to a confidence level of approximately 95%.

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. *L* = length in inches, *D* = diagonal length in inches.
3. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1498.01.

