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 Centers

22 Cotton Road, Suite 150

Nashua, NH 03063

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-1498.10
Certificate Number

ANAB Approval

Certificate Valid: 05/15/2018-11/16/2020
Version No. 004 Issued: 05/15/2018

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).

ANSI-ASQ National Accreditation Board

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

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CALIBRATION

Valid to: **November 16, 2020** Certificate Number: **AC-1498.10**

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source[1]	Up to 220 mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (0.22 to 1.1) kV	7 µV/V + 0.16 µV 5 µV/V + 0.15 µV 3 µV/V + 0.32 µV 4 µV/V + 5 µV 5 µV/V + 14 µV 7 µV/V + 41 µV	Fluke 5720A or 5730A Multifunction Calibrator with Fluke 5725A Amplifier
DC Voltage - Source Fixed Values[1]	100 mV 1 V 10 V 100 V 1 000 V	0.72 µV 2.9 µV 2.6 µV 0.5 mV 7.3 mV	Fluke 57x0A Multifunction Calibrator disciplined with Keysight 3458A/100 NPLC Option 002
DC Voltage - Measure[1]	Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (0.1 to 1) kV	5.6 µV/V + 1.5 µV 5.2 µV/V + 1.2 µV 4.7 µV/V + 2.5 µV 6.6 µV/V + 45 µV 19 µV/V + 0.16 mV	Keysight 3458A/100 NPLC Option 002 Multimeter
DC Voltage Transfer – Measure[1]	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	0.62 µV/V + 62 nV 0.37 µV/V + 124 nV 62 nV/V + 0.62 µV 0.62 µV/V + 12.4 µV 1.85 µV/V + 63 µV	Keysight 3458A Multimeter

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source[1]	0 to 220 µA 220 µA to 22 mA 22 to 100 mA 100 to 220 mA 220 mA to 1 A 1 A to 2.2 A	35 µA/A 29 µA/A 37 µA/A 50 µA/A - 1.2 µA 59 µA/A + 12 µA 120 µA/A – 42 µA	Fluke 5720A or 5730A Multifunction Calibrator
DC Current - Source[1]	2.2 to 11 A	280 µA/A + 41 µA	Fluke 5725A Amplifier
DC Current – Source[1]	100 µA 1 mA 10 mA 100 mA 1 A	1.9 nA 16 nA 0.16 µA 2.3 µA 49 µA	Fluke 57x0A Multifunction Calibrator disciplined with Keysight 3458A Multimeter
DC Current – Source[1]	(10 to 20) A (20 to 200) A (200 to 1 000) A	0.53 % of reading + 22 mA 0.54 % of reading + 0.15 A 0.54 % of reading + 0.52 A	Fluke 552xA Multifunction Calibrator with 50 turn coil
DC Current – Measure[1]	(0 to 100) nA (0.1 to 1) µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	42 µA/A + 50 pA 21 µA/A + 50 pA 25 µA/A + 0.11 nA 25 µA/A + 0.85 nA 22 µA/A + 6.4 nA 23 µA/A + 59 nA 41 µA/A + 0.6 µA 125 µA/A + 12 µA	Keysight 3458A Multimeter
DC Current – Measure[1]	(1 to 3) A	1.4 mA/A + 0.74 mA	Keysight 34401A Multimeter
DC Dissipated Power - 300 mA to Full Power[1]	Shunt 15 A 100 mΩ, 25 W	0.14 mΩ/Ω	Guildline 9230-15 Shunt
	Shunt 100A 10 mΩ, 100 W	0.14 mΩ/Ω	Guildline 9230-100 Shunt
	Shunt 300A 10 mΩ, 90 W	0.12 mΩ/Ω	Guildline 9230-300 Shunt
Resistance – Source[1]	(0 to 11) Ω (11 to 110) Ω (0.11 to 1.1) kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 110) kΩ (0.11 to 1.1) MΩ	33 µΩ/Ω + 8.3 mΩ 25 µΩ/Ω + 12.5 mΩ 23 µΩ/Ω + 17 mΩ 23 µΩ/Ω + 170 mΩ 23 µΩ/Ω + 84 mΩ 23 µΩ/Ω + 0.84 Ω 27 µΩ/Ω + 8 Ω	Fluke 552X A Multifunction Calibrator

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source[1]	(1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (330 to 1 100) MΩ	50 μΩ/Ω + 125 Ω 110 μΩ/Ω + 0.2 kΩ 210 μΩ/Ω + 2 kΩ 410 μΩ/Ω + 2.8 kΩ 2.5 mΩ/Ω + 83 kΩ 12.5 mΩ/Ω + 0.4 MΩ	Fluke 552X A Multifunction Calibrator
Resistance - Source[1] Fixed Points	0 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ	21 μΩ 89 μΩ 0.86 mΩ 7.5 mΩ 75 mΩ 0.75 Ω 8 Ω 0.15 kΩ 24 kΩ	Fluke 57X0A Multifunction Calibrator disciplined with Keysight 3458A Multimeter
Resistance - Source[1] Fixed Points	0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 k Ω 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	0.25 mΩ 0.27 mΩ 0.31 mΩ 0.34 mΩ 2.5 mΩ 2.7 mΩ 3.3 mΩ 9.3 mΩ 31 mΩ 93 mΩ 0.19 Ω 1.2 Ω 2.2 Ω 20 Ω 42 Ω 0.4 kΩ 1.5 kΩ 12 kΩ	Fluke 57X0A Multifunction Calibrator
Resistance – Measure[1]	(0 to 10) Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ	22 μΩ/Ω + 90 μΩ 19 μΩ/Ω + 0.88 mΩ 16 μΩ/Ω + 0.95 mΩ 16 μΩ/Ω + 9.5 mΩ 16 μΩ/Ω + 95 mΩ 22 μΩ/Ω + 3 Ω	Keysight 3458A Multimeter

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure[1]	(1 to 10) MΩ (10 to 100) MΩ (0.1 to 1) GΩ	65 μΩ/Ω + 132 Ω 624 μΩ/Ω + 4.5 kΩ 6.2 mΩ/Ω + 0.35 MΩ	Keysight 3458A Multimeter
AC Voltage – Source[1]	Up to 2.2 mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz 2.2 to 22 mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	 250 μV/V + 4.1 μV 94 μV/V + 4.1 μV 83 μV/V + 4.1 μV 210 μV/V + 4.1 μV 520 μV/V + 4.1 μV 1.1 mV/V + 4.1 μV 1.5 mV/V + 4.1 μV 2.8 mV/V + 4.1 μV 250 μV/V + 4.1 μV 94 μV/V + 4.1 μV 83 μV/V + 4.1 μV 210 μV/V + 4.1 μV 520 μV/V + 4.1 μV 1.1 mV/V + 4.1 μV 1.4 mV/V + 4.1 μV 2.8 mV/V + 4.1 μV	Fluke 57X0A Multifunction Calibrator
AC Voltage – Source[1]	(22 to 220) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz 220 mV to 2.2 V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	 250 μV/V + 39 μV 94 μVV + 16 μV 83 μV/V + 8.7 μV 200 μV/V + 10 μV 470 μV/V + 210 μV 930 μV/V + 600 μV 1.5 mV/V + 190 μV 2.8 mV/V + 300 μV 250 mV/V + 39 μV 94 μVV + 16 μV 46 μV/V + 9 μV 78 μV/V + 10 μV 100 μV/V + 70 μV 290 μV/V + 80 μV 1.1 mV/V + 200 μV 1.8 mV/V + 300 μV	Fluke 57X0A Multifunction Calibrator

