



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

10090 Foothills Blvd.

Roseville, CA 95747

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

Certificate Number



ANAB Approval

Certificate Valid: 05/15/2018-11/16/2018
Version No. 016 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).



**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, 2018**

Certificate Number: **AC-1498**

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage - Source	Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V 220 V to 1.1 kV	7 μ V/V + 0.16 μ V 5 μ V/V + 0.15 μ V 3 μ V/V + 0.32 μ V 4 μ V/V + 5 μ V 5 μ V/V + 14 μ V 7 μ V/V + 41 μ V	Fluke 5720A or 5730A Multiproduct Calibrator with Fluke 5725A Amplifier
DC Voltage – Source Fixed Values	100 mV 1 V 10 V 100 V 1 000 V	0.72 μ V 2.9 μ V 2.6 μ V 0.5 mV 7.3 mV	Fluke 57x0A Multiproduct Calibrator disciplined with HP 3458A/100 NPLC Option 002 Multimeter
	10 V	3 μ V/V	Fluke 732A DC Reference Standard
DC Voltage - Measure	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV	5.6 μ V/V + 1.5 μ V 5.2 μ V/V + 1.2 μ V 4.7 μ V/V + 2.5 μ V 6.6 μ V/V + 45 μ V 19 μ V/V + 0.16 mV	Keysight 3458A/100 NPLC Option 002 Multimeter



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage - Measure	0 V	0.15 μ V/V	Fluke 732A DC Reference Standard, Fluke 752A Divider, Keysight 34420A Multimeter
	100 mV	1.9 μ V/V	
	1 V	0.61 μ V/V	
	10 V	0.51 μ V/V	
	100 V	0.63 μ V/V	
	1 kV	1.1 μ V/V	
DC Voltage Transfer – Measure	(0 to 0.1) V	0.62 μ V/V + 62 nV	Keysight 3458A Multimeter
	(0.1 to 1) V	0.37 μ V/V + 124 nV	
	(1 to 10) V	62 nV/V + 0.62 μ V	
	(10 to 100) V	0.62 μ V/V + 12 μ V	
	(100 to 1 000) V	1.9 μ V/V + 63 μ V	
DC Current - Source	Up to 220 μ A	36 μ A/A + 0.12 nA	Fluke 5720A Multiproduct Calibrator
	220 μ A to 2.2 mA	33 μ A/A + 1.2 nA	
	(2.2 to 22) mA	34 μ A/A + 12 nA	
DC Current - Source	(22 to 100) mA	42 μ A/A + 0.12 μ A	Fluke 5720A Multiproduct Calibrator with Fluke 5725A Amplifier
	(100 to 220) mA	51 μ A/A	
	220 mA to 1 A	76 μ A/A + 1.5 μ A	
DC Current - Source	(1 to 2.2) A	1.5 mA/A + 66 μ A	Fluke 57x0A Multiproduct Calibrator disciplined with HP 3458A/100 NPLC Option 002 Multimeter
	(2.2 to 11) A	0.3 mA/A + 0.4 mA	
	100 μ A	1.9 nA	
	1 mA	16 nA	
DC Current – Source	10 mA	0.16 μ A	Fluke 5520A Multiproduct Calibrator, Fluke Current Coil
	100 mA	2.3 μ A	
	1 A	49 μ A	
	(10 to 20) A	0.57 % of reading + 21 mA	
DC Current – Measure	(20 to 200) A	0.57 % of reading + 145 mA	Keysight 3458A Multimeter
	(200 to 1 000) A	0.57 % of reading + 510 mA	
	(0 to 100) nA	42 μ A/A + 50 pA	
	(0.1 to 1) μ A	21 μ A/A + 50 pA	
	(1 to 10) μ A	25 μ A/A + 0.11 nA	
	(10 to 100) μ A	25 μ A/A + 0.85 nA	
	(0.1 to 1) mA	22 μ A/A + 6.4 nA	
	(1 to 10) mA	23 μ A/A + 59 nA	
	(10 to 100) mA	41 μ A/A + 0.6 μ A	
	(0.1 to 1) A	125 μ A/A + 12 μ A	
	(1 to 3) A	1.4 mA/A + 0.74 mA	Keysight 34401A Multimeter

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure	10 μ A	0.13 nA	Keysight 3458A Multimeter, Reference Resistors
	200 μ A	1.1 nA	
	2 mA	10 nA	
	20 mA	0.15 μ A	
	100 mA	1 μ A	
	200 mA	1.5 μ A	
	1 A	31 μ A	
	2 A	64 μ A	
	3 A	0.12 mA	
	5 A	0.15 mA	
10 A	0.45 mA		
DC Current - Measure ¹	(0.01 to 15) A	76 μ A/A	Guildline 9230-15, Keysight 3458A, Electronic Load
	(15 A to 100) A	75.5 μ A/A	Guildline 9230-100, Keysight 3458A, Electronic Load
	(100 A to 300) A	130 μ A/A	Guildline 9230-300, Keysight 3458A, Electronic Load
	(300 A to 1 000) A	325 μ A/A	Guildline 9230-1000, Keysight 3458A, Electronic Load
Resistance - Source Fixed Points	1 Ω	8 $\mu\Omega/\Omega$	Fluke 742-1, Fluke 742-10k Resistor
	10 k Ω	4 $\mu\Omega/\Omega$ (trend \pm 1 $\mu\Omega/\Omega$)	
Resistance - Source Fixed Points	0 Ω	0.25 m Ω	Fluke 5720A Multiproduct Calibrator
	1 Ω	0.27 m Ω	
	1.9 Ω	0.31 m Ω	
	10 Ω	0.34 m Ω	
	19 Ω	2.5 m Ω	
	100 Ω	2.7 m Ω	
	190 Ω	3.3 m Ω	
	1 k Ω	9.3 m Ω	
	1.9 k Ω	31 m Ω	
	10 k Ω	93 m Ω	
	19 k Ω	0.19 Ω	
	100 k Ω	1.2 Ω	
	190 k Ω	2.2 Ω	
	1 M Ω	20 Ω	



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance - Source Fixed Points	1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	42 Ω 0.40 kΩ 1.5 kΩ 12 kΩ	Fluke 5720A Multiproduct Calibrator
	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 Multiproduct Calibrator disciplined with HP 3458A Multimeter
Resistance – Source	(0 to 11) Ω (11 to 110) Ω 110 Ω to 1.1 kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 110) kΩ 110 kΩ to 1.1 MΩ (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	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 50 μΩ/Ω + 125 Ω 0.11 mΩ/Ω + 0.2 kΩ 0.21 mΩ/Ω + 2 kΩ 0.41 mΩ/Ω + 2.8 kΩ 2.5 mΩ/Ω + 83 kΩ 13 mΩ/Ω + 0.4 MΩ	Fluke 5520A Multiproduct Calibrator
Resistance – Measure	(0 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	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 65 μΩ/Ω + 132 Ω 0.62 mΩ/Ω + 4.5 kΩ 6.2 mΩ/Ω + 0.35 MΩ	Keysight 3458A Multimeter



