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
Avenida Marcos Penteado de Ulhoa Rodrigues, 939 – 6º andar
Castelo Branco Office Park - Torre Jacarandá -Tamboré,
Barueri, SP, Brazil

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

ISO/IEC 17025:2005

and national standards

ANSI/NCSL Z540-1-1994 AND
ANSI/NCSL Z540.3-2006

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-1498.14
Certificate Number

ANAB Approval

Certificate Valid: 04/07/2017-11/16/2018
Version No. 002 Issued: 04/07/2017

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 January 2009).

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

Keysight Technologies, Inc. Service Center

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CALIBRATION

Valid to: November 16, 2018 Certificate Number: AC-1498.14

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
DC Voltage - Source	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 with Fluke 5725A
DC Voltage - Source Fixed Values	100 mV 1 V 10 V 100 V 1000 V	0.72 µV 2.9 µV 2.6 µV 0.5 mV 7.3 mV	Fluke 57x0A disciplined with HP 3458A
	10 V	3 µV/V	Fluke 732A
DC Voltage - Measure	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 PLC Option 002
DC Voltage Transfer – Measure	(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	3458A
DC Current - Source	Up to 220 µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA	36 µA/A + 0.12 nA 33 µA/A + 1.2 nA 34 µA/A + 12 nA 42 µA/A + 0.12 µA 51 µA/A	Fluke 5720A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
DC Current - Source	(0.22 to 1) A (1 to 2.2) A (2.2 to 11) A	76 µA/A + 1.5 µA 1.5 mA/A + 66 µA 0.30 mA/A + 0.4 mA	Fluke 5720A with Fluke 5725A
	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 disciplined with HP 3458A
DC Current – Source	(10 to 20) A (20 to 200) A (200 to 1 000) A	0.53% + 22 mA 0.54% + 0.15 A 0.54% + 0.52 A	Fluke 552xA with 50 turn coil
DC Current - Measure	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1.1) A	20 µA/A 20 µA/A + 0.1 µA 20 µA/A + 60 nA 35 µA/A + 0.6 µA 0.11 mA/A + 11 µA	Keysight 3458A
DC Dissipated Power - 300 mA to Full Power	Shunt 15 A 100 mΩ, 25 W	0.14 mΩ/Ω	Guildline 9230-15
	Shunt 100A 10 mΩ, 100 W	0.14 mΩ/Ω	Guildline 9230-100
	Shunt 300A 10 mΩ, 90 W	0.12 mΩ/Ω	Guildline 9230-300
	Shunt 1 000A 100 µΩ, 100 W	0.36 mΩ/Ω	Guildline 9230-1000
Resistance – Source	(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 (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 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 5720A
Resistance - Source 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 disciplined with HP 3458A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Resistance - Source 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 5720A
Resistance – Measure	(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 (1 to 10) MΩ (10 to 100) MΩ (0.1 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 624 μΩ/Ω + 4.5 kΩ 6.2 mΩ/Ω + 0.35 MΩ	3458A
AC Voltage - Source	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	 0.25 mV/V + 12 μV 95 μV/V + 7.3 μV 86 μV/V + 7.3 μV 0.18 mV/V + 9.4 μV 0.49 mV/V + 16 μV 0.88 mV/V + 20 μV 1.4 mV/V + 33 μV 2.7 mV/V + 0.48 mV 0.27 mV/V + 4.5 μV 0.13 mV/V + 4.5 μV 0.11 mV/V + 4.5 μV 0.27 mV/V + 4.5 μV 0.54 mV/V + 5.3 μV 1.2 mV/V + 10 μV 1.7 mV/V + 24 μV 3 mV/V + 24 μV	Fluke 5720A