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source[1]	(2.2 to 22) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) V 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (220 to 1 100) V 40 Hz to 20 kHz (20 to 50) kHz	 250 µV/V + 390 µV 93 µV/V + 160 µV 47 µV/V + 48 µV 78 µV/V + 100 µV 110 µV/V + 70 µV 430 µV/V + 97 µV 1 mV/V + 2.1 mV 1.6 mV/V + 3.3 mV 54 µV/V + 65 µV 83 µV/V + 34 µV 155 µV/V + 2.9 µV 940 µV/V + 180 µV 4.6 mV/V + 40 µV 8.3 mV/V + 8.4 µV 310 µV/V + 20 µV 73 µV/V	Fluke 57X0A Multifunction Calibrator
AC Voltage – Source[1]	to 1 100 V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz to 750 V (30 to 50) kHz (50 to 100) kHz	 78 µV/V + 14 mV 170 µV/V 620 µV/V 620 µV/V 2.35 mV/V	Fluke 57X0A Multifunction Calibrator with Fluke 5725A Amplifier
AC Voltage - Source [1] Fixed Values, Fixed Frequencies	(0 to 250) V (15 to 50) Hz 250 V to 1.1 kV 50 Hz to 1 kHz 220 V to 1.1 kV 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (220 to 750) V (30 to 50) kHz (50 to 100) kHz	 0.31 mV/V + 17 mV 87 µV/V + 2.9 mV 0.91 mV/V + 2.9 mV 0.91 mV/V + 2.9 mV 5.1 mV/V + 9.6 mV 0.52 mV/V + 8.6 mV 1.9 mV/V + 37 mV	Fluke 57X0A Multifunction Calibrator disciplined with Keysight 3458A Multimeter

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Source [1] Fixed Values, Fixed Frequencies	0.01 V		Fluke 57X0A Multifunction Calibrator disciplined with Keysight 3458A Multimeter
	1 kHz	2.8 µV	
	20 kHz	2.9 µV	
	100 kHz	9 µV	
	300 kHz	66 µV	
	0.1 V		
	1 kHz	5.7 µV	
	20 kHz	7.8 µV	
	100 kHz	37 µV	
	300 kHz	69 µV	
	1 V		
	1 kHz	55 µV	
	20 kHz	69 µV	
	50 kHz	0.13 mV	
	100 kHz	0.21 mV	
	300 kHz	0.6 mV	
	500 kHz	1.7 mV	
	3V		
	100 kHz	0.57 mV	
AC Voltage - Source[1] (cont.) Fixed Values, Fixed Frequencies	10 V		Fluke 57X0A Multifunction Calibrator disciplined with Keysight 3458A Multimeter
	10 Hz	0.78 mV	
	20 Hz	0.59 mV	
	40 Hz	0.52 mV	
	200 Hz	0.59 mV	
	500 Hz	0.59 mV	
	1 kHz	0.49 mV	
	10 kHz	0.68 mV	
	20 kHz	0.68 mV	
	50 kHz	1.3 mV	
	100 kHz	1.6 mV	
	300 kHz	5.1 mV	
	500 kHz	16 mV	
	1 MHz	19 mV	
	100 V		
	1 kHz	8.4 mV	
	20 kHz	12 mV	
	50 kHz	14 mV	
	100 kHz	34 mV	
	700 V		
	1 kHz	77 mV	

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Flatness - Source[1]	300 µV to 3.5 V (10 to 30) Hz 30 Hz to 120 kHz 300 µV to 1.1 mV 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz 1.1 µV to 3 mV 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz 3 mV to 3.5 V 120 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 2.7 mV/V 1.4 mV/V 4.6 mV/V 6.2 mV/V 8 mV/V 24 mV/V 2.2 mV/V 3.7 mV/V 5.5 mV/V 14 mV/V 1.2 mV/V 2.1 mV/V 3.8 mV/V 8.6 mV/V	Fluke 57X0A Multifunction Calibrator, (referenced to 1 kHz)
AC Voltage Flatness – Measure[1]	Up to 3 V 10 Hz 100 Hz (10, 30) kHz 100 kHz 300 kHz 1 MHz 3 MHz 8 MHz 10 MHz 20 MHz 30 MHz 50 MHz 70 MHz 80 MHz 100 MHz	 0.2 mV/V + 6.9 µV 80 µV/V + 5.5 µV 80 µV/V + 3.2 µV 0.1 mV/V + 8 µV 0.1 mV/V + 5.2 µV 0.1 mV/V + 6.5 µV 1.3 mV/V + 59 µV 1.3 mV/V + 0.11 mV 1.3 mV/V + 91 µV 2.5 mV/V + 0.21 mV 2.5 mV/V + 0.24 mV 6.1 mV/V + 0.34 mV 9 mV/V + 0.24 mV 11 mV/V + 0.79 mV 13 mV/V + 0.94 mV	Agilent 11049A, Agilent 11050A, Agilent 11051A Thermal Voltage Converters, Keysight 3458A Multimeter
AC Voltage – Measure[1]	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz	 0.3 mV/V + 3.1 µV 0.2 mV/V + 1.2 µV 0.3 mV/V + 1.7 µV 1 mV/V + 1.6 µV	Keysight 3458A Multimeter

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure[1]	(50 to 100) kHz	5 mV/V + 1.3 µV	Keysight 3458A Multimeter
	(100 to 300) kHz	40 mV/V + 2.1 µV	
	300 kHz to 1 MHz	12 mV/V + 6.6 µV	
	(1 to 4) MHz	70 mV/V + 7.5 µV	
	(4 to 8) MHz	20 mV/V + 8.2 µV	
	(10 to 100) mV		
	(1 to 40) Hz	70 µV/V + 4.1 µV	
	40 Hz to 1 kHz	70 µV/V + 2.1 µV	
	(1 to 20) kHz	0.14 mV/V + 2.3 µV	
	(20 to 50) kHz	0.30 V/V + 2.6 µV	
	(50 to 100) kHz	0.8 mV/V + 2.3 µV	
	(100 to 300) kHz	3 mV/V + 15 µV	
	300 kHz to 1 MHz	10 mV/V + 28 µV	
	(1 to 2) MHz	15 mV/V + 20 µV	
	(2 to 4) MHz	40 mV/V + 74 µV	
	(4 to 8) MHz	40 mV/V + 83 µV	
	(8 to 10) MHz	0.15 V/V + 0.11 mV	
	(0.1 to 1) V		
	(1 to 40) Hz	70 µV/V + 41 µV	
	40 Hz to 1 kHz	70 µV/V + 21 µV	
	(1 to 20) kHz	0.14 mV/V + 22 µV	
	(20 to 50) kHz	0.3 mV/V + 22 µV	
	(50 to 100) kHz	0.8 mV/V + 22 µV	
	(100 to 300) kHz	3 mV/V + 0.12 mV	
	300 kHz to 1 MHz	10 mV/V + 0.30 mV	
	(1 to 2) MHz	15 mV/V + 0.21 mV	
	(2 to 4) MHz	40 mV/V + 0.73 mV	
	(4 to 8) MHz	40 mV/V + 0.83 mV	
	(8 to 10) MHz	0.15 V/V + 1 mV	
AC Voltage – Measure[1]	(1 to 10) V		Keysight 3458A Multimeter
	(1 to 40) Hz	70 µV/V + 0.42 mV	
	40 Hz to 1 kHz	70 µV/V + 0.22 mV	
	(1 to 20) kHz	0.14 mV/V + 0.24 mV	
	(20 to 50) kHz	0.3 mV/V + 0.25 mV	
	(50 to 100) kHz	0.8 mV/V + 0.22 mV	
	(100 to 300) kHz	3 mV/V + 1.1 mV	
	300 kHz to 1 MHz	10 mV/V + 1.1 mV	
	(1 to 2) MHz	15 mV/V + 1.1 mV	