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure Fixed Points	1 Ω	11 μΩ	Keysight 3458A Multimeter
	1.9 Ω	15 μΩ	
	10 Ω	47 μΩ	
	19 Ω	0.11 mΩ	
	100 Ω	0.44 mΩ	
	190 Ω	0.5 mΩ	
	1 k Ω	2.4 mΩ	
	1.9 kΩ	4.1 mΩ	
	10 kΩ	20 mΩ	
	19 kΩ	61 mΩ	
	100 kΩ	0.31 Ω	
	190 kΩ	0.6 Ω	
	1 MΩ	5.3 Ω	
	1.9 MΩ	11 Ω	
	10 MΩ	67 Ω	
19 MΩ	0.22 kΩ		
100 MΩ	8.4 kΩ		
AC Voltage - Source	Up to 2.2 mV		Fluke 5720A Multiproduct Calibrator
	(10 to 20) Hz	250 μV/V + 4.1 μV	
	(20 to 40) Hz	94 μV/V + 4.1 μV	
	40 Hz to 20 kHz	83 μV/V + 4.1 μV	
	(20 to 50) kHz	210 μV/V + 4.1 μV	
	(50 to 100) kHz	520 μV/V + 4.1 μV	
	(100 to 300) kHz	1.1 mV/V + 4.1 μV	
	(300 to 500) kHz	1.5 mV/V + 4.1 μV	
	500 kHz to 1 MHz	2.8 mV/V + 4.1 μV	
	Up to 22 mV		
	(10 to 20) Hz	250 μV/V + 4.1 μV	
	(20 to 40) Hz	94 μV/V + 4.1 μV	
	40 Hz to 20 kHz	83 μV/V + 4.1 μV	
	(20 to 50) kHz	210 μV/V + 4.1 μV	
	(50 to 100) kHz	520 μV/V + 4.1 μV	
(100 to 300) kHz	1.1 mV/V + 4.1 μV		
(300 to 500) kHz	1.4 mV/V + 4.1 μV		
500 kHz to 1 MHz	2.8 mV/V + 4.1 μV		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Source	(22 to 220) mV		Fluke 5720A Multiproduct Calibrator
	(10 to 20) Hz	250 $\mu\text{V/V} + 39 \mu\text{V}$	
	(20 to 40) Hz	94 $\mu\text{V/V} + 16 \mu\text{V}$	
	40 Hz to 20 kHz	83 $\mu\text{V/V} + 8.7 \mu\text{V}$	
	(20 to 50) kHz	200 $\mu\text{V/V} + 10 \mu\text{V}$	
	(50 to 100) kHz	470 $\mu\text{V/V} + 210 \mu\text{V}$	
	(100 to 300) kHz	930 $\mu\text{V/V} + 600 \mu\text{V}$	
	(300 to 500) kHz	1.5 mV/V + 190 μV	
	500 kHz to 1 MHz	2.8 mV/V + 300 μV	
	220 mV to 2.2 V		
	(10 to 20) Hz	250 mV/V + 39 μV	
	(20 to 40) Hz	94 $\mu\text{V/V} + 16 \mu\text{V}$	
	40 Hz to 20 kHz	46 $\mu\text{V/V} + 9 \mu\text{V}$	
	(20 to 50) kHz	78 $\mu\text{V/V} + 10 \mu\text{V}$	
	(50 to 100) kHz	100 $\mu\text{V/V} + 70 \mu\text{V}$	
	(100 to 300) kHz	290 $\mu\text{V/V} + 80 \mu\text{V}$	
	(300 to 500) kHz	1.1 mV/V + 200 μV	
	500 kHz to 1 MHz	1.8 mV/V + 300 μV	
	(2.2 to 22) V		
	(10 to 20) Hz	250 $\mu\text{V/V} + 390 \mu\text{V}$	
	(20 to 40) Hz	93 $\mu\text{V/V} + 160 \mu\text{V}$	
	40 Hz to 20 kHz	47 $\mu\text{V/V} + 48 \mu\text{V}$	
	(20 to 50) kHz	78 $\mu\text{V/V} + 100 \mu\text{V}$	
	(50 to 100) kHz	110 $\mu\text{V/V} + 70 \mu\text{V}$	
(100 to 300) kHz	430 $\mu\text{V/V} + 97 \mu\text{V}$		
(300 to 500) kHz	1 mV/V + 2.1 mV		
500 kHz to 1 MHz	1.6 mV/V + 3.3 mV		
(22 to 220) V			
40 Hz to 20 kHz	54 $\mu\text{V/V} + 65 \mu\text{V}$		
(20 to 50) kHz	83 $\mu\text{V/V} + 34 \mu\text{V}$		
(50 to 100) kHz	155 $\mu\text{V/V} + 2.9 \mu\text{V}$		
(100 to 300) kHz	940 $\mu\text{V/V} + 180 \mu\text{V}$		
(300 to 500) kHz	4.6 mV/V + 40 μV		
500 kHz to 1 MHz	8.3 mV/V + 8.4 μV		
(220 to 1 100) V			
40 Hz to 20 kHz	310 $\mu\text{V/V} + 20 \mu\text{V}$		
(20 to 50) kHz	73 $\mu\text{V/V}$		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Source	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 μ V/V + 14 mV 170 μ V/V 620 μ V/V 620 μ V/V 2.35 mV/V	Fluke 5720A Multiproduct Calibrator with Fluke 5725A Amplifier
AC Voltage – Source	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 Up 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 (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	250 μ V/V + 4.1 μ V 94 μ V/V + 4.1 μ V 83 μ V/V + 4.1 μ V 210 μ V/V + 4.1 μ V 520 μ V/V + 4.1 μ V 1.1 mV/V + 4.1 μ V 1.5 mV/V + 4.1 μ V 2.8 mV/V + 4.1 μ V 250 μ V/V + 4.1 μ V 94 μ V/V + 4.1 μ V 83 μ V/V + 4.1 μ V 210 μ V/V + 4.1 μ V 520 μ V/V + 4.1 μ V 1.1 mV/V + 4.1 μ V 1.4 mV/V + 4.1 μ V 2.8 mV/V + 4.1 μ V 250 μ V/V + 39 μ V 94 μ V/V + 16 μ V 60 μ V/V + 7 μ V 120 μ V/V + 8 μ V 320 μ V/V + 18 μ V 680 μ V/V + 20 μ V 1.5 mV/V + 20 μ V 2.8 mV/V + 50 μ V	Fluke 5730A Multiproduct Calibrator



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source	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 mV/V + 39 μV 94 μV/V + 16 μV 43 μV/V + 8.8 μV 70 μV/V + 10 μV 89 μV/V + 30 μV 350 μV/V + 83 μV 1.1 mV/V + 190 μV 1.8 mV/V + 300 μV	Fluke 5730A Multiproduct Calibrator
AC Voltage - Source 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 5700A or Fluke 5720A Multiproduct Calibrator disciplined with Keysight 3458A Multimeter
Fixed Values, Fixed Frequencies	0.01 V 1 kHz 20 kHz 100 kHz 300 kHz 0.1 V 1 kHz 20 kHz 100 kHz 300 kHz 1 V 1 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 3V 100 kHz	2.8 μV 2.9 μV 9 μV 66 μV 5.7 μV 7.8 μV 37 μV 69 μV 55 μV 69 μV 0.13 mV 0.21 mV 0.6 mV 1.7 mV 0.57 mV	Fluke 5700A or Fluke 5720A Multiproduct 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 (cont.) Fixed Values, Fixed Frequencies	10 V		Fluke 5700A or Fluke 5720A Multiproduct 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		
AC Voltage Flatness - Source	300 μ V to 3.5 V (10 to 30) Hz	2.7 mV/V	Fluke 5720A, Fluke 5700A, or Fluke 5700A-03 Multiproduct Calibrator (referenced to 1 kHz)
	30 Hz to 120 kHz	1.4 mV/V	
	300 μ V to 1.1 mV 120 kHz to 2 MHz	4.6 mV/V	
	(2 to 10) MHz	6.2 mV/V	
	(10 to 20) MHz	8 mV/V	
	(20 to 30) MHz	24 mV/V	
	1.1 μ V to 3 mV 120 kHz to 2 MHz	2.2 mV/V	
	(2 to 10) MHz	3.7 mV/V	
	(10 to 20) MHz	5.5 mV/V	
	(20 to 30) MHz	14 mV/V	
	3 mV to 3.5 V 120 kHz to 2 MHz	1.2 mV/V	
	(2 to 10) MHz	2.1 mV/V	
	(10 to 20) MHz	3.8 mV/V	
	(20 to 30) MHz	8.6 mV/V	



