



CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

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

This is to certify that

Keysight Technologies, Inc. Service Centers

10090 Foothills Blvd., Roseville, CA 95747

Including Satellite Sites located in:

Colorado Springs, CO; Arlington Heights, IL; Richardson, TX; Montreal, QC, Canada;

Mississauga, ON, Canada; West Valley City, UT; Ft. Wayne, IN

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: 11/03/2017-11/16/2018
Version No. 015 Issued: 11/03/2017



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 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 Centers

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CALIBRATION

Valid to: **November 16, 2018**

Certificate Number: **AC-1498**

Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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 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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada
DC Voltage – Source Fixed Values	100 mV 1 V 10 V 100 V 1 000 V	0.72 μV 2.9 μV 2.6 μV 0.5 mV 7.3 mV	Fluke 57x0A disciplined with HP 3458A	Mississauga, Ontario, Canada Salt Lake City, UT
	10 V	3 μV/V	Fluke 732A	Fort Wayne, IN

Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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 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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
DC Voltage - Measure	0 V 100 mV 1 V 10 V 100 V 1 kV	0.15 μV/V 1.9 μV/V 0.61 μV/V 0.51 μV/V 0.63 μV/V 1.1 μV/V	Fluke 732A, Fluke 752A, Keysight 34420A	Roseville, CA
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 μV 1.9 μV/V + 63 μV	Keysight 3458A	Roseville, CA Colorado Springs, CO Richardson, TX Arlington Heights, IL Montreal, Ontario, Canada Mississauga, Ontario, Canada Fort Wayne, IN Salt Lake City, UT



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
DC Current - Source	Up to 220 µA 220 µA 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	Roseville, CA Colorado Springs, CO Arlington Heights, IL
	220 mA 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 0.3 mA/A + 0.4 mA	Fluke 5720A with Fluke 5725A	Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada
	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 Keysight 3458A	Salt Lake City, UT Fort Wayne, IN
DC Current – Source	(10 to 20) A (20 to 200) A (200 to 1 000) A	0.57 % + 21 mA 0.57 % + 145 mA 0.57 % + 510 mA	Fluke 5520A, Fluke Current Coil	Roseville, CA Arlington Heights, IL Richardson, TX Montreal, QC Canada Mississauga, ON Canada
DC Current – Measure	(0 to 100) nA (0.1 to 1) µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	42 µA/A + 50 pA 21 µA/A + 50 pA 25 µA/A + 0.11 nA 25 µA/A + 0.85 nA 22 µA/A + 6.4 nA 23 µA/A + 59 nA 41 µA/A + 0.6 µA 125 µA/A + 12 µA	Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada
	(1 to 3) A	1.4 mA/A + 0.74 mA	Keysight 34401A	Salt Lake City, UT Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
DC Current – Measure	10 μA 200 μA 2 mA 20 mA 100 mA 200 mA 1 A 2 A 3 A 5 A 10 A	0.13 nA 1.1 nA 10 nA 0.15 μA 1 μA 1.5 μA 31 μA 64 μA 0.12 mA 0.15 mA 0.45 mA	Keysight 3458A, Reference Resistors	Roseville, CA
DC Dissipated Power - 300 mA to Full Power	Shunt 15 A 100 mΩ, 25 W	0.14 mΩ/Ω	Guildline 9230-15	Roseville, CA Colorado Springs, CO
	Shunt 100A 10 mΩ, 100 W	0.14 mΩ/Ω	Guildline 9230-100	Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada
	Shunt 300A 10 mΩ, 90 W	0.12 mΩ/Ω	Guildline 9230-300	Mississauga, Ontario, Canada
	Shunt 1 000A 100 μΩ, 100 W	0.36 mΩ/Ω	Guildline 9230-1000	Salt Lake City, UT Fort Wayne, IN
Resistance - Source Fixed Points	1 Ω 10 kΩ	8 μΩ/Ω 4 μΩ/Ω (trend ± 1 μΩ/Ω)	Fluke 742-1 Fluke 742-10k	Roseville, CA