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure[1]	(2 to 4) MHz (4 to 8) MHz (8 to 10) MHz (10 to 100) V (1 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	40 mV/V + 7.1 mV 40 mV/V + 8.1 mV 0.15 mV/V + 11 mV 0.2 mV/V + 4.1 mV 0.2 mV/V + 2.6 mV 0.35 mV/V + 2.4 mV 1.2 mV/V + 2.1 mV 4 mV/V + 11 mV 15 mV/V + 50 mV	Keysight 3458A Multimeter
	(100 to 750) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.4 mV/V + 31 mV 0.4 mV/V + 16 mV 0.6 mV/V + 16 mV 1.2 mV/V + 16 mV 3 mV/V + 15 mV	
	1 mV to 8 V 20 Hz to 20 MHz	4.6 % of reading	Keysight DSO 9104A Oscilloscope
AC Current Source[1]	0 to 220 µA 10 to 20 Hz 20 to 40 Hz 40 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz 220 µA to 2.2 mA 10 to 20 Hz 20 to 40 Hz 40 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz	 230 µA/A + 17 nA 150 µA/A + 10 nA 108 µA/A + 8.4 nA 266 µA/A + 13 nA 915 µA/A + 66 nA 233 µA/A + 42 nA 150 µA/A + 34 nA 108 µA/A + 34 nA 183 µA/A + 109 nA 915 µA/A + 655 nA	Fluke 5720A or 5730A Multifunction Calibrator
AC Current Source[1]	(2.2 to 22) mA 10 to 20 Hz 20 to 40 Hz 40 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz (22 to 220) mA 10 to 20 Hz 20 to 40 Hz	 233 µA/A + 422 nA 149 µA/A + 342 nA 108 µA/A + 343 nA 183 µA/A + 588 nA 915 µA/A + 5 µA 233 µA/A + 4.2 µA 149 µA/A + 3.4 µA	Fluke 5720A or 5730A Multifunction Calibrator

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Source[1]	40 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz (0.22 to 2.2) A 20 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz (2.2 to 11) A 20 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz	108 µA/A + 2.6 µA 183 µA/A + 3.4 µA 915 µA/A + 10 µA 249 µA/A + 34 µA 383 µA/A + 83 µA 5.8 mA/A + 166 µA 332 µA/A + 149 µA 707 µA/A + 320 µA 2.8 mA/A + 600 µA	Fluke 5720A or 5730A Multifunction Calibrator
	(10 to 20) A 45 Hz to 65 Hz 65 Hz to 440 Hz (20 to 100) A 45 Hz to 65 Hz 65 Hz to 440 Hz (200 to 1 000) A 45 Hz to 65 Hz 65 Hz to 100 Hz 100 Hz to 440 Hz	0.3 % of reading + 27 mA 0.88 % of reading - 1 mA 0.3 % of reading + 27 mA 0.85 % of reading + 28 mA 0.33 % of reading + 60 mA 0.86 % of reading + 90 mA 1 % of reading - 0.17 A	Fluke 552XA Multifunction Calibrator with 50 turn coil
AC Current – Source[1] Fixed Values	1 kHz 10 uA 100 uA 1 mA 10 mA 100 mA 1 A	 5.1 pA 11 pA 110 pA 1 µA 11 µA 120 µA	Fluke 57X0A Multifunction Calibrator disciplined with Keysight 3458A

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure[1]	Up to 100 µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1.05) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 4 mA/A + 31 nA 1.5 mA/A + 31 nA 0.6 mA/A + 31 nA 4 mA/A + 0.31 µA 0.15 mA/A + 0.21 µA 0.6 mA/A + 0.21 µA 4 mA/A + 3.1 µA 1.5 mA/A + 2.1 µA 0.6 mA/A + 2.1 µA 4 mA/A + 31 µA 1.5 mA/A + 21 µA 0.60 mA/A + 21 µA 4 mA/A + 0.22 mA 1.6 mA/A + 0.22 mA 0.8 mA/A + 0.22 mA 1 mA/A + 0.22 mA	Keysight 3458A Multimeter
Resistance – Source DC to 1 MHz, Direct Measurement[1]	0.1 Ω (1, 10) Ω 100 Ω (1, 10, 100) kΩ	10 mΩ/Ω 1 mΩ/Ω 0.3 mΩ/Ω 0.3 mΩ/Ω	Agilent 16074A RL Standard
Resistance Source, High Resistance[1]	1 GΩ 10 GΩ 100 GΩ	0.23 MΩ 2.7 MΩ 24 MΩ	Agilent 16340A RC Calibration Fixture
Capacitance – Source-[1] Fixed Points	1 pF 1 kHz, 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.19 fF 0.31 fF 0.49 fF 0.68 fF 0.9 fF 2.5 fF 3.7 fF	Agilent 16380A, Agilent 16380C Standard

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source-[1] Fixed Points	10 pF 1 kHz (1 to 10) MHz 10 MHz 13 MHz 100 pF 1 kHz to 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz 1 000 pF 1 kHz, 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz 10 nF 120 Hz to 100 kHz 100 nF 120 Hz to 100 kHz 1 µF 120 Hz to 10 kHz 100 kHz	 2 fF 1.5 fF 2 fF 2.2 fF 14 fF 17 fF 20 fF 37 fF 53 fF 0.14 pF 0.21 pF 0.31 pF 0.47 pF 0.64 pF 1.9 pF 2.9 pF 1.5 pF 15 pF 0.15 nF 0.17 nF	Agilent 16380A, Agilent 16380C Standard
Capacitance - Source[1]	0.19 to 3.29 nF 3.3 to 10.99 nF 11 to 109.99 nF 110 to 329.99 nF 0.33 to 1.099 µF 1.1 to 3.299 µF 3.3 to 10.99 µF 11 to 32.99 µF 33 to 109.99 µF 110 to 329.99 µF 0.33 to 1.099 mF 1.1 to 3.299 mF 3.3 to 10.00 mF	3.2 mF/F + 8.3 pF 1.6 mF/F + 8.3 pF 1.6 mF/F + 83 pF 1.6 mF/F + 0.25 nF 1.6 mF/F + 0.83 nF 1.6 mF/F + 2.5 nF 1.6 mF/F + 8.3 nF 2.5 mF/F + 25 nF 2.8 mF/F + 84 nF 2.8 mF/F + 0.25 µF 4 mF/F + 1.2 µF 4 mF/F + 3.6 µF 4 mF/F + 12 µF	Fluke 5520A or 5522A Multifunction Calibrator

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance - Source[1]	11 to 32.99 mF 33 to 110 mF	8.3 mF/F + 36 µF 12 mF/F + 0.11 mF	Fluke 5520A or 5522A Multifunction Calibrator
Dissipation Factor – Source[1,3] Fixed Points	1 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz 10 pF 1 kHz 1 MHz 2 MHz (3 to 4) MHz 5 MHz 10 MHz 13 MHz 100 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz 1 000 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.002 7 0.000 17 0.000 39 0.000 2 0.000 15 0.000 21 0.000 57 0.000 84 0.000 042 0.000 026 0.000 073 0.000 067 0.000 097 0.000 076 0.000 095 0.000 023 0.000 021 0.000 069 0.000 055 0.000 065 0.000 072 0.000 16 0.000 24 0.000 02 0.000 031 0.000 075 0.000 1 0.001 6 0.000 22 0.000 58 0.000 86	Agilent 16380A, Agilent 16380C Capacitance Standards

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dissipation Factor – Source[1,3] Fixed Points	10 nF 120 Hz 1 kHz (10 to 100) kHz 100 nF 120 Hz 1 kHz 10 kHz 100 kHz 1 µF 120 Hz 1 kHz 10 kHz 100 kHz	 0.000 025 0.000 02 0.000 021 0.000 03 0.000 02 0.000 12 0.000 031 0.000 042 0.000 02 0.000 031 0.000 055	Agilent 16380A, Agilent 16380C Capacitance Standards
High Voltage Measure[1] DC Voltage AC Voltage	 (1 to 90) kV (1 to 64) kV (50 to 60) Hz 60 Hz to 1 MHz	 1.8 mV/V 6.2 mV/V 36 mV/V	Ross Engineering VD90 Voltage Divider, Keysight 34401A Multimeter
Electrical Simulation of Thermocouples[1]	Type B (600 to 800) °C (800 to 1 000) °C (1 000 to 1 550) °C (1 550 to 1 820) °C	 0.47 °C 0.36 °C 0.32 °C 0.35 °C	Fluke 5520A, Fluke 5522A Multifunction Calibrator
	Type C (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 316) °C Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 1 000) °C	 0.32 °C 0.28 °C 0.33 °C 0.53°C 0.88 °C 0.53 °C 0.18 °C 0.16 °C 0.18 °C 0.23 °C	Fluke 552XA Multifunction Calibrator