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Flatness - Measure	Up to 3 V		Agilent 11049A, Agilent 11050A, Agilent 11051A Thermal Voltage Converters
	10 Hz	0.2 mV/V + 6.9 μ V	
	100 Hz	80 μ V/V + 5.5 μ V	
	(10, 30) kHz	80 μ V/V + 3.2 μ V	
	100 kHz	0.1 mV/V + 8 μ V	
	300 kHz	0.1 mV/V + 5.2 μ V	
	1 MHz	0.1 mV/V + 6.5 μ V	
	3 MHz	1.3 mV/V + 59 μ V	
	8 MHz	1.3 mV/V + 0.11 mV	
	10 MHz	1.3 mV/V + 91 μ V	
	20 MHz	2.5 mV/V + 0.21 mV	
	30 MHz	2.5 mV/V + 0.24 mV	
	50 MHz	6.1 mV/V + 0.34 mV	
	70 MHz	9 mV/V + 0.24 mV	
80 MHz	11 mV/V + 0.79 mV		
100 MHz	13 mV/V + 0.94 mV		
AC Voltage - Measure	Up to 10 mV		Keysight 3458A Multimeter
	(1 to 40) Hz	0.3 mV/V + 3.1 μ V	
	40 Hz to 1 kHz	0.2 mV/V + 1.2 μ V	
	(1 to 20) kHz	0.3 mV/V + 1.7 μ V	
	(20 to 50) kHz	1 mV/V + 1.6 μ V	
	(50 to 100) kHz	5 mV/V + 1.3 μ V	
	(100 to 300) kHz	40 mV/V + 2.1 μ V	
	300 kHz to 1 MHz	12 mV/V + 6.6 μ V	
	(1 to 4) MHz	70 mV/V + 7.5 μ V	
	(4 to 8) MHz	20 mV/V + 8.2 μ V	
	(10 to 100) mV		
	(1 to 40) Hz	70 μ V/V + 4.1 μ V	
	40 Hz to 1 kHz	70 μ V/V + 2.1 μ V	
	(1 to 20) kHz	0.14 mV/V + 2.3 μ V	
	(20 to 50) kHz	0.3 V/V + 2.6 μ V	
	(50 to 100) kHz	0.8 mV/V + 2.3 μ V	
	(100 to 300) kHz	3 mV/V + 15 μ V	
	300 kHz to 1 MHz	10 mV/V + 28 μ V	
	(1 to 2) MHz	15 mV/V + 20 μ V	
	(2 to 4) MHz	40 mV/V + 74 μ V	
(4 to 8) MHz	40 mV/V + 83 μ V		
(8 to 10) MHz	0.15 V/V + 0.11 mV		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	100 mV to 1 V		Keysight 3458A Multimeter
	(1 to 40) Hz	70 μ V/V + 41 μ V	
	40 Hz to 1 kHz	70 μ V/V + 21 μ V	
	(1 to 20) kHz	0.14 mV/V + 22 μ V	
	(20 to 50) kHz	0.3 mV/V + 22 μ V	
	(50 to 100) kHz	0.8 mV/V + 22 μ V	
	(100 to 300) kHz	3 mV/V + 0.12 mV	
	300 kHz to 1 MHz	10 mV/V + 0.3 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	
	(1 to 10) V		
	(1 to 40) Hz	70 μ V/V + 0.42 mV	
	40 Hz to 1 kHz	70 μ V/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	
	(2 to 4) MHz	40 mV/V + 7.1 mV	
	(4 to 8) MHz	40 mV/V + 8.1 mV	
	(8 to 10) MHz	0.15 mV/V + 11 mV	
(10 to 100) V			
(1 to 40) Hz	0.2 mV/V + 4.1 mV		
40 Hz to 20 kHz	0.2 mV/V + 2.6 mV		
(20 to 50) kHz	0.35 mV/V + 2.4 mV		
(50 to 100) kHz	1.2 mV/V + 2.1 mV		
(100 to 300) kHz	4 mV/V + 11 mV		
300 kHz to 1 MHz	15 mV/V + 50 mV		
(100 to 750) V			
(1 to 40) Hz	0.4 mV/V + 31 mV		
40 Hz to 1 kHz	0.4 mV/V + 16 mV		
(1 to 20) kHz	0.6 mV/V + 16 mV		
(20 to 50) kHz	1.2 mV/V + 16 mV		
(50 to 100) kHz	3 mV/V + 15 mV		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	Up to 1 mV		URE3 Voltmeter
	0.02 Hz to 100 kHz	6 mV/V + 90 nV	
	100 kHz to 1 MHz	16 mV/V + 2 μV	
	(1 to 3) MHz	30 mV/V + 9 μV	
	(3 to 10) MHz	90 mV/V + 7 μV	
	(10 to 20) MHz	0.22 V/V + 20 μV	
	(1 to 3) mV		
	0.02 Hz to 100 kHz	6 mV/V + 30 nV	
	100 kHz to 1 MHz	7 mV/V + 5 μV	
	(1 to 3) MHz	33 mV/V + 10 μV	
	(3 to 10) MHz	93 mV/V + 8 μV	
	(10 to 20) MHz	0.24 V/V + 5 μV	
AC Voltage - Measure	(3 to 10) mV		Fluke 5790A Multiproduct Calibrator
	0.02 Hz to 100 kHz	6 mV/V + 10 nV	
	100 kHz to 1 MHz	8 mV/V + 8 μV	
	(1 to 3) MHz	16 mV/V + 20 μV	
	(3 to 10) MHz	26 mV/V + 50 μV	
	(10 to 20) MHz	65 mV/V + 90 μV	
	0.6 mV		
	1 kHz	0.4 μV	
	2 mV		
	10 Hz	2.4 μV	
	20 Hz	1.5 μV	
	40 Hz to 20 kHz	1.2 μV	
50 kHz	1.9 μV		
100 kHz	2.5 μV		
300 kHz	4.3 μV		
500 kHz	5.5 μV		
1 MHz	6.7 μV		
20 mV			
10 Hz	3.8 μV		
20 Hz	2.8 μV		
40 Hz	2 μV		
(1 to 20) kHz	1.9 μV		
50 kHz	3.3 μV		
100 kHz	4.7 μV		
300 kHz	11 μV		
500 kHz	13 μV		
1 MHz	19 μV		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	200 mV		Fluke 5790A Multiproduct Calibrator
	10 Hz	23 μ V	
	20 Hz	10 μ V	
	40 Hz	5.3 μ V	
	1 kHz	5.2 μ V	
	20 kHz	5.4 μ V	
	50 kHz	9.3 μ V	
	100 kHz	20 μ V	
	300 kHz	31 μ V	
	500 kHz	47 μ V	
	1 MHz	0.11 mV	
	0.5 V		
	40 Hz	9.3 μ V	
	1 kHz	9.4 μ V	
	20 kHz	9.6 μ V	
	100 kHz	24 μ V	
	300 kHz	49 μ V	
	1 MHz	0.24 mV	
	1 V		
	40 Hz	14 μ V	
	1 kHz	14 μ V	
	20 kHz	14 μ V	
	100 kHz	38 μ V	
	300 kHz	86 μ V	
	1 MHz	0.51 mV	
	2V		
	10 Hz	0.21 mV	
	20 Hz	75 μ V	
	40 Hz	28 μ V	
	1 kHz	27 μ V	
	20 kHz	27 μ V	
	50 kHz	57 μ V	
100 kHz	77 μ V		
300 kHz	0.17 mV		
500 kHz	0.29 mV		
1 MHz	1 mV		
2.3 V			
1 kHz	32 μ V		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	20 V		Fluke 5790A Multiproduct Calibrator
	10 Hz	2.1 mV	
	20 Hz	0.77 mV	
	40 Hz to 20 kHz	0.31 mV	
	50 kHz	0.51 mV	
	100 kHz	0.86 mV	
	300 kHz	2 mV	
	500 kHz	4.1 mV	
	1 MHz	13 mV	
	200 V		
	10 Hz	22 mV	
	20 Hz	7.8 mV	
	40 Hz	3.7 mV	
	1 kHz	3.6 mV	
	20 kHz	3.7 mV	
	50 kHz	7.3 mV	
	100 kHz	11 mV	
	300 kHz	5.4 mV	
	500 kHz	13 mV	
	1 MHz	25 mV	
	250 V		
	15 Hz	50 mV	
	300 V		
	40 Hz	7.5 mV	
	1 kHz	7.7 mV	
	20 kHz	7.8 mV	
	50 kHz	21 mV	
	100 kHz	78mV	
500 V			
50 Hz	13 mV		
1 kHz	13 mV		
600 V			
40 Hz	15 mV		
1 kHz	16 mV		
20 kV	16 mV		
50 kV	41 mV		
100 kV	0.15 V		