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Resistance - Source Fixed Points	0 Ω	0.25 mΩ	Fluke 5720A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT
	1 Ω	0.27 mΩ		
	1.9 Ω	0.31 mΩ		
	10 Ω	0.34 mΩ		
	19 Ω	2.5 mΩ		
	100 Ω	2.7 mΩ		
	190 Ω	3.3 mΩ		
	1 kΩ	9.3 mΩ		
	1.9 k Ω	31 mΩ		
	10 kΩ	93 mΩ		
	19 kΩ	0.19 Ω		
	100 kΩ	1.2 Ω		
	190 kΩ	2.2 Ω		
	1 MΩ	20 Ω		
	1.9 MΩ	42 Ω		
	10 MΩ	0.40 kΩ	Fluke 57x0A disciplined with Keysight 3458A	Fort Wayne, IN
	19 MΩ	1.5 kΩ		
	100 MΩ	12 kΩ		
	0 Ω	21 μΩ		
	10 Ω	89 μΩ		
	100 Ω	0.86 mΩ		
	1 kΩ	7.5 mΩ		
	10 kΩ	75 mΩ		
	100 kΩ	0.75 Ω		
	1 MΩ	8 Ω		
	10 MΩ	0.15 kΩ		
	100 MΩ	24 kΩ		



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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	Roseville, CA Colorado Springs, CO Richardson, TX Arlington Heights, IL Montreal, QC Canada Fort Wayne, IN
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	Roseville, CA Colorado Springs, CO Richardson, TX Arlington Heights, IL Montreal, QC Canada Fort Wayne, IN Salt Lake City, UT



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Resistance – Measure	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	11 μΩ 15 μΩ 47 μΩ 0.11 mΩ 0.44 mΩ 0.5 mΩ 2.4 mΩ 4.1 mΩ 20 mΩ 61 mΩ 0.31 Ω 0.6 Ω 5.3 Ω 11 Ω 67 Ω 0.22 kΩ 8.4 kΩ	Keysight 3458A	Roseville, CA
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	250 μV/V + 4.1 μV 94 μV/V + 4.1 μV 83 μV/V + 4.1 μV 210 μV/V + 4.1 μV 520 μV/V + 4.1 μV 1.1 mV/V + 4.1 μV 1.5 mV/V + 4.1 μV 2.8 mV/V + 4.1 μV 250 μV/V + 4.1 μV 94 μV/V + 4.1 μV 83 μV/V + 4.1 μV 210 μV/V + 4.1 μV 520 μV/V + 4.1 μV 1.1 mV/V + 4.1 μV 1.4 mV/V + 4.1 μV 2.8 mV/V + 4.1 μV	Fluke 5720A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Source	(22 to 220) mV		Fluke 5720A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	(10 to 20) Hz	250 μV/V + 39 μV		
	(20 to 40) Hz	94 μV/V + 16 μV		
	40 Hz to 20 kHz	83 μV/V + 8.7 μV		
	(20 to 50) kHz	200 μV/V + 10 μV		
	(50 to 100) kHz	470 μV/V + 210 μV		
	(100 to 300) kHz	930 μV/V + 600 μV		
	(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 μV/V + 16 μV		
	40 Hz to 20 kHz	46 μV/V + 9 μV		
	(20 to 50) kHz	78 μV/V + 10 μV		
(50 to 100) kHz	100 μV/V + 70 μV			
(100 to 300) kHz	290 μV/V + 80 μV			
(300 to 500) kHz	1.1 mV/V + 200 μV			
500 kHz to 1 MHz	1.8 mV/V + 300 μV			
AC Voltage - Source	(2.2 to 22) V		Fluke 5720A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	(10 to 20) Hz	250 μV/V + 390 μV		
	(20 to 40) Hz	93 μV/V + 160 μV		
	40 Hz to 20 kHz	47 μV/V + 48 μV		
	(20 to 50) kHz	78 μV/V + 100 μV		
	(50 to 100) kHz	110 μV/V + 70 μV		
	(100 to 300) kHz	430 μV/V + 97 μV		
	(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 μV/V + 65 μV		
	(20 to 50) kHz	83 μV/V + 34 μV		
	(50 to 100) kHz	155 μV/V + 2.9 μV		
	(100 to 300) kHz	940 μV/V + 180 μV		
(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 μV/V + 20 μV			
(20 to 50) kHz	73 μV/V			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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 µV/V + 14 mV 170 µV/V 620 µV/V 620 µV/V 2.35 mV/V	Fluke 5720A with Fluke 5725A Amplifier	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
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	250 µV/V + 4.1 µV 94 µV/V + 4.1 µV 83 µV/V + 4.1 µV 210 µV/V + 4.1 µV 520 µV/V + 4.1 µV 1.1 mV/V + 4.1 µV 1.5 mV/V + 4.1 µV 2.8 mV/V + 4.1 µV 250 µV/V + 4.1 µV 94 µV/V + 4.1 µV 83 µV/V + 4.1 µV 210 µV/V + 4.1 µV 520 µV/V + 4.1 µV 1.1 mV/V + 4.1 µV 1.4 mV/V + 4.1 µV 2.8 mV/V + 4.1 µV	Fluke 5730A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage – Source	(22 to 220) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz 220 mV to 2.2 V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	250 μV/V + 39 μV 94 μV/V + 16 μV 60 μV/V + 7 μV 120 μV/V + 8 μV 320 μV/V + 18 μV 680 μV/V + 20 μV 1.5 mV/V + 20 μV 2.8 mV/V + 50 μV 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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Fort Wayne, IN
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 disciplined with Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN

Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Fixed Values, Fixed Frequencies	0.01 V		Fluke 5700A or Fluke 5720A disciplined with Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	1 kHz	2.8 μV		
	20 kHz	2.9 μV		
	100 kHz	9 μV		
	300 kHz	66 μV		
	0.1 V			
	1 kHz	5.7 μV		
	20 kHz	7.8 μV		
	100 kHz	37 μV		
	300 kHz	69 μV		
	1 V			
	1 kHz	55 μV		
	20 kHz	69 μV		
	50 kHz	0.13 mV		
100 kHz	0.21 mV			
300 kHz	0.6 mV			
500 kHz	1.7 mV			
3V				
100 kHz	0.57 mV			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Source (cont.) Fixed Values, Fixed Frequencies	10 V		Fluke 5700A or Fluke 5720A disciplined with Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	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 – Source	Up to 2.2 mV		Fluke 5730A	Salt Lake City, UT Richardson, TX Fort Wayne, IN
	(10 to 20) Hz	0.3 mV/V + 4 μV		
	(20 to 40) Hz	90 μV/V + 4 μV		
	40 Hz to 20 kHz	80 μV/V + 4 μV		
	(20 to 50) kHz	0.2 mV/V + 4 μV		
	(50 to 100) kHz	0.5 mV/V + 4 μV		
	(100 to 300) kHz	1.1 mV/V + 4 μV		
	(300 to 500) kHz	1.5 mV/V + 4 μV		
	500 kHz to 1 MHz	2.8 mV/V + 4 μV		
	(2.2 to 22) mV			
	(10 to 20) Hz	0.3 mV/V + 4 μV		
	(20 to 40) Hz	90 μV/V + 4 μV		
	40 Hz to 20 kHz	80 μV/V + 4 μV		
	(20 to 50) kHz	0.2 mV/V + 4 μV		
	(50 to 100) kHz	0.5 mV/V + 4 μV		
(100 to 300) kHz	1.1 mV/V + 4 μV			
(300 to 500) kHz	1.5 mV/V + 4 μV			
500 kHz to 1 MHz	2.8 mV/V + 4 μV			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage – Source	(22 to 220) mV		Fluke 5730A	Salt Lake City, UT Richardson, TX Fort Wayne, IN
	(10 to 20) Hz	3 mV/V + 10 μV		
	(20 to 40) Hz	90 μV/V + 7 μV		
	40 Hz to 20 kHz	60 μV/V + 7 μV		
	(20 to 50) kHz	0.1 mV/V + 7 μV		
	(50 to 100) kHz	0.3 mV/V + 20 μV		
	(100 to 300) kHz	0.7 mV/V + 20 μV		
	(300 to 500) kHz	1.5 mV/V + 30 μV		
	500 kHz to 1 MHz	2.8 mV/V + 50 μV		
	220 mV to 2.2 V			
	(10 to 20) Hz	0.3 mV/V + 40 μV		
	(20 to 40) Hz	90 μV/V + 20 μV		
	40 Hz to 20 kHz	40 μV/V + 9 μV		
	(20 to 50) kHz	70 μV/V + 10 μV		
	(50 to 100) kHz	90 μV/V + 30 μV		
	(100 to 300) kHz	0.4 mV/V + 80 μV		
	(300 to 500) kHz	1 mV/V + 0.2 mV		
	500 kHz to 1 MHz	1.8 mV/V + 0.2 mV		
	(2.2 to 22) V			
	(10 to 20) Hz	0.3 mV/V + 0.4 mV		
	(20 to 40) Hz	90 μV/V + 0.2 mV		
	40 Hz to 20 kHz	40 μV/V + 50 μV		
	(20 to 50) kHz	70 μV/V + 0.1 mV		
	(50 to 100) kHz	90 μV/V + 0.2 mV		
(100 to 300) kHz	0.3 mV/V + 0.6 mV			
(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	50 μV/V + 80 μV			
(20 to 50) kHz	80 μV/V + 30 μV			
(50 to 100) kHz	0.2 mV/V + 3 μV			
(100 to 300) kHz	0.9 mV/V – 0.2 mV			
(300 to 500) kHz	4.6 mV/V + 40 μV			
500 kHz to 1 MHz	8.3 mV/V + 80 μV			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage – Source	220 V to 1.1 kV 15 Hz to 50 Hz 50 Hz to 1 kHz 750 V to 1.1 kV 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	0.3 mV/V + 20 μV 70 μV/V + 90 μV 80 μV/V + 16 mV 0.2 mV/V – 0.8 mV 0.6 mV/V + 10 μV 0.6 mV/V – 5.6 mV 2.4 mV/V – 20 mV	Fluke 5730A with Fluke 5725A	Salt Lake City, UT Richardson, TX Fort Wayne, IN
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)	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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 0.1 mV/V + 8 μV 0.1 mV/V + 5.2 μV 0.1 mV/V + 6.5 μV 1.3 mV/V + 59 μV 1.3 mV/V + 0.11 mV 1.3 mV/V + 91 μV 2.5 mV/V + 0.21 mV 2.5 mV/V + 0.24 mV 6.1 mV/V + 0.34 mV 9 mV/V + 0.24 mV 11 mV/V + 0.79 mV 13 mV/V + 0.94 mV	Agilent 11049A, Agilent 11050A, Agilent 11051A Thermal Voltage Converters	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
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 (10 to 100) 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 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz	0.3 mV/V + 3.1 μV 0.2 mV/V + 1.2 μV 0.3 mV/V + 1.7 μV 1 mV/V + 1.6 μV 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 70 μV/V + 4.1 μV 70 μV/V + 2.1 μV 0.14 mV/V + 2.3 μV 0.3 V/V + 2.6 μV 0.8 mV/V + 2.3 μV 3 mV/V + 15 μV 10 mV/V + 28 μV 15 mV/V + 20 μV 40 mV/V + 74 μV 40 mV/V + 83 μV 0.15 V/V + 0.11 mV	Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Measure	100 mV to 1 V		Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	(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 + 0.3 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 µV/V + 0.42 mV		
	40 Hz to 1 kHz	70 µV/V + 0.22 mV		
	(1 to 20) kHz	0.14 mV/V + 0.24 mV		
	(20 to 50) kHz	0.3 mV/V + 0.25 mV		
	(50 to 100) kHz	0.8 mV/V + 0.22 mV		
	(100 to 300) kHz	3 mV/V + 1.1 mV		
	300 kHz to 1 MHz	10 mV/V + 1.1 mV		
	(1 to 2) MHz	15 mV/V + 1.1 mV		
	(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			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Measure	Up to 1 mV		URE3	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	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	Roseville, CA
	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			

Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Measure	200 mV		Fluke 5790A	Roseville, CA
	10 Hz	23 μV		
	20 Hz	10 μV		
	40 Hz	5.3 μV		
	1 kHz	5.2 μV		
	20 kHz	5.4 μV		
	50 kHz	9.3 μV		
	100 kHz	20 μV		
	300 kHz	31 μV		
	500 kHz	47 μV		
	1 MHz	0.11 mV		
	0.5 V			
	40 Hz	9.3 μV		
	1 kHz	9.4 μV		
	20 kHz	9.6 μV		
	100 kHz	24 μV		
	300 kHz	49 μV		
	1 MHz	0.24 mV		
	1 V			
	40 Hz	14 μV		
	1 kHz	14 μV		
	20 kHz	14 μV		
	100 kHz	38 μV		
	300 kHz	86 μV		
	1 MHz	0.51 mV		
	2V			
	10 Hz	0.21 mV		
	20 Hz	75 μV		
	40 Hz	28 μV		
	1 kHz	27 μV		
	20 kHz	27 μV		
	50 kHz	57 μV		
100 kHz	77 μV			
300 kHz	0.17 mV			
500 kHz	0.29 mV			
1 MHz	1 mV			
2.3 V				
1 kHz	32 μV			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Measure	20 V		Fluke 5790A	Roseville, CA
	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			