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Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Voltage - Source	(0.22 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 (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 100) 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	 0.25 mV/V + 39 µV 99 µV/V + 15 µV 63 µV/V + 5.9 µV 86 µV/V + 8.3 µV 0.11 mV/V + 30 µV 0.41 mV/V + 78 µV 0.99 mV/V + 0.20 mV 1.6 mV/V + 0.32 mV 0.26 mV/V + 0.42 mV 0.11 mV/V + 0.15 mV 67 µV/V + 44 µV 91 µV/V + 90 µV 1.1 µV/V + 0.21 mV 2.9 µV/V + 0.65 mV 1.1 mV/V + 2 mV 1.6 mV/V + 3.3 mV 0.24 mV/V + 3.9 mV 0.1 mV/V + 1.5 mV 69 µV/V + 0.43 mV 98 µV/V + 0.91 mV 0.16 mV/V + 2.4 mV 0.87 mV/V + 16 mV 0.43 mV/V + 39 mV 7.9 mV/V + 79 mV	Fluke 5720A
AC Voltage - Source	(100 to 220) 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	 0.24 mV/V + 3.9 mV 0.1 mV/V + 1.5 mV 69 µV/V + 0.43 mV 0.17 mV/V + 0.56 mV 0.21 mV/V + 1.9 mV 0.87 mV/V + 16 mV 0.43 mV/V + 39 mV 7.9 mV/V + 79 mV	Fluke 5720A, Fluke 5720A with Fluke 5725A Amplifier
AC Voltage - Source	(0 to 250) V (15 to 50) Hz (0.25 to 1.1) kV 50 Hz to 1 kHz (0.22 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 disciplined with Keysight 3458A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Voltage - Source Fixed Values at Fixed Frequencies	**0.01 V**		Fluke 57x0A disciplined with Keysight 3458A
	1 kHz	2.8 µV	
	20 kHz	2.9 µV	
	100 kHz	9.0 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	
	10 V		
	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 Fixed Points	0.1 V at 1 MHz 1 V at 1 MHz	94 µV 0.73 mV	Fluke 5700A or Fluke 5720A disciplined with Keysight 3458A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Voltage Flatness - Source	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 5720A, Fluke 5700A, or Fluke 5700A-03 (referenced to 1 kHz)
AC Voltage Flatness - Measure	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 0.10 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 3458A
AC Voltage - Measure	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz	 0.30 mV/V + 3.1 µV 0.20 mV/V + 1.2 µV 0.30 mV/V + 1.7 µV 1 mV/V + 1.6 µV 5 mV/V + 1.3 µV 40 mV/V + 2.1 µV 12 mV/V + 6.6 µV 70 mV/V + 7.5 µV 20 mV/V + 8.2 µV	Keysight 3458A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Voltage - Measure	(10 to 100) mV		Keysight 3458A
	(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	
	(1 to 10) V		
	(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	0.30 mV/V + 0.25 mV	
	(50 to 100) kHz	0.80 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	0.20 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	