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	1 kV		Fluke 5790A Multiproduct Calibrator
	40 Hz	38 mV	
	50 Hz	38 mV	
	300 Hz	24 mV	
	1 kHz	24mV	
	20 kHz	25 mV	
AC Current Source	30 kHz	72 mV	Fluke 5720A or 5730A Multiproduct Calibrator
	0 to 220 μ A		
	10 to 20 Hz	230 μ A/A + 17 nA	
	20 to 40 Hz	150 μ A/A + 10 nA	
	40 Hz to 1 kHz	108 μ A/A + 8.4 nA	
	1 to 5 kHz	266 μ A/A + 12.5 nA	
	5 to 10 kHz	915 μ A/A + 66 nA	
	220 μ A to 2.2 mA		
	10 to 20 Hz	233 μ A/A + 42 nA	
	20 to 40 Hz	150 μ A/A + 34 nA	
	40 Hz to 1 kHz	108 μ A/A + 34 nA	
	1 to 5 kHz	183 μ A/A + 109 nA	
	5 to 10 kHz	915 μ A/A + 655 nA	
	(2.2 to 22) mA		
	10 to 20 Hz	233 μ A/A + 422 nA	
20 to 40 Hz	149 μ A/A + 342 nA		
40 Hz to 1 kHz	108 μ A/A + 343 nA		
1 to 5 kHz	183 μ A/A + 588 nA		
5 to 10 kHz	915 μ A/A + 5 μ A		
AC Current Source	(22 to 220) mA		Fluke 5720A or 5730A Multiproduct Calibrator
	10 to 20 Hz	233 μ A/A + 4.2 μ A	
	20 to 40 Hz	149 μ A/A + 3.4 μ A	
	40 Hz to 1 kHz	108 μ A/A + 2.6 μ A	
	1 to 5 kHz	183 μ A/A + 3.4 μ A	
	5 to 10 kHz	915 μ A/A + 10 μ A	
	(0.22 to 2.2) A		
	20 Hz to 1 kHz	249 μ A/A + 34 μ A	
	1 to 5 kHz	383 μ A/A + 83 μ A	
	5 to 10 kHz	5.8 mA/A + 166 μ A	
	(2.2 to 11) A		
	20 Hz to 1 kHz	332 μ A/A + 149 μ A	
	1 to 5 kHz	707 μ A/A + 320 μ A	
	5 to 10 kHz	2.8 mA/A + 600 μ A	

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Source	(0 to 0.33) mA 10 to 30 kHz (0.33 to 3.3) mA 10 to 30 kHz (3.3 to 33) mA 10 to 30 kHz (33 to 330) mA 10 to 30 kHz (2.2 to 20.5) A 45 to 100 Hz 100 Hz to 1 kHz 1 to 5 kHz	10 mA/A + 330 nA 6.6 mA/A + 550 nA 2.7 mA/A + 2.7 μA 2.7 mA/A + 160 μA 830 mA/A + 4.2 mA 1.1 mA/A + 3.9 mA 21 mA/A + 1 mA	Fluke 552xA Multiproduct Calibrator
AC Current – Source	(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 100 Hz 100 Hz to 440 Hz (100 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 0.33 % of reading + 50 mA 0.85 % of reading + 3.6 mA 0.85 % of reading + 29 mA 0.85 % of reading + 100 mA 0.85 % of reading + 3.6 mA 0.85 % of reading + 28 mA 1 % of reading + 0.25 A	Fluke 5520A Multiproduct Calibrator, Fluke Current Coil
AC Current - Source 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 5700A or Fluke 5720A Multiproduct Calibrator disciplined with Keysight 3458A Multimeter



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Measure	Up to 100 μ A		Keysight 3458A Multimeter
	(10 to 20) Hz	4 mA/A + 31 nA	
	(20 to 45) Hz	1.5 mA/A + 31 nA	
	45 Hz to 1 kHz	0.6 mA/A + 31 nA	
	100 μ A to 1 mA		
	(10 to 20) Hz	4 mA/A + 0.31 μ A	
	(20 to 45) Hz	0.15 mA/A + 0.21 μ A	
	45 Hz to 1 kHz	0.6 mA/A + 0.21 μ A	
	(1 to 10) mA		
	(10 to 20) Hz	4 mA/A + 3.1 μ A	
	(20 to 45) Hz	1.5 mA/A + 2.1 μ A	
	45 Hz to 1 kHz	0.6 mA/A + 2.1 μ A	
	(10 to 100) mA		
	(10 to 20) Hz	4 mA/A + 31 μ A	
(20 to 45) Hz	1.5 mA/A + 21 μ A		
45 Hz to 1 kHz	0.6 mA/A + 21 μ A		
100 mA to 1.05 A			
(10 to 20) Hz	4 mA/A + 0.22 mA		
(20 to 45) Hz	1.6 mA/A + 0.22 mA		
(45 to 100) Hz	0.8 mA/A + 0.22 mA		
100 Hz to 5 kHz	1 mA/A + 0.22 mA		
AC Current – Measure	20 μ A		Fluke 5790A Multiproduct Calibrator ET22703
	1 kHz, 10 kHz	2.8 nA	
	200 μ A		
	10 Hz	31 nA	
	20 Hz	23 nA	
	40 Hz	21 nA	
	(1 to 5) kHz	21 nA	
	10 kHz	21 nA	
	2 mA		
	10 Hz	0.27 μ A	
	20 Hz	0.18 μ A	
	40 Hz	0.15 μ A	
	(1 to 5) kHz	0.15 μ A	
	10 kHz	0.15 μ A	



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure	20 mA		Fluke 5790A Multiproduct Calibrator ET22703
	10 Hz	2.6 μ A	
	20 Hz	1.6 μ A	
	40 Hz to 10 kHz	1.3 μ A	
	200 mA		
	10 Hz	26 μ A	
	20 Hz	16 μ A	
	40 Hz to 10 kHz	13 μ A	
	2A		
	20 Hz	0.19 mA	
	40 Hz	0.17 mA	
	1 kHz	0.17 mA	
	5 kHz	0.17 mA	
	10 kHz	0.59 mA	
	3A		
40 Hz	64 μ A		
1 kHz	93 μ A		
5 kHz	93 μ A		
10 kHz	0.2 mA		
10 A			
40 Hz	0.36 mA		
1 kHz	0.39 mA		
5 kHz	0.79 mA		
10 kHz	8 mA		
Voltage Ratio - Source 1 kHz	Decades 1 and 2 All Other Decades	1.1 x 10 ⁻⁶ input 0.51 x 10 ⁻⁶ input	DT-72 Ratio Transformer
Resistance - Source DC to 1 MHz, Direct Measurement	0.1 Ω (1, 10) Ω 100 Ω (1, 10, 100) k Ω	10 m Ω / Ω 1 m Ω / Ω 0.3 m Ω / Ω 0.3 m Ω / Ω	Agilent 16074A RL Standard
Resistance Source, High Resistance	1 G Ω 10 G Ω 100 G Ω	0.23 M Ω 2.7 M Ω 24 M Ω	Agilent 16340A RC Calibration Fixture
Capacitance - Source Direct Measure 1 kHz	(1, 10, 100) pF (1, 10, 100) nF 1 μ F	0.1 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance - Source Algorithmic Derivation	1 pF		Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair
	1 MHz	50 μ F/F	
	2 MHz	60 μ F/F	
	3 MHz	1 mF/F	
	4 MHz	2 mF/F	
	5 MHz	3 mF/F	
	10 MHz	10 mF/F	
	13 MHz	15 mF/F	
	(10, 100) pF		
	(1, 2) MHz	0.25 mF/F	
	3 MHz	3 mF/F	
	4 MHz	4 mF/F	
	5 MHz	6 mF/F	
	10 MHz	15 mF/F	
	13 MHz	20 mF/F	
1 nF	1 MHz	0.5 mF/F	
	2 MHz	0.6 mF/F	
	3 MHz	1 mF/F	
	4 MHz	1.5 mF/F	
	5 MHz	2 mF/F	
	10 MHz	5 mF/F	
	13 MHz	7 mF/F	
Capacitance - Source Substitution Method 120 Hz to 10 kHz 100 kHz	(0.01, 0.1, 1) μ F	0.25 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair
	(0.01, 0.1) μ F	0.5 mF/F	
	1 μ F	1 mF/F	
Capacitance - Source Direct Measure 10 Hz to 1 kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz	(3.3 to 33) nF	4 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair
	330 nF to 110 μ F	4 mF/F	
	(110 to 330) μ F	4 mF/F	
	(3.3 to 11) μ F	4 mF/F	
		4 mF/F	
Electrical Simulation of Thermocouples	Type B		Fluke 5520A, Fluke 5522A Multiproduct Calibrator
	(600 to 800) $^{\circ}$ C	0.47 $^{\circ}$ C	
	(800 to 1 000) $^{\circ}$ C	0.36 $^{\circ}$ C	
	(1 000 to 1 550) $^{\circ}$ C	0.32 $^{\circ}$ C	
	(1 550 to 1 820) $^{\circ}$ C	0.35 $^{\circ}$ C	



Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouples	Type C (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1800) °C (1 800 to 2316) °C	0.32 °C 0.28 °C 0.33 °C 0.53 °C 0.88 °C	Fluke 5520A, Fluke 5522A Multiproduct Calibrator
	Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 1000) °C	0.53 °C 0.18 °C 0.16 °C 0.18 °C 0.23 °C	
	Type J (-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1 200) °C	0.29 °C 0.18 °C 0.16 °C 0.19 °C 0.25 °C	
	Type K (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1 000) °C (1 000 to 1 372) °C	0.35 °C 0.2 °C 0.18 °C 0.28 °C 0.42 °C	
	Type L (-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.39 °C 0.28 °C 0.19 °C	
	Type N (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1 300) °C	0.42 °C 0.24 °C 0.21 °C 0.2 °C 0.29 °C	
	Type R (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (1 000 to 1 767) °C	0.6 °C 0.37 °C 0.35 °C 0.42 °C	

Electrical - DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouples	Type S		Fluke 5520A, Fluke 5522A Multiproduct Calibrator
	(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	
	Type T		
	(-250 to -150) °C	0.66 °C	
	(-150 to 0) °C	0.26 °C	
	(0 to 120) °C	0.18 °C	
(120 to 400) °C	0.16 °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 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 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 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 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 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 ² (EVM)	Mod Frequency Span: f ≤ 100kHz 100kHz ≤ f ≤ 1MHz f > 1MHz	0.43 % 0.48 % 0.82 %	HP 89441A Vector Signal Analyzer
Phase Error	Mod Frequency Span: f ≤ 100kHz 100kHz ≤ f ≤ 1MHz f > 1MHz	0.17 ° rms 0.34 ° rms 0.57 ° rms	
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	
Modulation Accuracy (Rho)	Mod Frequency Span: f ≤ 100kHz 0.9999 ≤ ρ ≤ 1 0.9975 ≤ ρ < 0.9999 0.9936 ≤ ρ < 0.9975 0.99 ≤ ρ < 0.9936 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	



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
Modulation Accuracy (Rho)	Mod Frequency Span: 100 kHz ≤ f ≤ 1 MHz 0.9999 ≤ ρ ≤ 1 0.9975 ≤ ρ < 0.9999 0.9936 ≤ ρ < 0.9975 0.99 ≤ ρ < 0.9936 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	
	Mod Frequency Span: f > 1MHz 0.9999 ≤ ρ ≤ 1 0.9975 ≤ ρ < 0.9999 0.9936 ≤ ρ < 0.9975 0.99 ≤ ρ < 0.9936 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		
Phase Modulation – Measure	(0.15 to 10) MHz Rate: (0.02 to 10) kHz	4.1 % Deviation	HP 8902A Measuring Receiver	
	(0.01 to 26.5) GHz Rate: (0.2 to 20) kHz	3.1 % Deviation		
Phase Modulation – Measure	100 kHz to 6.6 GHz Deviations: (0.3 to 7) rad Deviations: > 7 rad	3.1 % Deviation 1 % Deviation	Keysight E444xA with Opt. 233 Spectrum Analyzer	
	(6.6 to 13.2) GHz Deviations: (0.6 to 2) rad	3.1 % Deviation		
	(13.2 to 26.5) GHz Deviations: > 2 rad	1 % Deviation		
	Deviations: (1.2 to 4) rad	3.1 % Deviation		
	(26.5 to 31.5) GHz Deviations: > 4 rad	1 % Deviation		
	Deviations: (1.3 to 4) rad	3.1 % Deviation		
(31.5 to 50) GHz Deviations: > 4 rad Deviations (2.4 to 8) rad Deviations: > 8 rad	1 % Deviation 3.1 % Deviation 1 % Deviation			
	Distortion Measure	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	HP 8903A/B Audio Analyzer



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Power Meter Reference	1 mW 50 MHz	0.22 % of reading	Agilent 432A or N432A Power Meter, Agilent 478A Option H75 or H76 Power Sensor
Tuned RF Power - Absolute - Measure 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 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 - Calibration Factors	(9 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 3 MHz (3 to 10) MHz (10 to 300) MHz 300 MHz to 1 GHz (1 to 1.5) GHz (1.5 to 4) GHz	0.57 % of reading 0.67 % of reading 0.49 % of reading 0.46 % of reading 0.45 % of reading 0.4 % of reading 0.5 % of reading 0.51 % of reading 0.5 % of reading	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors

Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensors - Calibration Factors	(4 to 5) GHz	0.51 % of reading	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors
	(5 to 6) GHz	0.6 % of reading	
	(6 to 9) GHz	0.62 % of reading	
	(9 to 10) GHz	0.71 % of reading	
	(10 to 11) GHz	0.74 % of reading	
	(11 to 12) GHz	0.72 % of reading	
	(12 to 12.4) GHz	0.68 % of reading	
	(12.4 to 13) GHz	0.73 % of reading	
	(13 to 14) GHz	0.7 % of reading	
	(14 to 15) GHz	0.72 % of reading	
	(15 to 16) GHz	0.74 % of reading	
	(16 to 17) GHz	0.82 % of reading	
	(17 to 18) GHz	0.83 % of reading	
	(18 to 19) GHz	0.89 % of reading	
	(19 to 20) GHz	1.2 % of reading	
	(20 to 21) GHz	1.2 % of reading	
	(21 to 22) GHz	1.2 % of reading	
	(22 to 24) GHz	1.2 % of reading	
	(24 to 26) GHz	1.2 % of reading	
	(26 to 26.5) GHz	1.2 % of reading	
	(26.5 to 27) GHz	0.93 % of reading	
	(27 to 28) GHz	0.9 % of reading	
	(28 to 29) GHz	0.88 % of reading	
	(29 to 30) GHz	0.89 % of reading	
	(30 to 32) GHz	0.91 % of reading	
	(32 to 34) GHz	0.92 % of reading	
	(34 to 35) GHz	0.93 % of reading	
	(35 to 36) GHz	0.92 % of reading	
(36 to 37) GHz	0.91 % of reading		
(37 to 38) GHz	0.90 % of reading		
(38 to 39) GHz	0.89 % of reading		
(39 to 40) GHz	0.88 % of reading		
(40 to 41) GHz	0.91 % of reading		
(41 to 42) GHz	1.1 % of reading		
(42 to 43) GHz	1.1 % of reading		
(43 to 44) GHz	1.1 % of reading		
(44 to 45) GHz	1.1 % of reading		
(45 to 46) GHz	1.2 % of reading		
(46 to 47) GHz	1.1 % of reading		



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensors - Calibration Factors	(47 to 48) GHz	1.1 % Deviation	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors
	(48 to 49) GHz	1.1 % of reading	
	(49 to 50) GHz	1.1 % of reading	
	(50 to 51) GHz	1.1 % of reading	
	(51 to 52) GHz	4.6 % of reading	
	(52 to 53) GHz	4.4 % of reading	
	(53 to 54) GHz	4.1 % of reading	
	(54 to 55) GHz	3.8 % of reading	
	(55 to 56) GHz	3.7 % of reading	
	(56 to 57) GHz	3.8 % of reading	
	(57 to 58) GHz	4.2 % of reading	
	(58 to 59) GHz	4.5 % of reading	
	(59 to 60) GHz	4.7 % of reading	
	(60 to 61) GHz	4.8 % of reading	
	(61 to 62) GHz	4.6 % of reading	
	(62 to 63) GHz	4.4 % of reading	
	(63 to 64) GHz	4.2 % of reading	
	(64 to 65) GHz	4.1 % of reading	
(65 to 66) GHz	4.1 % of reading		
(66 to 67) GHz	4.2 % of reading		
67 GHz	4.4 % of reading		
50 MHz	0.3 % of reading		
RF Absolute Power - Source 50 MHz	-1 dB to -11 dB	0.025 dB	Signal Source and Step Attenuators PSG, ESG, 8496G/H and 8494G/H
	-10 dB to -30 dB	0.025 dB	
	-40 dB to -50 dB	0.027 dB	
	-60 dB	0.028 dB	
	-70 dB to -90 dB	0.033 dB	
	-100 dB	0.04 dB	
	-110 dB	0.048 dB	
RF Absolute Power - Source	$0.02 \text{ V} \leq V < 7 \text{ V}$ $f < 10 \text{ MHz}$	0.082 dB	Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A Multimeter
	$10 \text{ MHz} \leq f \leq 50 \text{ MHz}$	0.16 dB	
	$50 \text{ MHz} \leq f \leq 80 \text{ MHz}$	0.4 dB	
	$V \leq 10 \text{ mV}$ $20 \text{ Hz} \leq f \leq 20 \text{ kHz}$	0.017 mV	
	$20 \text{ kHz} < f \leq 50 \text{ kHz}$	0.021 mV	
	$50 \text{ kHz} < f \leq 100 \text{ kHz}$	0.05 mV	
	$100 \text{ kHz} < f \leq 300 \text{ kHz}$	0.38 mV	