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouples[1]	Type J		Fluke 552XA Multifunction Calibrator
	(-210 to -100) °C	0.29 °C	
	(-100 to -30) °C	0.18 °C	
	(-30 to 150) °C	0.16 °C	
	(150 to 760) °C	0.19 °C	
	(760 to 1 200) °C	0.25 °C	
	Type K		
	(-200 to -100) °C	0.35 °C	
	(-100 to -25) °C	0.2 °C	
	(-25 to 120) °C	0.18 °C	
	(120 to 1 000) °C	0.28 °C	
	(1 000 to 1 372) °C	0.42 °C	
	Type L		
	(-200 to -100) °C	0.39 °C	
	(-100 to 800) °C	0.28 °C	
	(800 to 900) °C	0.19 °C	
	Type N		
	(-200 to -100) °C	0.42 °C	
	(-100 to -25) °C	0.24 °C	
	(-25 to 120) °C	0.21 °C	
	(120 to 410) °C	0.2 °C	
	(410 to 1 300) °C	0.29 °C	
	Type R		
	(0 to 250) °C	0.6 °C	
	(250 to 400) °C	0.37 °C	
	(400 to 1 000) °C	0.35 °C	
	(1 000 to 1 767) °C	0.42 °C	
	Type S		
	(0 to 250) °C	0.5 °C	
	(250 to 1 000) °C	0.38 °C	
	(1 000 to 1 400) °C	0.39 °C	
	(1 400 to 1 767) °C	0.49 °C	
Electrical Simulation of Thermocouples[1]	Type T		Fluke 5520A, Fluke 5522A Multifunction Calibrator
	(-250 to -150) °C	0.26 °C	
	(-150 to 0) °C	0.18 °C	
	(0 to 120) °C	0.16 °C	
	(120 to 400) °C	0.66 °C	
	Type U		
	(-200 to 0) °C	0.59 °C	
	(0 to 600) °C	0.29 °C	

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure[1] Rate: (0.05 to 10) kHz Rate: (0.05 to 50) kHz Rate: (0.05 to 10) kHz	 (0.15 to 10) MHz (0.01 to 1.3) GHz (1.3 to 26.5) GHz	 2.1 % Depth 1.1 % Depth 1.6 % Depth	Agilent 8902A Measuring Receiver
Amplitude Modulation – Measure[1] Rate: (0.05 to 10) kHz Rate: (0.05 to 100) kHz	 (0.1 to 10) MHz (0.01 to 3) GHz (3 to 26.5) GHz (26.5 to 31.15) GHz (31.5 to 50) GHz	 0.8 % Depth 0.5 % Depth 1.5 % Depth 1.9 % Depth 6.1 % Depth	Agilent E444xA with Opt. 233 Spectrum Analyzer
Frequency Modulation – Measure[1] Rate: (0.02 to 10) kHz Rate: (0.05 to 100) kHz	 (0.25 to 10) MHz (0.01 to 26.5) GHz	 2.2 % Deviation 1.2 % Deviation	HP 8902A Measuring Receiver
Frequency Modulation – Measure[1] Rate: (0.02 to 10) kHz Rate: (0.05 to 200) kHz	 (0.25 to 10) MHz (0.01 to 50) GHz	 1.1 % Deviation 1.1 % Deviation	E444xA with Opt. 233 Spectrum Analyzer

DIGITAL MODULATION RF QUALITY		
PARAMETER/ EQUIPMENT	**MODULATION TYPES**	**FREQUENCY RANGE**
Digital Modulation RF Quality[1] Measure – Carrier 2 MHz to 44 GHz	TETRA, PDC, NADC, PHS, EDGE, CDMA 200A/C, WCDMA, 3GPP, QPSK, BPSK, PI/4 DQPSK, 16QAM, 256QAM, DECT, PHP, GSM, 2FSK, 4FSK, GMSK, MSK, DQPSK, 8PSK, 32QAM FSK	2 MHz to 2.65 GHz using the VSA directly (2.65 to 44) GHz. The digitally modulated RF signal needs to be down-converted with an external Mixer and a Local Oscillator L.O. center frequency = (RF-150 MHz)

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Error Vector Magnitude (EVM)	Mod Frequency Span: f ≤ 100kHz 100kHz ≤ f ≤ 1MHz f > 1MHz	 0.43 % of reading 0.48 % of reading 0.82 % of reading	HP 89441A Vector Signal Analyzer
Phase Error	Mod Frequency Span: f ≤ 100kHz 100kHz ≤ f ≤ 1MHz f > 1MHz	 0.17 º rms 0.34 º rms 0.57 º rms	HP 89441A Vector Signal Analyzer
Frequency Error	Mod Frequency 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz	 0.063 % of reading 0.068 % of reading 0.079 % of reading 0.099 % of reading 0.33 % of reading 0.39 % of reading	HP 89441A Vector Signal Analyzer
Modulation Accuracy (Rho)	Mod Frequency Span: f ≤ 100kHz 0.999 9 ≤ ρ ≤ 1 0.997 5 ≤ ρ< 0.999 9 0.993 6 ≤ ρ< 0.997 5 0.99 ≤ ρ< 0.993 6 0.978 ≤ ρ< 0.99 0.96 ≤ ρ< 0.978	 8.6 E-5 ρ 0.000 43 ρ 0.000 68 ρ 0.000 84 ρ 0.001 2 ρ 0.001 6 ρ	HP 89441A Vector Signal Analyzer
Modulation Accuracy (Rho)	Mod Frequency Span: 100 kHz ≤ f ≤ 1 MHz 0.9999 ≤ ρ≤ 1 0.997 5 ≤ ρ< 0.999 9 0.993 6 ≤ ρ< 0.997 5 0.99 ≤ ρ< 0.993 6 0.978 ≤ ρ< 0.99 0.96 ≤ ρ< 0.978	 9.6 E-5 ρ 0.000 48 ρ 0.000 76 ρ 0.000 94 ρ 0.001 4 ρ 0.001 8 ρ	HP 89441A Vector Signal Analyzer
Modulation Accuracy (Rho)	Mod Frequency Span: f > 1MHz 0.9999 ≤ ρ ≤ 1 0.997 5 ≤ ρ< 0.999 9 0.993 6 ≤ ρ< 0.997 5 0.99 ≤ ρ< 0.993 6 0.978 ≤ ρ< 0.99 0.96 ≤ ρ< 0.978	 1.6 E-4 ρ 0.000 82 ρ 0.001 3 ρ 0.001 6 ρ 0.002 4 ρ 0.003 ρ	HP 89441A Vector Signal Analyzer

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation – Measure[1]	(0.15 to 10) MHz Rate: (0.02 to 10) kHz (0.01 to 26.5) GHz Rate: (0.2 to 20) kHz	4.1 % Deviation 3.1 % Deviation	HP 8902A Measuring Receiver
Phase Modulation – Measure[1]	100 kHz to 6.6 GHz Deviations: (0.3 to 7) rad Deviations: > 7 rad (6.6 to 13.2) GHz Deviations: (0.6 to 2) rad (13.2 to 26.5) GHz Deviations: > 2 rad Deviations: (1.2 to 4) rad (26.5 to 31.5) GHz Deviations: > 4 rad Deviations: (1.3 to 4) rad (31.5 to 50) GHz Deviations: > 4 rad Deviations (2.4 to 8) rad Deviations: > 8 rad	 3.1 % Deviation 1 % Deviation 3.1 % Deviation 1 % Deviation 3.1 % Deviation 1 % Deviation 3.1 % Deviation 1 % Deviation 3.1 % Deviation 1 % Deviation	Keysight E444xA with Opt. 233 Spectrum Analyzer
Distortion Measure[1]	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	HP 8903A/B Audio Analyzer
RF Power - Power Meter Reference[1]	1 mW 50 MHz	0.32 % of reading	Agilent 432A or N432A Power Meter, Agilent 478A Option H75 or H76 Power Sensor