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Voltage - Measure	(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	 0.40 mV/V + 31 mV 0.40 mV/V + 16 mV 0.60 mV/V + 16 mV 1.2 mV/V + 16 mV 3 mV/V + 15 mV	Keysight 3458A
AC Voltage - Measure	Up to 1 mV 0.02 Hz to 100 kHz 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (1 to 3) mV 0.02 Hz to 100 kHz 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (3 to 10) mV 0.02 Hz to 100 kHz 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz	 6 mV/V + 90 nV 16 mV/V + 2 µV 30 mV/V + 9 µV 90 mV/V + 7 µV 0.22 V/V + 20 µV 6 mV/V + 30 nV 7 mV/V + 5 µV 33 mV/V + 10 µV 93 mV/V + 8 µV 0.24 V/V + 5 µV 6 mV/V + 10 nV 8 mV/V + 8 µV 16 mV/V + 20 µV 26 mV/V + 50 µV 65 mV/V + 90 µV	URE3
AC Current - Source	Up to 220 µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.16 mA/A + 63 nA 89 µA/A + 62 nA 60 µA/A + 62 nA 0.18 mA/A + 62 nA 0.1 mA/A + 90 nA 0.27 mA/A + 56 nA 0.20 mA/A + 51 nA 0.16 mA/A + 52 nA 0.23 mA/A + 0.12 µA 1.1 mA/A + 0.67 µA 0.27 mA/A + 0.56 µA 0.21 mA/A + 0.51 µA 0.16 mA/A + 0.52 µA 0.23 mA/A + 0.71 µA 1.1 mA + 5.1 µA 0.28 mA/A + 3.9 µA 0.21 mA/A + 3 µA 0.17 mA/A + 2.2 µA 0.24A/A + 3.1 µA 1.1 mA/A + 10 µA	Fluke 5720A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Current - Source	(0.22 to 1) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (1 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.3 mA/A + 32 µA 0.44 mA/A + 83 µA 0.67 mA/A + 72 µA 0.35 mA/A + 26 µA 0.55 mA/A + 72 µA 0.67 mA/A + 72 µA 0.4 mA/A + 0.13 mA 0.88 mA/A + 0.29 mA 3.1 mA/A + 0.64 mA	Fluke 5720A
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 440 Hz (200 to 1 000) A 45 Hz to 65 Hz 65 Hz to 100 Hz 100 Hz to 440 Hz	 0.3 % + 27 mA 0.88 % - 1 mA 0.3 % + 27 mA 0.85 % + 28 mA 0.33 % + 60 mA 0.86 % + 90 mA 1 % - 0.17 A	Fluke 552xA with 50 turn coil
AC Current - Source	Up to 220 µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.54 mA/A + 0.64 µA 0.25 mA/A + 0.64 µA 80 µA/A + 0.64 µA 0.59 mA/A + 0.42 µA 1.4 mA/A + 0.1 µA 0.68 mA/A + 51 nA 0.37 mA/A + 47 nA 0.17 mA/A + 52 nA 0.6 mA/A + 0.42 µA 1.5 mA/A + 0.84 µA 0.68 mA/A + 0.51 µA 0.37 mA/A + 0.47 µA 0.17 mA/A + 0.51 µA 0.6 mA/A + 4.2 µA 1.5 mA + 8.5 µA 0.68 mA/A + 4.2 µA 0.37 mA/A + 3.2 µA 0.2 mA/A + 3 µA 0.6 mA/A + 42 µA 1.5 mA/A + 80 µA	Fluke 5700A

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
AC Current - Source	(0.22 to 1) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (1 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.64 mA/A + 35 µA 0.72 mA/A + 87 µA 0.84 mA/A + 76 µA 0.67 mA/A + 30 µA 0.87 mA/A + 76 µA 8.4 mA/A + 76 µA	Fluke 5700A
AC Current - Measure	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
Resistance - Source DC to 1 MHz, Direct Measurement	0.1 Ω (1, 10) Ω 100 Ω (1, 10, 100) kΩ	10 mΩ/Ω 1 mΩ/Ω 0.30 mΩ/Ω 0.30 mΩ/Ω	Agilent 16074A
Resistance Source, High Resistance	1 GΩ 10 GΩ 100 GΩ	0.23 MΩ 2.7 MΩ 24 MΩ	Agilent 16340A
Capacitance - Source Direct Measure 1 kHz	(1, 10, 100) pF (1, 10, 100) nF 1 µF	0.1 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Capacitance - Source Algorithmic Derivation	1 pF 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz (10, 100) pF (1, 2) MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz 1 nF 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 50 µF/F 60 µF/F 1 mF/F 2 mF/F 3 mF/F 10 mF/F 15 mF/F 0.25 mF/F 3 mF/F 4 mF/F 6 mF/F 15 mF/F 20 mF/F 0.50 mF/F 0.60 mF/F 1 mF/F 1.5 mF/F 2 mF/F 5 mF/F 7 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair
Capacitance - Source Substitution Method 120 Hz to 10 kHz 100 kHz	 (0.01, 0.1, 1) µF (0.01, 0.1) µF 1 µF	 0.25 mF/F 0.50 mF/F 1 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair
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 330 nF to 110 µF (110 to 330) µF (3.3 to 11) µF	 4 mF/F 4 mF/F 4 mF/F 4 mF/F 4 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair
Electrical Simulation of Thermocouples	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