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power - Source	10 mV < V ≤ 100 mV		Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A Multimeter
	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	
	100 mV < V ≤ 1 V		
	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		
RF Absolute Power - Source	7dBm ≥ P ≥ 0 dBm		Signal Source PSG, ESG
	0.3 MHz ≤ f ≤ 1.1 GHz	0.49 dB	
	1.1 GHz ≤ f ≤ 2.985 GHz	0.58 dB	
	2.985 GHz < f ≤ 4 GHz	0.69 dB	
	4 GHz < f ≤ 6 GHz	0.79 dB	
	0 dBm > P ≥ -25 dBm		
	0.3 MHz ≤ f ≤ 1.1 GHz	0.49 dB	
	1.1 GHz ≤ f ≤ 2.985 GHz	0.59 dB	
	2.985 GHz < f ≤ 4 GHz	0.69 dB	
	4 GHz < f ≤ 6 GHz	0.8 dB	
	-25 dBm > P ≥ -70 dBm		
	0.3 MHz ≤ f ≤ 1.1 GHz	0.5 dB	
1.1 GHz ≤ f ≤ 2.985 GHz	0.59 dB		
2.985 GHz < f ≤ 4 GHz	0.69 dB		
4 GHz < f ≤ 6 GHz	0.8 dB		



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power - Source	-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	0.5 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
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 0.06 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
Thermal Noise - Source ENR (14 to 16) dB	10 MHz to 18 GHz SWR 1.25:1 (18 to 26.5) GHz SWR 1.35:1	0.21 dB 0.22 dB	HP 346B w/ APC-3.5 Noise Source



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise for Signal Analyzers Carrier 1 GHz Offsets: 0.1 kHz 1 kHz 10 kHz 30 kHz	Phase Noise Measurement dBc/Hz		Wenzel 500-13438C Oscillator
	$-84 \geq \text{PN} \leq -94$	1.1 dB	
	$-94 < \text{PN} \leq -95$	1.2 dB	
	$-95 < \text{PN} \leq -98$	1.4 dB	
	$-98 < \text{PN} \leq -100$	1.8 dB	
	$-100 < \text{PN} \leq -102$	2.4 dB	
	$-102 < \text{PN} \leq -105$	3.4 dB	
	$-78 \geq \text{PN} \leq -115$	0.75 dB	
	$-115 < \text{PN} \leq -121$	0.82 dB	
	$-121 < \text{PN} \leq -123$	0.91 dB	
	$-123 < \text{PN} \leq -125$	1.1 dB	
	$-125 < \text{PN} \leq -129$	1.9 dB	
	$-129 < \text{PN} \leq -130$	2.1 dB	
	$-130 < \text{PN} \leq -133$	3.3 dB	
	$-90 \geq \text{PN} \leq -129$	0.43 dB	
	$-129 < \text{PN} \leq -132$	0.45 dB	
	$-132 < \text{PN} \leq -135$	0.54 dB	
	$-135 < \text{PN} \leq -138$	0.74 dB	
	$-138 < \text{PN} \leq -142$	1.2 dB	
	$-142 < \text{PN} \leq -145$	2.1 dB	
	$-106 \geq \text{PN} \leq -112$	0.56 dB	
	$-112 < \text{PN} \leq -132$	0.57 dB	
	$-132 < \text{PN} \leq -134$	0.59 dB	
	$-134 < \text{PN} \leq -137$	0.65 dB	
	$-137 < \text{PN} \leq -140$	0.82 dB	
	$-140 < \text{PN} \leq -143$	1.3 dB	
	$-143 < \text{PN} \leq -144$	1.5 dB	
$-144 < \text{PN} \leq -147$	2.1 dB		



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise for Signal Analyzers Carrier 1 GHz Offsets: 100 kHz 1 MHz	Phase Noise Measurement dBc/Hz -102 ≥ PN ≤ -131 -131 < PN ≤ -132 -132 < PN ≤ -136 -136 < PN ≤ -139 -139 < PN ≤ -142 -142 < PN ≤ -145 -145 < PN ≤ -146 -146 < PN ≤ -149 -120 ≥ PN ≤ -139 -139 < PN ≤ -142 -142 < PN ≤ -145 -143 < PN ≤ -148 -148 < PN ≤ -150 -150 < PN ≤ -152 -152 < PN ≤ -155 -155 < PN ≤ -158	 0.55 dB 0.56 dB 0.58 dB 0.64 dB 0.81 dB 1.3 dB 1.5 dB 2.1 dB 0.55 dB 0.56 dB 0.58 dB 0.64 dB 0.74 dB 0.93 dB 1.5 dB 2.1 dB	 Wenzel 500-13438C Oscillator
Phase Noise for Signal Analyzers Carrier 1 GHz Offsets 9.9 and 10 MHz	Phase Noise Measurement dBc/Hz -131 ≥ PN ≤ -136 -136 < PN ≤ -156 -156 < PN ≤ -158 -158 < PN ≤ -159 -159 < PN ≤ -162 -162 < PN ≤ -165	 0.69 dB 0.79 dB 0.91 dB 1 dB 1.5 dB 2.1 dB	 Wenzel 500-13438C Oscillator
Rise Time	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
Pulse - Source Transition Time	<100 ps	0.13 ns	HP 8133A Pulse Generator



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pulse - Source Width	150 ps to 10 ns (10 to 100) ns 100 μs to 10 ms (10 to 100) ms 100 ms 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	HP 8161A Pulse Generator
Pulse - Source RMS Jitter - Period, Delay and Width	33 MHz to 3 GHz	10 ps	HP 8133A Pulse Generator
Phase Noise for Signal Sources			Keysight E5500 Phase Noise System
Offset Frequency	$(L_{REF} - L_{DUT}) \geq 10\text{dB}$		
≤ 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	
Offset Frequency	$10\text{dB} > (L_{REF} - L_{DUT}) \geq 5\text{dB}$		
≤ 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	
< 100 MHz	50 kHz < f ≤ 26.5 GHz	± 5.3 dB	
Offset Frequency	$5\text{dB} > (L_{REF} - L_{DUT}) \geq 3\text{dB}$		
≤ 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	
Offset Frequency	$3\text{dB} > (L_{REF} - L_{DUT}) \geq 0\text{dB}$		
≤ 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 Offset Frequency ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 100 kHz ≤ 1 MHz ≤ 10 MHz < 100 MHz	3 dB > (L _{REF} - L _{DUT}) ≥ 0 dB ≤ 100 MHz 100 MHz < f ≤ 255 MHz 255 MHz < f ≤ 600 MHz 600 MHz < f ≤ 1.8 GHz 1.8 GHz < f ≤ 3.2 GHz 3.2 GHz < f ≤ 10 GHz 10 GHz < f ≤ 20 GHz 20 GHz < f ≤ 26.5 GHz 50 kHz < f ≤ 26.5 GHz 50 kHz < f ≤ 26.5 GHz 50 kHz < f ≤ 26.5 GHz	± 4.3 dB ± 4.6 dB ± 4.6 dB ± 4.5 dB ± 4.5 dB ± 4.8 dB ± 4.8 dB ± 4.5 dB ± 4.7 dB ± 6.2 dB ± 6.2 dB	Keysight E5500 Phase Noise System
Thermal Noise - Measure	(5 to 22) 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	0.10 dB 0.09 dB 0.09 dB 0.09 dB 0.08 dB 0.06 dB 0.11 dB 0.11 dB 0.09 dB 0.07 dB 0.04 dB 0.04 dB 0.07 dB 0.07 dB 0.07 dB 0.07 dB 0.08 dB 0.1 dB 0.06 dB 0.07 dB 0.1 dB 0.08 dB 0.09 dB 0.1 dB 0.1 dB	HP 346A/B/C, 346C K01, R347B, Q347B Noise Source