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tuned RF Power - Absolute - Measure[1] 2.5 MHz to 26.5 GHz	(-22 to +10) dBm (-42 to -22) dBm (-50 to -42) dBm (-60 to-50) dBm (-72 to -60) dBm (-80 to -72) dBm (-92 to -80) dBm (-102 to -92) dBm (-110 to -102) dBm (-120 to -110) dBm (-127 to -120) dBm	0.17 dB 0.18 dB 0.2 dB 0.21 dB 0.22 dB 0.23 dB 0.24 dB 0.27 dB 0.28 dB 0.31 dB 0.34 dB	HP 8902A Measuring Receiver with HP 11722A or with HP 11792A and HP 11793A Power Sensor
Tuned RF Power - Relative – Measure[1] 2.5 MHz to 26.5 GHz	(+2 to +10) dBm (-12 to +2) dBm (-22 to -12) dBm (-31 to -22) dBm (-40 to -31) dBm (-50 to -40) dBm (-61 to -50) dBm (-71 to -61) dBm (-80 to -71) dBm (-90 to -80) dBm (-100 to -90) dBm (-110 to -100) dBm (-120 to -110) dBm (-127 to -120) dBm	0.08 dB 0.07 dB 0.08 dB 0.09 dB 0.1 dB 0.12 dB 0.15 dB 0.16 dB 0.17 dB 0.19 dB 0.22 dB 0.23 dB 0.27 dB 0.3 dB	HP 8902A Measuring Receiver with HP 11722A or with HP 11792A and HP 11793A Power Sensor
RF Power Sensors Cal Factors [1,3]	9 kHz to 10 MHz	0.69 %	E9304A Power Sensor

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensors Cal Factors[1,3]	10 MHz 30 MHz 50 MHz 100 MHz 300 MHz to 3 GHz 4 GHz 5 GHz (6 to 7) GHz 8 GHz 9 GHz 10 GHz 11 GHz 12 GHz 12.4 GHz (13 to 15) GHz 16 GHz 17 GHz 18 GHz (19 to 26) GHz 26.5 GHz 27 GHz (28 to 29) GHz 30 GHz (31 to 32) GHz 33 GHz (34 to 40) GHz 41 GHz (42 to 44) GHz (45 to 47) GHz (48 to 50) GHz	0.58 % 0.54 % 0.41 % 0.51 % 0.6 % 0.61 % 0.67 % 0.68 % 0.7 % 0.79 % 0.82 % 0.79 % 0.76 % 0.8 % 0.79 % 0.87 % 0.91 % 0.97 % 1.5 % 1.6 % 1.7 % 1.8 % 1.7 % 1.8 % 1.7 % 1.8 % 2.4 % 2.5 % 2.6 % 2.5 %	Keysight PNA-X Network Analyzer 2.4, 3.5 mm Calibration Kits Reference Power Sensors
RF Absolute Power - Source[1] 50 MHz	(-11 to -1) dB (-30 to -10) dB (-50 to -40) dB -60 dB (-90 to -70) dB -100 dB -110 dB	0.025 dB 0.025 dB 0.027 dB 0.028 dB 0.033 dB 0.04 dB 0.048 dB	Signal Source and Step Attenuators PSG, ESG, 8496G/H and 8494G/H

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source[1]	0.02 V ≤ V < 7 V		Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A
	f < 10 MHz	0.082 dB	
	10 MHz ≤ f ≤ 50 MHz	0.16 dB	
	50 MHz ≤ f ≤ 80 MHz	0.4 dB	
	V ≤ 10mV		
	20 Hz ≤ f ≤ 20 kHz	0.017 mV	
	20 kHz < f ≤ 50 kHz	0.021 mV	
	50 kHz < f ≤ 100 kHz	0.05 mV	
	100 kHz < f ≤ 300 kHz	0.38 mV	
	10 mV < V ≤ 100 mV		
	20 Hz ≤ f ≤ 40 Hz	0.029 mV	
	40 Hz ≤ f ≤ 1 kHz	0.028 mV	
	1 kHz < f ≤ 20 kHz	0.032 mV	
	20 kHz < f ≤ 50 kHz	0.045 mV	
	50 kHz < f ≤ 100 kHz	0.08 mV	
	100 kHz < f ≤ 300 kHz	0.3 mV	
RF Absolute Power – Source[1]	100 mV < V ≤ 1 V		Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A
	20 Hz ≤ f ≤ 1 kHz	0.7 mV	
	1 kHz < f ≤ 20 kHz	0.72 mV	
	20 kHz < f ≤ 50 kHz	0.79 mV	
	50 kHz < f ≤ 100 kHz	1.3 mV	
	100 kHz < f ≤ 300 kHz	3.7 mV	
	1 V < V ≤ 3.5 V		
	20 Hz ≤ f ≤ 40 Hz	2.2 mV	
	40 Hz ≤ f ≤ 1 kHz	2.1 mV	
	1 kHz < f ≤ 20 kHz	2.2 mV	
	20 kHz < f ≤ 50 kHz	2.5 mV	
	50 kHz < f ≤ 100 kHz	4 mV	
	100 kHz < f ≤ 300 kHz	13 mV	

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source[1]	7dBm ≥ P ≥ 0 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz 0 dBm > P ≥ -25 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz -25 dBm > P ≥ -70 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz -70 dBm > P ≥ -95 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz -95 dBm > P ≥ -125 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz	 0.49 dB 0.58 dB 0.69 dB 0.79 dB 0.49 dB 0.59 dB 0.69 dB 0.8 dB 0.5 dB 0.59 dB 0.69 dB 0.8 dB 0.5 dB 0.6 dB 0.7 dB 0.8 dB 0.51 dB 0.6 dB 0.7 dB 1.5 dB	Signal Source PSG, ESG, E4438C, E4428C
Rise Time - Generate[1]	2 kHz to 2 MHz (200 to 300) ps (2 to 10) MHz (200 to 350) ps	37 ps 37 ps	Fluke 55xxA + SC600/1100 Multifunction Calibrator
Rise Time - Measure	(7 to 500) ps	8.1 ps	Keysight 86100x Oscilloscope with 86117A Module

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pulse – Source Transition Time[1]	<100 ps	0.13 ns	HP 8133A Pulse Generator
Width	150 ps to 10 ns (10 to 100) ns 100 µs to 10 ms (10 to 100) ms (100 to 0.99) ms	0.13 ns (0.013 * Width) + 1.2 ns (0.013 * Width) + 0.14 µs (0.012 * Width) + 2 ns (0.012 * Width) + 0.19 µs	
RMS Jitter - Period, Delay and Width[1]	33 MHz to 3 GHz	10 ps	
Thermal Noise – Source ENR	5 dB, 15 dB, or 21 dB 0.01 GHz 0.1 GHz 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz 7 GHz 8 GHz 9 GHz 10 GHz 11 GHz 12 GHz 13 GHz 14 GHz 15 GHz 16 GHz 17 GHz 18 GHz 19 GHz 20 GHz 21 GHz 22 GHz 23 GHz 24 GHz 25 GHz 26 GHz 26.5 GHz	0.06 dB 0.06 dB 0.11 dB 0.07 dB 0.07 dB 0.06 dB 0.06 dB 0.06 dB 0.06 dB 0.07 dB 0.06 dB 0.09 dB 0.07 dB 0.07 dB 0.07 dB 0.06 dB 0.06 dB 0.06 dB 0.07 dB 0.06 dB 0.13 dB 0.14 dB 0.14 dB 0.16 dB 0.17 dB 0.14 dB 0.13 dB 0.15 dB 0.15 dB	HP 346B opt. 002 346B/N4001A opt. 001 346B opt. 004 346C/N4002A Noise Source

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise for Signal Sources[1]			
$(L_{REF} - L_{DUT}) \geq 10dB$			
Offset Frequency			
≤ 100 kHz	≤ 100 MHz	2.3 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5 GHz	2.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	2.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	4.6 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	4.6 dB	
$10dB > (L_{REF} - L_{DUT}) \geq 5dB$			
Offset Frequency			
≤ 100 kHz	≤ 100 MHz	2.8 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5 MHz	2.9 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	2.9 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	5.2 dB	E5500 Phase Noise System
< 100 MHz	50 kHz < f ≤ 26.5 GHz	5.3 dB	
$5dB > (L_{REF} - L_{DUT}) \geq 3dB$			
Offset Frequency			
≤ 100 kHz	≤ 100 MHz	3.2 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5G Hz	3.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	3.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	5.4 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	5.5 dB	
$3dB > (L_{REF} - L_{DUT}) \geq 0dB$			
Offset Frequency			
≤ 100 kHz	≤ 100 MHz	4.3 dB	
≤ 100 kHz	100 MHz < f ≤ 26.5 GHz	4.3 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	4.3 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	6.1 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	6.2 dB	