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Electrical Simulation of Thermocouples	Type C		Fluke 5520A, Fluke 5522A
	(0 to 150) °C	0.32 °C	
	(150 to 650) °C	0.28 °C	
	(650 to 1 000) °C	0.33 °C	
	(1 000 to 1 800) °C	0.53°C	
	(1 800 to 2 316) °C	0.88 °C	
	Type E		
	(-250 to -100) °C	0.53 °C	
	(-100 to -25) °C	0.18 °C	
	(-25 to 350) °C	0.16 °C	
	(350 to 650) °C	0.18 °C	
	(650 1 000) °C	0.23 °C	
	Type J		
	(-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	0.20 °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	0.20 °C	
	(410 to 1 300) °C	0.29 °C	
	Type R		
	(0 to 250) °C	0.60 °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	0.50 °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	

Electromagnetic DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Electrical Simulation of Thermocouples	Type T (-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.26 °C 0.18 °C 0.16 °C 0.66 °C 0.59 °C 0.29 °C	Fluke 5520A, Fluke 5522A

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Amplitude Modulation - Measure			HP 8902
rate: 50 Hz to 10 kHz, depth: 5 % to 99 %	150 kHz to 10 MHz (5 to 10) % (10 to 99) %	 0.025AM + 0.03 % 0.025AM + 0.14 %	
rate: 20 Hz to 10 kHz, depth: to 99 %	150 kHz to 10 MHz (5 to 10) % (10 to 99) %	 0.038AM + 0.03 % 0.038AM + 0.13 %	
rate: 50 Hz to 50 kHz, depth: 5 % to 99 %	10 MHz to 1.3 GHz (5 to 10) % (10 to 99) %	 0.012AM + 0.033 % 0.012AM + 0.17 %	
rate: 20 Hz to 100 kHz, depth: to 99 %	10 MHz to 1.3 GHz (5 to 10) % (10 to 99) %	 0.038AM + 0.03 % 0.037AM + 0.16 %	
Amplitude Modulation - Measure			HP 8902 with HP 11793A
rate: 50 Hz to 10 kHz, depth: 5 % to 99 %	(1.3 to 26.5) GHz (5 to 10) % (10 to 99) %	 0.019AM + 0.029 % 0.019AM + 0.14 %	
rate: 20 Hz to 10 kHz, depth: to 99 %	10 MHz to 26.5 GHz (5 to 10) % (10 to 99) %	 0.038AM + 0.03 % 0.038AM + 0.11 %	
Frequency Modulation - Measure			HP 8902
rate: 20 Hz to 10 kHz, ≤40 kHz	250 kHz to 10 MHz (0 to 4) kHz $_{Peak}$ FM (4 to 40) kHz $_{Peak}$ FM	 0.024*FM* + 2.6 Hz $_{Peak}$ 0.024*FM* + 10 Hz $_{Peak}$	
rate: 50 Hz to 100 kHz, ≤400 kHz	10 MHz to 1.3 GHz (0 to 4) kHz $_{Peak}$ FM (4 to 40) kHz $_{Peak}$ FM (40 to 400) kHz $_{Peak}$ FM	 0.012*FM* + 2.6 Hz $_{Peak}$ 0.012*FM* + 12 Hz $_{Peak}$ 0.012*FM* + 110 Hz $_{Peak}$	
rate: 50 Hz to 100 kHz, ≤400 kHz	(1.3 to 6.2) GHz (0 to 4) kHz $_{Peak}$ FM (4 to 40) kHz $_{Peak}$ FM (40 to 400) kHz $_{Peak}$ FM	 0.0099*FM* + 10 Hz $_{Peak}$ 0.012*FM* + 12 Hz $_{Peak}$ 0.012*FM* + 100 Hz $_{Peak}$	