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thermal Noise - Measure	(5 to 22) dB		HP 346A/B/C, 346C K01, R347B, Q347B Noise Source
	23 GHz	0.1 dB	
	24 GHz	0.09 dB	
	25 GHz	0.07 dB	
	26 GHz	0.09 dB	
	26.5 GHz	0.1 dB	
	27 GHz	0.1 dB	
	28 GHz	0.08 dB	
	29 GHz	0.09 dB	
	30 GHz	0.1 dB	
	31 GHz	0.11 dB	
	32 GHz	0.1 dB	
	33 GHz	0.08 dB	
	34 GHz	0.09 dB	
	35 GHz	0.1 dB	
	36 GHz	0.12 dB	
	37 GHz	0.12 dB	
	38 GHz	0.1 dB	
	39 GHz	0.1 dB	
	40 GHz	0.1 dB	
	41 GHz	0.13 dB	
	42 GHz	0.15 dB	
	43 GHz	0.17 dB	
	44 GHz	0.19 dB	
	44.5 GHz	0.18 dB	
	45 GHz	0.18 dB	
46 GHz	0.1 dB		
47 GHz	0.11 dB		
48 GHz	0.11 dB		
49 GHz	0.12 dB		
50 GHz	0.16 dB		



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment			
Attenuation - Source Coaxial, 1 dB Steps (0 to 11) dB	3 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB	HP 8496G w/ Type-N(f) Step Attenuator		
	4 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	5 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	6 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	7 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	8 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	9 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	10 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	11 dB	50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	Attenuation – Source Coaxial, 10 dB Steps	0 dB	50 MHz to 2 GHz (2 to 4) GHz		0.03 dB 0.03 dB	HP 8496G With Type-N(f) Step Attenuator
		10 dB	50 MHz to 2 GHz (2 to 4) GHz		0.03 dB 0.03 dB	
		20 dB	50 MHz to 2 GHz (2 to 4) GHz		0.03 dB 0.03 dB	
		30 dB	50 MHz to 2 GHz (2 to 4) GHz		0.04 dB 0.04 dB	

Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment			
Attenuation – Source Coaxial, 10 dB Steps	40 dB	50 MHz to 2 GHz (2 to 4) GHz	0.06 dB 0.05 dB	HP 8496G With Type-N(f) Step Attenuator		
	50 dB	50 MHz to 2 GHz (2 to 4) GHz	0.06 dB 0.06 dB			
	60 dB	50 MHz to 2 GHz (2 to 4) GHz	0.07 dB 0.06 dB			
	70 dB	50 MHz to 2 GHz (2 to 4) GHz	0.07 dB 0.06 dB			
	80 dB	50 MHz to 2 GHz (2 to 4) GHz	0.09 dB 0.07 dB			
	90 dB	50 MHz to 2 GHz (2 to 4) GHz	0.09 dB 0.08 dB			
	100 dB	50 MHz to 2 GHz (2 to 4) GHz	0.1 dB 0.08 dB			
	110 dB	50 MHz to 2 GHz (2 to 4) GHz	0.11 dB 0.08 dB			
	Attenuation - Source Coaxial, Fixed	3 dB	DC to 2 GHz, SWR < 1.25:1 (2 to 4) GHz, SWR < 1.2:1 (4 to 18) GHz, SWR < 1.2:1		0.03 dB 0.03 dB 0.06 dB	HP 8491A/B With Type-N Step Attenuator
		6 dB	DC to 2 GHz, SWR < 1.25:1 (2 to 4) GHz, SWR < 1.2:1 (4 to 18) GHz, SWR < 1.2:1		0.03 dB 0.03 dB 0.06 dB	



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation - Source Coaxial, Fixed	10 dB DC to 2 GHz, SWR < 1.25:1 (2 to 4) GHz, SWR < 1.2:1 (4 to 18) GHz, SWR < 1.2:1	0.03 dB 0.03 dB 0.06 dB	HP 8491A/B With Type-N Step Attenuator
	20 dB DC to 2 GHz, SWR < 1.25:1 (2 to 4) GHz, SWR < 1.2:1 (4 to 18) GHz, SWR < 1.2:1	0.03 dB 0.03 dB 0.06 dB	
	1 dB steps (1 to 3) dB (4 to 11) dB 12 dB	0.003 dB 0.003 dB 0.003 dB	
	1 dB steps (1 to 9) dB (10 to 12) dB	0.005 dB 0.005 dB	
Attenuation - Measure 20 Hz to 50 MHz	(1 to 3) dB (4 to 11) dB 12 dB	0.003 dB 0.003 dB 0.003 dB	ESI PRT 73 Ratio Transformer 35670A Signal Analyzer
>50 MHz to 1 GHz	(1 to 9) dB (10 to 12) dB	0.005 dB 0.005 dB	
>1 GHz to 2 GHz	(1 to 12) dB	0.006 dB	
>2 GHz to 4 GHz	(1 to 2) dB (3 to 12) dB	0.008 dB 0.008 dB	
Attenuation - Measure 10 dB steps	20 Hz to 50 MHz		ESI PRT 73 Ratio Transformer 35670A Signal Analyzer
	10 dB	0.003 dB	
	20 dB	0.004 dB	
	30 dB	0.004 dB	
	40 dB	0.007 dB	
	50 dB	0.009 dB	
	60 dB	0.01 dB	
	70 dB	0.02 dB	
	80 dB	0.02 dB	
	90 dB	0.02 dB	
	100 dB	0.03 dB	
110 dB	0.04 dB		



Electrical RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation - Measure 10 dB steps	>50 MHz to 1 GHz		ESI PRT 73 Ratio Transformer 35670A Signal Analyzer
	10 dB	0.005 dB	
	20 dB	0.007 dB	
	30 dB	0.009 dB	
	40 dB	0.02 dB	
	50 dB	0.02 dB	
	60 dB	0.02 dB	
	70 dB	0.03 dB	
	80 dB	0.04 dB	
	90 dB	0.04 dB	
	100 dB	0.06 dB	
	110 dB	0.07 dB	
	>1 GHz to 2 GHz		
	10 dB	0.007 dB	
	20 dB	0.01 dB	
	30 dB	0.01 dB	
	40 dB	0.02 dB	
	50 dB	0.03 dB	
	60 dB	0.03 dB	
	70 dB	0.04 dB	
	80 dB	0.05 dB	
	90 dB	0.06 dB	
	100 dB	0.08 dB	
	110 dB	0.1 dB	
	2 GHz to 4 GHz		
	10 dB	0.007 dB	
	20 dB	0.01 dB	
	30 dB	0.02 dB	
	40 dB	0.03 dB	
	50 dB	0.03 dB	
	60 dB	0.04 dB	
	70 dB	0.06 dB	
	80 dB	0.07 dB	
90 dB	0.08 dB		
100 dB	0.11 dB		
110 dB	0.14 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

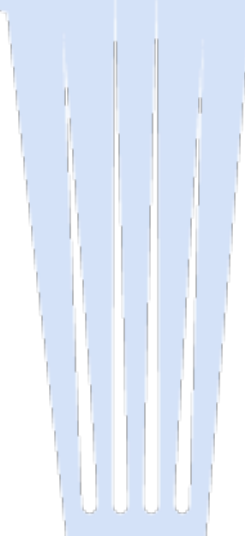


PARAMETER	Attenuation - Measure											
REFERENCE STANDARD OR EQUIPMENT	N5230A/C + cal kit											
Attenuation Levels (dB)												
Frequency Ranges	0	1	2	3	4	5	6	7	8	9	10	11
10 MHz ≤ f < 300 MHz	0.028	0.03	0.031	0.03	0.032	0.033	0.032	0.034	0.035	0.035	0.035	0.037
300 MHz ≤ f < 2 GHz	0.028	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	RF Absolute Power Measure										
REFERENCE STANDARD OR EQUIPMENT	8482A, 8485A, 8487A, V8486A, 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										
REFERENCE STANDARD OR EQUIPMENT	8482A, 8485A, 8487A, V8486A, 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	f = 51 GHz	52 GHz ≤ f ≤ 54 GHz	f = 55 GHz	56 GHz ≤ f ≤ 59 GHz	f = 60 GHz	f = 61 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	0.34	0.33	0.29	0.34	0.3	0.34
-20 dBm ≤ P < -10 dBm	0.07	0.05	0.05	0.06	0.06	0.34	0.33	0.29	0.34	0.3	0.34
-10 dBm ≤ P < 0 dBm	0.07	0.06	0.06	0.06	0.06	0.34	0.33	0.29	0.34	0.3	0.34
-1 dBm ≤ P < 2 dBm	0.07	0.05	0.05	0.06	0.06	0.34	0.33	0.29	0.34	0.3	0.34
2 dBm ≤ P < 10 dBm	0.13	0.15	0.15	0.21	0.23	0.34	0.33	0.29	0.34	0.3	0.34
10 dBm ≤ P < 15 dBm	0.07	0.06	0.06	0.06	0.06	0.34	0.34	0.3	0.34	0.3	0.35
15 dBm ≤ P < 20 dBm	0.08	0.07	0.07	0.07	0.07	0.34	0.34	0.3	0.34	0.3	0.35
20 dBm ≤ P < 30 dBm	0.172										