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise for Signal Sources[1] 3 dB > (L_{REF} - L_{DUT}) ≥ 0 dB Offset Frequency			E5500 Phase Noise System
≤ 100 kHz	≤ 100 MHz	4.3 dB	
≤ 100 kHz	100 MHz < f ≤ 255 MHz	4.6 dB	
≤ 100 kHz	255 MHz < f ≤ 600 MHz	4.6 dB	
≤ 100 kHz	600 MHz < f ≤ 1.8 GHz	4.5 dB	
≤ 100 kHz	1.8 GHz < f ≤ 3.2 GHz	4.5 dB	
≤ 100 kHz	3.2 GHz < f ≤ 10 GHz	4.8 dB	
≤ 100 kHz	10 GHz < f ≤ 20 GHz	.8 dB	
≤ 100 kHz	20 GHz < f ≤ 26.5 GHz	4.5 dB	
≤ 1 MHz	50 kHz < f ≤ 26.5 GHz	4.7 dB	
≤ 10 MHz	50 kHz < f ≤ 26.5 GHz	6.2 dB	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	6.2 dB	
Phase Noise for Signal Analyzers[1] Carrier 1 GHz Offsets:	Phase Noise Measurement dBc/Hz		Wenzel 500-13438C Oscillator
0.1 kHz	-84 ≥ PN ≤ -94	1.1 dB	
	-94 < PN ≤ -95	1.2 dB	
	-95 < PN ≤ -98	1.4 dB	
	-98 < PN ≤ -100	1.8 dB	
	-100 < PN ≤ -102	2.4 dB	
	-102 < PN ≤ -105	3.4 dB	
1 kHz	-78 ≥ PN ≤ -115	0.75 dB	
	-115 < PN ≤ -121	0.82 dB	
	-121 < PN ≤ -123	0.91 dB	
	-123 < PN ≤ -125	1.1 dB	
	-125 < PN ≤ -129	1.9 dB	
	-129 < PN ≤ -130	2.1 dB	
	-130 < PN ≤ -133	3.3 dB	
10 kHz	-90 ≥ PN ≤ -129	0.43 dB	
	-129 < PN ≤ -132	0.45 dB	
	-132 < PN ≤ -135	0.54 dB	
	-135 < PN ≤ -138	0.74 dB	
	-138 < PN ≤ -142	1.2 dB	
	-142 < PN ≤ -145	2.1 dB	

Electrical - RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise for Signal Analyzers[1]	Phase Noise Measurement dBc/Hz		
Carrier 1 GHz	-106 ≥ PN ≤ -112	0.56 dB	
Offsets:	-112 < PN ≤ -132	0.57 dB	
	-132 < PN ≤ -134	0.59 dB	Wenzel 500-13438C
30 kHz	-134 < PN ≤ -137	0.65 dB	Oscillator
	-137 < PN ≤ -140	0.82 dB	
	-140 < PN ≤ -143	1.3 dB	
	-143 < PN ≤ -144	1.5 dB	
	-144 < PN ≤ -147	2.1 dB	
Phase Noise for Signal Analyzers[1]	Phase Noise (PN) Measurement dBc/Hz		
Carrier 1 GHz Offsets:	-102 ≥ PN ≤ -131	0.55 dB	
100 kHz	-131 < PN ≤ -132	0.56 dB	
	-132 < PN ≤ -136	0.58 dB	
	-136 < PN ≤ -139	0.64 dB	
	-139 < PN ≤ -142	0.81 dB	
	-142 < PN ≤ -145	1.3 dB	
	-145 < PN ≤ -146	1.5 dB	
	-146 < PN ≤ -149	2.1 dB	
	-120 ≥ PN ≤ -139	0.55 dB	
1 MHz	-139 < PN ≤ -142	0.56 dB	Wenzel 500-13438C
	-142 < PN ≤ -145	0.58 dB	Oscillator
	-143 < PN ≤ -148	0.64 dB	
	-148 < PN ≤ -150	0.74 dB	
	-150 < PN ≤ -152	0.93 dB	
	-152 < PN ≤ -155	1.5 dB	
	-155 < PN ≤ -158	2.1 dB	
	-131 ≥ PN ≤ -136	0.69 dB	
9.9 and 10 MHz	-136 < PN ≤ -156	0.79 dB	
	-156 < PN ≤ -158	0.91 dB	
	-158 < PN ≤ -159	1 dB	
	-159 < PN ≤ -162	1.5 dB	
	-162 < PN ≤ -165	2.1 dB	

PARAMETER	Attenuation - Source										
REFERENCE STANDARD OR EQUIPMENT	8494H										
	Frequency Ranges (uncertainties in dB)										
Attenuation Level	1	2	3	4	5	6	7	8	9	10	11
20 Hz ≤ f < 300 kHz	0.002 8	0.002 7	0.002 7	0.002 8	0.002 9	0.002 8	0.002 9	0.002 8	0.002 8	0.002 8	0.003 3
300 kHz ≤ f < 80 MHz	0.002 9	0.002 8	0.002 8	0.003	0.003	0.003	0.003	0.003 4	0.003 7	0.003 7	0.003 8
80 MHz ≤ f < 1 GHz	0.005 4	0.005 4	0.005 4	0.005 3	0.005 4	0.005 4	0.005 1	0.005 4	0.005 4	0.005 9	0.005 3
1 GHz ≤ f < 4 GHz	0.066	0.068	0.068	0.069	0.071	0.071	0.072	0.073	0.073	0.074	0.074
4 GHz ≤ f < 10 GHz	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.11	0.11	0.11
10 GHz ≤ f < 14 GHz	0.14	0.14	0.14	0.14	0.15	0.14	0.14	0.15	0.15	0.14	0.14
14 GHz ≤ f ≤ 18 GHz	0.19	0.18	0.19	0.17	0.2	0.19	0.19	0.19	0.18	0.19	0.2

PARAMETER	Attenuation - Source										
REFERENCE STANDARD OR EQUIPMENT	8496H										
	Attenuation Levels (dB)										
Frequency Ranges	10	20	30	40	50	60	70	80	90	100	110
1 kHz ≤ f < 100 MHz	0.0037	0.0071	0.052	0.064	0.049	0.089	0.083	0.12	0.14	0.16	0.2
100 MHz ≤ f < 300 MHz	0.0042	0.0092	0.058	0.071	0.055	0.089	0.083	0.12	0.14	0.17	0.18
300 MHz ≤ f < 500 MHz	0.0073	0.014	0.065	0.079	0.062	0.096	0.088	0.13	0.14	0.18	0.19
500 MHz ≤ f < 1 GHz	0.0073	0.016	0.082	0.086	0.071	0.1	0.094	0.13	0.15	0.22	0.24
1 GHz ≤ f < 4 GHz	0.0096	0.02	0.097	0.1	0.086	0.11	0.1	0.15	0.16	0.22	0.24
4 GHz ≤ f < 8 GHz	0.011	0.023	0.1	0.11	0.089	0.15	0.14	0.19	0.21	0.36	0.37
8 GHz ≤ f < 10 GHz	0.016	0.032	0.12	0.13	0.11	0.19	0.18	0.27	0.28	0.42	0.45
10 GHz ≤ f < 12 GHz	0.019	0.039	0.12	0.12	0.1	0.16	0.15	0.2	0.23	0.38	0.46
12 GHz ≤ f < 14 GHz	0.022	0.045	0.14	0.14	0.12	0.2	0.19	0.27	0.29	0.43	0.51
14 GHz ≤ f < 18 GHz	0.032	0.063	0.14	0.14	0.12	0.21	0.2	0.27	0.29	0.36	0.5
18 GHz	0.039	0.075	0.16	0.17	0.14	0.26	0.24	0.34	0.36	0.56	0.58