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Frequency Modulation - Measure			HP 8902
rate: 50 Hz to 100 kHz, ≤400 kHz	(6.2 to 12.4) GHz		
	(0 to 4) kHz $_{Peak}$ FM	0.0075*FM* + 24 Hz $_{Peak}$	
	(4 to 40) kHz $_{Peak}$ FM	0.012*FM* + 12 Hz $_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.012*FM* + 85 Hz $_{Peak}$	
rate: 50 Hz to 100 kHz, ≤400 kHz	(12.4 to 18.6) GHz		
	(0 to 4) kHz $_{Peak}$ FM	0.0049*FM* + 52 Hz $_{Peak}$	
rate: 50 Hz to 100 kHz, ≤400 kHz	(4 to 40) kHz $_{Peak}$ FM	0.011*FM* + 36 Hz$_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.012*FM* + 110 Hz$_{Peak}$	
	(18.6 to 26.5) GHz		
	(0 to 4) kHz $_{Peak}$ FM	0.0035*FM* + 80 Hz$_{Peak}$	
rate: 20 Hz to 200 kHz, ≤400 kHz	(4 to 40) kHz $_{Peak}$ FM	0.011*FM* + 46 Hz$_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.012*FM* + 100 Hz$_{Peak}$	
	10 MHz to 1.3 GHz		
	(0 to 4) kHz $_{Peak}$ FM	0.059FM + 2.8 Hz$_{Peak}$	
rate: 20 Hz to 200 kHz, ≤400 kHz	(4 to 40) kHz $_{Peak}$ FM	0.059FM + 14 Hz$_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.059FM + 120 Hz$_{Peak}$	
	(1.3 to 6.2) GHz		
	(0 to 4) kHz $_{Peak}$ FM	0.058FM + 5.2 Hz $_{Peak}$	
rate: 20 Hz to 200 kHz, ≤400 kHz	(4 to 40) kHz $_{Peak}$ FM	0.059FM + 14 Hz $_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.059FM + 120 Hz $_{Peak}$	
	(6.2 to 12.4) GHz		
	(0 to 4) kHz $_{Peak}$ FM	0.055FM + 15 Hz $_{Peak}$	
	(4 to 40) kHz $_{Peak}$ FM	0.059FM + 14 Hz $_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.059FM + 120 Hz $_{Peak}$	
Frequency Modulation - Measure			HP 8902 with HP 11793A
	(12.4 to 18.6) GHz		
rate: 20 Hz to 200 kHz, ≤400 kHz	(0 to 4) kHz $_{Peak}$ FM	0.05FM + 37 Hz $_{Peak}$	
	(4 to 40) kHz $_{Peak}$ FM	0.059FM + 15 Hz $_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.059FM + 120 Hz $_{Peak}$	
	(18.6 to 26.5) GHz		
rate: 20 Hz to 200 kHz, ≤400 kHz	(0 to 4) kHz $_{Peak}$ FM	0.045FM + 60 Hz $_{Peak}$	
	(4 to 40) kHz $_{Peak}$ FM	0.059FM + 16 Hz $_{Peak}$	
	(40 to 400) kHz $_{Peak}$ FM	0.059FM + 120 Hz $_{Peak}$	

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)

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Error Vector Magnitude (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 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 % 0.068 % 0.079 % 0.099 % 0.33 % 0.39 %	HP 89441A Vector Signal Analyzer
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 0.00043 ρ 0.00068 ρ 0.00084 ρ 0.0012 ρ 0.0016 ρ	HP 89441A Vector Signal Analyzer
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 0.00048 ρ 0.00076 ρ 0.00094 ρ 0.0014 ρ 0.0018 ρ	HP 89441A Vector Signal Analyzer
Modulation Accuracy (Rho)	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 0.00082 ρ 0.0013 ρ 0.0016 ρ 0.0024 ρ 0.0030 ρ	HP 89441A Vector Signal Analyzer

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
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 with HP 11722A or with HP 11792A and HP 11793A
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 with HP 11722A or with HP 11792A and HP 11793A