PARAMETER	RF Absolute Power Measure				
REFERENCE STANDARD OR EQUIPMENT	8482A, 8485A, 8487A, V8486A, N8481B, N8482B, N9030A, E444xA, E9300A, E9304A, N8485A				
	Frequencies / Frequency Ranges (uncertainties in dB)				
Frequency Range	f = 62 GHz	63 GHz ≤ f ≤ 64 GHz	f = 65 GHz	f = 66 GHz	f = 67 GHz
-30 dBm ≤ P < -20 dBm	0.34	0.33	0.29	0.35	0.36
-20 dBm ≤ P < -10 dBm	0.34	0.33	0.29	0.35	0.36
-10 dBm ≤ P < 0 dBm	0.34	0.33	0.29	0.35	0.36
-1 dBm ≤ P < 2 dBm	0.34	0.33	0.29	0.35	0.36
2 dBm ≤ P < 10 dBm	0.34	0.33	0.29	0.35	0.36
10 dBm ≤ P < 15 dBm	0.34	0.34	0.2	0.36	0.36
15 dBm ≤ P < 20 dBm	0.34	0.34	0.2	0.36	0.36



PARAMETER	(S11 - Reflection) Magnitude Uncertainty (lin)									
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B									
Freq	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
(0.02 to 2) GHz	0.00054	0.00062	0.0007	0.00081	0.00093	0.0011	0.0012	0.0014	0.0016	0.0017
(2 to 8) GHz	0.00078	0.00082	0.00089	0.00098	0.0011	0.0012	0.0014	0.0015	0.0017	0.0019
(8 to 20) GHz	0.0014	0.0014	0.0015	0.0015	0.0016	0.0017	0.0018	0.002	0.0023	0.0026
(20 to 26.5) GHz	0.0019	0.0019	0.0019	0.002	0.002	0.0021	0.0023	0.0025	0.0027	0.0031
(26.5 to 40) GHz	0.0039	0.0041	0.0044	0.0049	0.0056	0.0066	0.0077	0.0091	0.011	0.012
(40 to 50) GHz	0.0052	0.0054	0.0058	0.0063	0.007	0.0081	0.0095	0.011	0.013	0.015
(50 to 67) GHz	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.018	0.018	0.019

PARAMETER	(S11 - Reflection) Phase Uncertainty (deg)									
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B									
Freq:	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
(0.02 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
(50 to 67) GHz	7.7	3.8	2.6	1.9	1.6	1.3	1.2	1	0.95	0.88



PARAMETER	(S21 - Transmission) Magnitude Uncertainty (dB)								
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B								
Freq:	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
(20 to 130) MHz	0.016	0.015	0.015	0.017	0.02	0.03	0.052	0.074	0.13
(0.13 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
(50 to 67) GHz	0.094	0.094	0.095	0.096	0.099	0.11	0.14	0.28	0.78

PARAMETER	(S21 - Transmission) Phase Uncertainty (deg)								
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B								
Freq:	Measured Magnitude (+/- Degrees)								
	10 to ≤ 0	> 0 to ≤ 3	> 3 to ≤ 6	> 6 to ≤ -0	> 10 to ≤ 20	> 20 to ≤ 30	> 30 to ≤ 40	> 40 to ≤ 50	> 50 to ≤ 60
(20 to 130) MHz	0.16	0.16	0.16	0.17	0.19	0.26	0.66	0.6	0.92
(0.13 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
(50 to 67) GHz	0.63	0.63	0.64	0.66	0.67	0.76	0.97	1.9	5.5



Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque	8 in·lbf 12 in·lbf	0.10 in·lbf 0.13 in·lbf	Mountz EZ50I Torque Analyzer
Pressure	(70 to 110) kPa	0.02 kPa	DH Instruments RPM4 Pressure Monitor

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Laser Optical Power - Measure	(80 to 1 000) μ W (488 to 788) nm	5.9% * Output Power	Laser Power Meter Vega Photodiode PD300-1W
Laser Wavelength - Measure	633 nm	5.1×10^{-6} nm	HP 5517B Laser Head/5508A Display
Optical Power - Measure	850 nm -10 dBm (10 to -60) dBm 1 310 nm -10 dBm (10 to -60) dBm 1 550 nm -10 dBm (10 to -60) dBm	0.06 dB 0.08 dB 0.06 dB 0.08 dB 0.06 dB 0.08 dB	81520A, 81623B, 81626B Optical Head
Optical Power - Source	(10 to -60) dBm (600 to 1 020) nm (1 020 to 1 800) nm	0.11 dB 0.09 dB	Agilent 81520A, 81623B, 81626B Optical Head
Optical Power Stability - Source 600 nm to 1 020 nm 1 020 nm to 1 800 nm	(10 to -60) dBm (10 to -60) dBm	0.001 dB 0.002 dB	81520A, 81623B, 81626B Optical Head
Optical Wavelength - Measure	1 310 nm 1 530 nm 1 550 nm $600 \text{ nm} \leq \lambda \leq 1\,800 \text{ nm}$	0.46 pm 0.53 pm 0.52 pm $0.48 \times 10^{-6} * \lambda$	Burleigh WA-1500 Wavelength Meter



Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Power Linearity - Measure 850 nm 1 310 nm and 1 550 nm	(0 to -20) dBm (-20 to -30) dBm (-30 to -40) dBm (-40 to -50) dBm (-50 to -60) dBm (20 to 0) dBm (0 to -20) dBm (-20 to -30) dBm (-30 to -40) dBm (-40 to -50) dBm (-50 to -60) dBm	0.02 dB 0.02 dB 0.03 dB 0.03 dB 0.03 dB 0.02 dB 0.01 dB 0.02 dB 0.02 dB 0.02 dB 0.02 dB	81520A, 81623B, 81626B Optical Head
Optical Wavelength - Source	$600 \text{ nm} \leq \lambda \leq 1\,800 \text{ nm}$	$0.42 \times 10^{-6} * \lambda$	81520A, 81623B, 81626B Optical Head
Optical Attenuation - Measure Optical Fixed Attenuators of Fiber Coils 850 nm 1 310 nm 1 550 nm	(-60 to 0) dB	0.08 dB 0.07 dB 0.07 dB	81520A, 81623B, 81626B Optical Head
Optical Attenuation - Measure Optical Step Attenuators 850 nm 1 310 nm 1 550 nm	Insertion Loss (0 dB) (1 to -60) dB Insertion Loss (0 dB) (1 to -60) dB Insertion Loss (0 dB) (1 to -60) dB	0.08 dB 0.07 dB 0.07 dB 0.06 dB 0.07 dB 0.06 dB	81520A, 81623B, 81626B Optical Head

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature	(-1 to 41) °C	0.01 °C	Hart Scientific 1529 Thermometer and 5610 PRT



Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity	(10 to 90) %RH	2 %RH	Thunder Scientific 1200 Humidity Generator

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Time Interval - Measure	(60 to 700) ps 700 ps to 1.4 ns (1.4 to 4.4) ns (4.4 to 9) ns (9 to 18) ns (18 to 44) ns (44 to 88) ns (88 to 180) ns (180 to 440) ns (440 to 880) ns 880 ns to 1 μs	12 ps 13 ps $1.4 \times 10^{-3} TI + 13$ ps $1.1 \times 10^{-3} TI + 17$ ps $9.5 \times 10^{-4} TI + 26$ ps $8 \times 10^{-4} TI + 56$ ps $7.6 \times 10^{-4} TI + 110$ ps $7.2 \times 10^{-4} TI + 210$ ps $6.8 \times 10^{-4} TI + 540$ ps $7 \times 10^{-4} TI + 1$ ns $5.4 \times 10^{-4} TI + 2.3$ ns	HP 54124T Oscilloscope, includes transition time; Δt is the time interval in seconds.
Time Interval - Measure	10 ns to 10 s	2.9 ns	HP 5334B Counter connected to Time base (HP 5071A or Datum 8040)
Frequency - Source	5 MHz, 10 MHz	16 pHz/Hz	HP 5071A Cesium Beam Frequency Standard, 2½ day avg, GPS disciplined
Frequency - Measure	1 Hz to 40 GHz	50 pHz/Hz	HP 53132A Counter, HP 5352B Counter

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. Unitless linear measure.
3. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1498.


 Vice President