PARAMETER	Attenuation - Measure											
REFERENCE STANDARD OR EQUIPMENT	N5230A/C + cal kit											
	Attenuation Levels (dB)											
Frequency Ranges	0	1	2	3	4	5	6	7	8	9	10	11
10 MHz ≤ f < 300 MHz	0.028	0.03	0.031	0.03	0.032	0.033	0.032	0.034	0.035	0.035	0.035	0.037
300 MHz ≤ f < 2 GHz	0.028	0.03	0.032	0.032	0.033	0.034	0.034	0.036	0.037	0.037	0.037	0.039
2 GHz ≤ f < 8 GHz	0.047	0.048	0.049	0.049	0.051	0.052	0.052	0.054	0.055	0.055	0.054	0.057
8 GHz ≤ f < 12 GHz	0.052	0.053	0.055	0.054	0.056	0.057	0.056	0.059	0.06	0.06	0.059	0.062
12 GHz ≤ f < 18 GHz	0.059	0.061	0.062	0.061	0.064	0.065	0.064	0.067	0.067	0.068	0.067	0.07
18 GHz ≤ f < 20 GHz				0.061			0.064				0.067	
20 GHz ≤ f < 30 GHz				0.11			0.11				0.12	
30 GHz ≤ f < 40 GHz				0.12			0.13				0.13	
40 GHz ≤ f < 50 GHz				0.18			0.19				0.2	

PARAMETER	Attenuation - Measure									
REFERENCE STANDARD OR EQUIPMENT	N5230A/C + cal kit									
	Attenuation Levels (dB)									
Frequency Ranges	20	30	40	50	60	70	80	90	100	110
10 MHz ≤ f < 50 MHz	0.042	0.053	0.089	0.17	0.12	0.14	0.17	0.18	0.18	0.19
50 MHz ≤ f < 500 MHz	0.042	0.053	0.063	0.095	0.097	0.11	0.12	0.14	0.14	0.16
500 MHz ≤ f < 2 GHz	0.044	0.051	0.06	0.085	0.1	0.11	0.1	0.11	0.12	0.14
2 GHz ≤ f < 8 GHz	0.061	0.051	0.078	0.11	0.14	0.19	0.15	0.2	0.2	0.25
8 GHz ≤ f < 12 GHz	0.066	0.068	0.089	0.15	0.19	0.25	0.21	0.26	0.29	0.33
12 GHz ≤ f < 18 GHz	0.074	0.074	0.096	0.16	0.34	0.39	0.35	0.4	0.41	0.47
18 GHz ≤ f < 20 GHz	0.074	0.082	0.096							
20 GHz ≤ f < 26.5 GHz	0.12	0.12	0.12							
26.5 GHz ≤ f < 30 GHz	0.13	0.13	0.15							
30 GHz ≤ f < 40 GHz	0.14	0.15	0.17							
40 GHz ≤ f < 50 GHz	0.2	0.21	0.24							

PARAMETER	(S11 - Reflection) Magnitude Uncertainty (lin) [1]									
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B									
Frequency Range	Measured Magnitude (+/- Linear)									
	≤ 0.1	> 0.1 to ≤ 0.2	> 0.2 to ≤ 0.3	> 0.3 to ≤ 0.4	> 0.4 to ≤ 0.5	> 0.5 to ≤ 0.6	> 0.6 to ≤ 0.7	> 0.7 to ≤ 0.8	> 0.8 to ≤ 0.9	> 0.9 to ≤ 1
300 kHz to 20 MHz	0.002 4	0.002 6	0.002 9	0.002 8	0.003 1	0.003 5	0.003 9	0.004 3	0.004 6	0.004 9
20 MHz to 2 GHz	0.000 54	0.000 62	0.000 7	0.000 81	0.000 93	0.001 1	0.001 2	0.001 4	0.001 6	0.001 7
(2 to 8) GHz	0.000 78	0.000 82	0.000 89	0.000 98	0.001 1	0.001 2	0.001 4	0.001 5	0.001 7	0.001 9
(8 to 20) GHz	0.001 4	0.001 4	0.001 5	0.001 5	0.001 6	0.001 7	0.001 8	0.002	0.002 3	0.002 6
(20 to 26.5) GHz	0.001 9	0.001 9	0.001 9	0.002	0.002	0.002 1	0.002 3	0.002 5	0.002 7	0.0031
(26.5 to 40) GHz	0.003 9	0.004 1	0.004 4	0.004 9	0.005 6	0.006 6	0.007 7	0.009 1	0.011	0.012
(40 to 50) GHz	0.005 2	0.005 4	0.005 8	0.006 3	0.007	0.008 1	0.009 5	0.011	0.013	0.015

PARAMETER	(S11 - Reflection) Phase Uncertainty (deg) [1]									
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B									
Frequency Range	Measured Magnitude (+/- Degrees)									
	≤ 0.1	> 0.1 to ≤ 0.2	> 0.2 to ≤ 0.3	> 0.3 to ≤ 0.4	> 0.4 to ≤ 0.5	> 0.5 to ≤ 0.6	> 0.6 to ≤ 0.7	> 0.7 to ≤ 0.8	> 0.8 to ≤ 0.9	> 0.9 to ≤ 1
300 kHz to 20 MHz	0.91	0.55	0.43	0.38	0.34	0.32	0.3	0.29	0.28	0.27
20 MHz to 2 GHz	0.31	0.17	0.13	0.11	0.1	0.1	0.098	0.098	0.1	0.1
(2 to 8) GHz	0.45	0.24	0.17	0.14	0.12	0.12	0.11	0.11	0.11	0.11
(8 to 20) GHz	0.81	0.42	0.29	0.23	0.19	0.16	0.15	0.14	0.13	0.13
(20 to 26.5) GHz	1.1	0.55	0.38	0.29	0.24	0.2	0.18	0.17	0.17	0.17
(26.5 to 40) GHz	2.3	1.3	1	0.93	0.9	0.91	0.93	0.94	0.96	0.99
(40 to 50) GHz	3.1	1.7	1.3	1.2	1.1	1.1	1.1	1.2	1.2	1.2

PARAMETER	(S21 - Transmission) Magnitude Uncertainty (dB) [1]								
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B								
Frequency Range	Measured Magnitude (+/- Linear)								
	10 to ≤ 0	> 0 to ≤ 3	> 3 to ≤ 6	>-6 to ≤ 10	> 10 to ≤ 20	> 20 to ≤ 30	> 30 to ≤ 40	> 40 to ≤ 50	> 50 to ≤ 60
300 kHz to 45 MHz	0.018	0.021	0.023	0.027	0.026	0.027	0.029	0.032	0.065
(45 to 130) MHz	0.016	0.015	0.015	0.017	0.02	0.03	0.052	0.074	0.13
130 MHz to 1.25 GHz	0.031	0.034	0.034	0.034	0.034	0.034	0.035	0.044	0.093
(1.25 to 4) GHZ	0.031	0.034	0.034	0.034	0.034	0.034	0.034	0.035	0.044
(4 to 5) GHz	0.032	0.035	0.035	0.035	0.035	0.035	0.035	0.036	0.045
(5 to 26.5) GHz	0.034	0.036	0.036	0.036	0.036	0.036	0.037	0.037	0.038
(26.5 to 40) GHz	0.037	0.039	0.039	0.039	0.039	0.039	0.04	0.04	0.048
(40 to 50) GHz	0.04	0.043	0.043	0.043	0.043	0.043	0.043	0.044	0.051

PARAMETER	(S21 - Transmission) Phase Uncertainty (deg) [1]								
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B								
Frequency Range	Measured Magnitude (+/- Degrees)								
	10 to ≤ 0	> 0 to ≤ 3	> 3 to ≤ 6	>-6 to ≤ 10	> 10 to ≤ 20	> 20 to ≤ 30	> 30 to ≤ 40	> 40 to ≤ 50	> 50 to ≤ 60
300 kHz to 45 MHz	0.62	0.62	0.62	0.62	0.23	0.23	0.23	0.23	0.58
(45 to 130) MHz	0.16	0.16	0.16	0.17	0.19	0.26	0.66	0.6	0.92
130 MHz to 1.25 GHz	0.37	0.37	0.37	0.37	0.38	0.38	0.38	0.41	0.68
(1.25 to 4) GHZ	0.42	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.46
(4.0 to 5) GHz	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.53
(5 to 26.5) GHz	0.89	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
(26.5 to 40) GHz	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
(40 to 50) GHz	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4