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
RF Absolute Power - Measure	-30 dBm ≤ P < 10 dBm f =50 GHz f =51 GHz 52 GHz ≤ f ≤ 54 GHz f =55 GHz 56 GHz ≤ f ≤ 59 GHz f =60 GHz 61 GHz ≤ f ≤ 62 GHz 63 GHz ≤ f ≤ 64 GHz f =65 GHz f =66 GHz f =67 GHz 10 dBm ≤ P ≤ 20 dBm f =50 GHz 51 GHz ≤ f ≤ 54 GHz f =55 GHz 56 GHz ≤ f ≤ 57 GHz 58 GHz ≤ f ≤ 59 GHz f =60 GHz f =61 GHz 62 GHz ≤ f ≤ 64 GHz f =65GHz 66 GHz ≤ f ≤ 67 GHz	 0.3 dB 0.34 dB 0.33 dB 0.29 dB 0.34 dB 0.3 dB 0.34 dB 0.33 dB 0.29 dB 0.35 dB 0.36 dB 0.31 dB 0.34 dB 0.3 dB 0.34 dB 0.34 dB 0.3 dB 0.35 dB 0.34 dB 0.1 dB 0.36 dB	Agilent V8486A
RF Absolute Power - Source	0.02 V ≤ V < 7 V f < 10 MHz 10 MHz ≤ f ≤ 50 MHz 50 MHz ≤ f ≤ 80 MHz V ≤ 10mV 20 Hz ≤ f ≤ 20 kHz 20 kHz < f ≤ 50 kHz 50 kHz < f ≤ 100 kHz 100 kHz < f ≤ 300 kHz 10 mV < V ≤ 100 mV 20 Hz ≤ f ≤ 40 Hz 40 Hz ≤ f ≤ 1 kHz 1 kHz < f ≤ 20 kHz 20 kHz < f ≤ 50 kHz 50 kHz < f ≤ 100 kHz 100 kHz < f ≤ 300 kHz	 0.082 dB 0.16 dB 0.4 dB 0.017 mV 0.021 mV 0.050 mV 0.38 mV 0.029 mV 0.028 mV 0.032 mV 0.045 mV 0.08 mV 0.30 mV	Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
RF Absolute Power - Source	100 mV < V ≤ 1 V 20 Hz ≤ f ≤ 1 kHz 1 kHz < f ≤ 20 kHz 20 kHz < f ≤ 50 kHz 50 kHz < f ≤ 100 kHz 100 kHz < f ≤ 300 kHz 1 V < V ≤ 3.5 V 20 Hz ≤ f ≤ 40 Hz 40 Hz ≤ f ≤ 1 kHz 1 kHz < f ≤ 20 kHz 20 kHz < f ≤ 50 kHz 50 kHz < f ≤ 100 kHz 100 kHz < f ≤ 300 kHz	 0.7 mV 0.72 mV 0.79 mV 1.3 mV 3.7 mV 2.2 mV 2.1 mV 2.2 mV 2.5 mV 4.0 mV 13 mV	Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A
RF Absolute Power - Source	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 0.80 dB 0.50 dB 0.59 dB 0.69 dB 0.80 dB 0.50 dB 0.60 dB 0.70 dB 0.80 dB 0.51 dB 0.60 dB 0.70 dB 1.5 dB	Signal Source PSG, ESG, E4438C, E4428C
Pulse - Measure RMS Jitter - Period, Delay and Width	33 MHz to 3 GHz	6.6 ps	HP 54124T or HP 86100 with 86107A

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Pulse - Source Transition Time	<100 ps	0.13 ns	HP 8133A
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	33 MHz to 3 GHz	10 ps	
Phase Noise for Signal Sources $(L_{REF} - L_{DUT}) \geq 10dB$ Offset Frequency			E5500 System
≤ 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	
< 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	

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Phase Noise for Signal Sources 3 dB > (L_{REF} - L_{DUT}) ≥ 0 dB Offset Frequency			E5500 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	±4.8 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 Carrier 1 GHz Offsets:	Phase Noise (PN) Measurement dBc/Hz		Wenzel 500-13438C
100 kHz	-102 ≥ PN ≤ -131	0.55 dB	
	-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	
1 MHz	-120 ≥ PN ≤ -139	0.55 dB	
	-139 < PN ≤ -142	0.56 dB	
	-142 < PN ≤ -145	0.58 dB	
	-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	
9.9 and 10 MHz	-131 ≥ PN ≤ -136	0.69 dB	
	-136 < PN ≤ -156	0.79 dB	
	-156 < PN ≤ -158	0.91 dB	
	-158 < PN ≤ -159	1.0 dB	
	-159 < PN ≤ -162	1.5 dB	
	-162 < PN ≤ -165	2.1 dB	
Attenuation - Source Coaxial, 1 dB Steps (0 to 11) dB	0 dB		HP 8496G w/ Type-N(f)
	50 MHz to 2 GHz	0.03 dB	
	(2 to 4) GHz	0.03 dB	
	1 dB		
	50 MHz to 2 GHz	0.03 dB	
	(2 to 4) GHz	0.03 dB	
	2 dB		
	50 MHz to 2 GHz	0.03 dB	
	(2 to 4) GHz	0.03 dB	