PARAMETER	RF Absolute Power Measure[1]										
REFERENCE STANDARD OR EQUIPMENT	8487A, N8481B, N8482B, N9030A, E444xA, E9300A, E9304A, N8485A										
	Frequency Ranges (uncertainties in dB)										
Frequency Range	9 kHz ≤ f < 100 kHz	100 kHz ≤ f < 10 MHz	10 MHz ≤ f < 30 MHz	30 MHz ≤ f < 500 MHz	500 MHz ≤ f < 1.2 GHz	1.2 GHz ≤ f < 2 GHz	2 GHz ≤ f < 6 GHz	6 GHz ≤ f < 8 GHz	8 GHz ≤ f < 12.4 GHz	12.4 GHz ≤ f < 14 GHz	14 GHz ≤ f < 18 GHz
-140 dBm ≤ P < -130 dBm	0.15	0.15	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
-130 dBm ≤ P < -110 dBm	0.13	0.13	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
-110 dBm ≤ P < -90 dBm	0.12	0.12	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07
-90 dBm ≤ P < -30 dBm	0.12	0.12	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
-30 dBm ≤ P < -20 dBm	0.11	0.11	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
-20 dBm ≤ P < -10 dBm	0.11	0.09	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
-10 dBm ≤ P < 0 dBm	0.11	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
-1 dBm ≤ P < 2 dBm	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
2 dBm ≤ P < 10 dBm	0.1	0.08	0.06	0.06	0.06	0.09	0.09	0.09	0.09	0.09	0.1
10 dBm ≤ P < 15 dBm	0.1	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
15 dBm ≤ P < 20 dBm	0.1	0.1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
20 dBm ≤ P < 30 dBm	0.16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.12	0.12
30 dBm ≤ P < 35 dBm		0.08	0.08	0.08	0.08	0.1	0.1	0.1	0.11	0.12	0.12
35 dBm ≤ P < 44 dBm		0.09	0.08	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.11

PARAMETER	RF Absolute Power Measure[1]										
REFERENCE STANDARD OR EQUIPMENT	8487A, N8481B, N8482B, N9030A, E444xA, E9300A, E9304A, N8485A										
	Frequencies / Frequency Ranges (uncertainties in dB)										
Frequency Range	18 GHz ≤ f ≤ 26.5 GHz	26.5 GHz ≤ f ≤ 33 GHz	33 GHz ≤ f < 40 GHz	40 GHz ≤ f < 45 GHz	45 GHz ≤ f ≤ 50 GHz						
-140 dBm ≤ P < -130 dBm	0.1	0.1	0.1	0.12	0.12						
-130 dBm ≤ P < -110 dBm	0.1	0.09	0.09	0.09	0.09						
-110 dBm ≤ P < -90 dBm	0.08	0.08	0.08	0.08	0.08						
-90 dBm ≤ P < -30 dBm	0.07	0.06	0.06	0.06	0.06						
-30 dBm ≤ P < -20 dBm	0.07	0.05	0.05	0.06	0.06						
-20 dBm ≤ P < -10 dBm	0.07	0.05	0.05	0.06	0.06						
-10 dBm ≤ P < 0 dBm	0.07	0.06	0.06	0.06	0.06						
-1 dBm ≤ P < 2 dBm	0.07	0.05	0.05	0.06	0.06						
2 dBm ≤ P < 10 dBm	0.13	0.15	0.15	0.21	0.23						
10 dBm ≤ P < 15 dBm	0.07	0.06	0.06	0.06	0.06						
15 dBm ≤ P < 20 dBm	0.08	0.07	0.07	0.07	0.07						
20 dBm ≤ P < 30 dBm	0.172										

Length - Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers – Length[2]	(0 to 12) in (>12 to 60) in	(310 + 2*L*) µin (310 + 4*L*) µin	Grade 0 & 1 Gage Blocks
Calipers – Jaw Parallelism	≤ 1 inch	372 µin	Grade ZZ Pin Gages

Length - Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length [2] Outside Diameter Micrometer	(0 to 12) in (>12 to 48) in	(30 + 6*L*) µin (30 + 7*L*) µin	Grade 0 & 1 Gage Blocks
Inside Diameter Micrometer	(0 to 12) in	(30 + 6*L*) µin	
Depth Micrometer	(0 to 12) in	(30 + 6*L*) µin	
Anvil Flatness	Up to 1 in	6 µin	Optical Flats and Monochromatic Light
Dial and Digital Indicators Digital Indicators	(0 to 1) in. (>1 to 2) in. (>2 to 6) in.	35 µin. 38 µin. 80 µin.	Grade 0 Gage Blocks + Accessories, Surface Plate
Dial Indicators	(0 to 1) in. (>1 to 6) in.	64 µin. 621 µin.	
Height Gages	(0 to 48) in.	(310 + 4*L*) µin	Grade 0 Gage Blocks, Surface Plate
Plug and Pin Gages[2]	Up to 4 inches	(5 + 4*D*) µin	Labmaster, Grade 00 Gage Blocks
Plain Rings[2]	Up to 4 in	(7 + 4*D*) µin	Grade 00 Gage Blocks, Labmaster
Bubble Levels[2]	Up to 15 in	0.65 *R* µin	Surface Plate, Grade 0 Gage Blocks
Level Base Flatness	0.002 in	37 µin	Surface Plate, Amplifier Gage/Electronic Height Gage
Protractors	Up to 90º	53 arc sec.	Sine Bar, rade 0 Gage Blocks, Surface Plate, Right Angle, Precision Level

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque Wrenches/Screwdrivers	(5 to 16) ozf-in	0.4 ozf-in	Dillon 49754-0245 Torque Tester
	1 lbf-in to 1 000 lbf-ft	0.4 % of reading	AWS QCMI-XX and QCMF-XX Torque Tester
Pneumatic Pressure Absolute / Gage	(-14.6 to 100) psi	0.02 psi	Ruska 7010 Pressure Controller
	(>100 to 200) psi (>200 to 350) psi (>350 to 500) psi	0.014 % of reading 0.01 % of reading 0.008 % of reading	Terranova 906A Pressure Controller
Scales and Balances	(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 300) g (> 300 to 500) g > 500 g to 1 kg (> 1 to 2) kg (> 2 to 5) kg (> 5 to 10) kg	0.099 mg 0.025 mg 0.039 mg 0.065 mg 0.15 mg 0.277 mg 0.548 mg 0.83 mg 3.4 mg 6.6 mg 16 mg 35 mg 67 mg	Class 1, F1 Weights

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Measure	(-196 to ≤ 0) °C (> 0 to ≤ 200) °C (> 200 to ≤ 420) °C (> 420 to ≤ 660) °C	0.010 °C 0.018 °C 0.028 °C 0.039 °C	Fluke 5628 PRT/1502A Indicator
Temperature Source	(-68 to < -30) °C (≥ -30 to ≤ 200) °C (> 200 to ≤ 500) °C (> 500 to 660) °C	0.097 °C 0.074 °C 0.095 °C 0.12 °C	Fluke 9011 Drywell
Humidity – Source	(10 to 90) %RH	0.8 %RH	Thunder Scientific 2500 Chamber

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Time Interval - Measure[1]	10 ns to 10 s	2.9 ns	HP 5334B Counter connected to Time base (HP 5071A or Datum 8040) Frequency Standard
Frequency - Source[1]	10 MHz	6.5E-11 Hz	8040C Frequency Standard
Frequency - Measure[1]	1 to 100 Hz (100 to 1 000) Hz 1 kHz to 12.4 GHz	71 pHz/Hz + 0.015 nHz 68 pHz/Hz + 0.5 nHz 67 pHz/Hz	Agilent 53132A Counter and 8040C Frequency Standard
	(12.4 to 46) GHz	30 pHz/Hz + 3.7 Hz	Agilent 53151A Counter and 8040C Frequency Standard

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. D = diameter in inches, L = length in inches, R = resolution of device under test.
3. Unitless linear measure.
4. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1498.10.