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Attenuation - Source Coaxial, 1 dB Steps (0 to 11) dB	3 dB 50 MHz to 2 GHz (2 to 4) GHz 4 dB 50 MHz to 2 GHz (2 to 4) GHz 5 dB 50 MHz to 2 GHz (2 to 4) GHz 6 dB 50 MHz to 2 GHz (2 to 4) GHz 7 dB 50 MHz to 2 GHz (2 to 4) GHz 8 dB 50 MHz to 2 GHz (2 to 4) GHz 9 dB 50 MHz to 2 GHz (2 to 4) GHz 10 dB 50 MHz to 2 GHz (2 to 4) GHz 11 dB 50 MHz to 2 GHz (2 to 4) GHz	 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB	HP 8496G w/ Type-N(f)
Attenuation – Source Coaxial, 10 dB Steps	0 dB 50 MHz to 2 GHz (2 to 4) GHz 10 dB 50 MHz to 2 GHz (2 to 4) GHz 20 dB 50 MHz to 2 GHz (2 to 4) GHz 30 dB 50 MHz to 2 GHz (2 to 4) GHz 40 dB 50 MHz to 2 GHz (2 to 4) GHz 50 dB 50 MHz to 2 GHz (2 to 4) GHz 60 dB 50 MHz to 2 GHz (2 to 4) GHz 70 dB 50 MHz to 2 GHz (2 to 4) GHz 80 dB 50 MHz to 2 GHz (2 to 4) GHz	 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.03 dB 0.04 dB 0.04 dB 0.06 dB 0.05 dB 0.06 dB 0.06 dB 0.07 dB 0.06 dB 0.07 dB 0.06 dB 0.09 dB 0.07 dB	HP 8496G With Type-N(f)

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Attenuation – Source Coaxial, 10 dB Steps	90 dB 50 MHz to 2 GHz (2 to 4) GHz 100 dB 50 MHz to 2 GHz (2 to 4) GHz 110 dB 50 MHz to 2 GHz (2 to 4) GHz	 0.09 dB 0.08 dB 0.1 dB 0.08 dB 0.11 dB 0.08 dB	HP 8496G With Type-N(f)
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
	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	HP 8491A/B With Type-N
	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
	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	HP 8491A/B With Type-N

PARAMETER	(S11 - Reflection) Magnitude Uncertainty (lin)									
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B									
Frequency Range	Measured Magnitude (+/- Linear)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
20 MHz 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

PARAMETER	(S11 - Reflection) Phase Uncertainty (deg)									
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B									
Frequency Range	Measured Magnitude (+/- Degrees)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
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)								
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B								
Frequency Range	Measured Magnitude (+/- Linear)								
	0	3	6	10	20	30	40	50	60
20 MHz 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)								
REFERENCE STANDARD OR EQUIPMENT	85054B, 85031B, ET33700, 85056A, 85058B								
Frequency Range	Measured Magnitude (+/- Degrees)								
	0	3	6	10	20	30	40	50	60
20 MHz 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										
REFERENCE STANDARD OR EQUIPMENT	8487A, V8486A, N8481B, N8482B, N9030A, E444xA, E9300A, E9304A, N8485A										
Frequency Range	Frequency Ranges (uncertainties in dB)										
	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	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	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

Time and Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment
Time Interval - Measure	10 ns to 10 s	2.9 ns	HP 5334B connected to Time base (HP 5071A or Datum 8040)
Frequency - Source	5 MHz, 10 MHz	10 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, HP 5352B

Notes:

1. Calibration and Measurement Capabilities (Expanded Uncertainties) are based on approximately a 95% confidence interval, using a coverage of k=2.
2. This laboratory offers field calibration services.
3. P = power applied, "ρ" = modulation accuracy or rho, "%" = percent of reading unless indicated otherwise, f = frequency,
4. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1498.14.

Vice President

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