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Voltage - Measure	1 kV 40 Hz 50 Hz 300 Hz 1 kHz 20 kHz 30 kHz	38 mV 38 mV 24 mV 24mV 25 mV 72 mV	Fluke 5790A	Roseville, CA
AC Current Source	0 to 220 µA 10 to 20 Hz 20 to 40 Hz 40 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz 220 µA to 2.2 mA 10 to 20 Hz 20 to 40 Hz 40 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz (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	230 µA/A + 17 nA 150 µA/A + 10 nA 108 µA/A + 8.4 nA 266 µA/A + 12.5 nA 915 µA/A + 66 nA 233 µA/A + 42 nA 150 µA/A + 34 nA 108 µA/A + 34 nA 183 µA/A + 109 nA 915 µA/A + 655 nA 233 µA/A + 422 nA 149 µA/A + 342 nA 108 µA/A + 343 nA 183 µA/A + 588 nA 915 µA/A + 5 µA	Fluke 5720A or 5730A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
AC Current Source	(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 (0.22 to 2.2) A 20 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz (2.2 to 11) A 20 Hz to 1 kHz 1 to 5 kHz 5 to 10 kHz	233 µA/A + 4.2 µA 149 µA/A + 3.4 µA 108 µA/A + 2.6 µA 183 µA/A + 3.4 µA 915 µA/A + 10 µA 249 µA/A + 34 µA 383 µA/A + 83 µA 5.8 mA/A + 166 µA 332 µA/A + 149 µA 707 µA/A + 320 µA 2.8 mA/A + 600 µA	Fluke 5720A or 5730A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
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 % + 27 mA 0.33 % + 50 mA 0.85 % + 3.6 mA 0.85 % + 29 mA 0.85 % + 100 mA 0.85 % + 3.6 mA 0.85 % + 28 mA 1 % + 0.25 A	Fluke 5520A, Fluke Current Coil	Roseville, CA Arlington Heights, IL Richardson, TX Montreal, QC Mississauga, ON
AC Current - Source Fixed Values	1 kHz 10 µA 100 µA 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 disciplined with Keysight 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Salt Lake City, UT Fort Wayne, IN



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Current - Measure	Up to 100 µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz 100 µA 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 100 mA 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 0.6 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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
AC Current – Measure	20 µA 1 kHz, 10 kHz 200 µA 10 Hz 20 Hz 40 Hz (1 to 5) kHz 10 kHz 2 mA 10 Hz 20 Hz 40 Hz (1 to 5) kHz 10 kHz	2.8 nA 31 nA 23 nA 21 nA 21 nA 21 nA 0.27 µA 0.18 µA 0.15 µA 0.15 µA 0.15 µA	Fluke 5790A ET22703	Roseville, CA



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
AC Current – Measure	20 mA		Fluke 5790A ET22703	Roseville, CA
	10 Hz	2.6 μA		
	20 Hz	1.6 μA		
	40 Hz to 10 kHz	1.3 μA		
	200 mA			
	10 Hz	26 μA		
	20 Hz	16 μA		
	40 Hz to 10 kHz	13 μA		
	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 μA			
1 kHz	93 μA			
5 kHz	93 μA			
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	Roseville, CA
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 0.3 mΩ/Ω 0.3 mΩ/Ω	Agilent 16074A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX

Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Resistance - Source DC to 1 MHz Direct Measurement	1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ	4.2 mΩ/Ω 3.8 mΩ/Ω 4 mΩ/Ω 3.8 mΩ/Ω 5 mΩ/Ω 23 mΩ/Ω 11 mΩ/Ω 2.4 mΩ/Ω 3.1 mΩ/Ω	HP 42030A, HP 42040A	Montreal, Quebec, Canada Mississauga, Ontario, Canada
Resistance Source, High Resistance	1 GΩ 10 GΩ 100 GΩ	0.23 MΩ 2.7 MΩ 24 MΩ	Agilent 16340A	Roseville, CA Richardson, TX Arlington Heights, IL Montreal, Quebec, Canada
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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Capacitance - Source Algorithmic Derivation	1 pF		Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada
	1 MHz	50 µF/F		
	2 MHz	60 µF/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		
Capacitance - Source Substitution Method 120 Hz to 10 kHz 100 kHz	1 nF		Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada
	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 Direct Measure 10 Hz to 1 kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz	(0.01, 0.1, 1) µF	0.25 mF/F	Agilent 16380A, Agilent 16380C Standard Air Capacitor Set, BNC 4 Terminal Pair	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada
	(0.01, 0.1) µF	0.5 mF/F		
	1 µF	1 mF/F		
	(3.3 to 33) nF	4 mF/F		
	330 nF to 110 µF	4 mF/F		
	(110 to 330) µF	4 mF/F		
	(3.3 to 11) µF	4 mF/F		





Electrical Simulation of Thermocouples	Type B			
	(600 to 800) °C	0.47 °C		
	(800 to 1 000) °C	0.36 °C		
	(1 000 to 1 550) °C	0.32 °C		
	(1 550 to 1 820) °C	0.35 °C		
	Type C			
	(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 1800) °C	0.53 °C		
	(1 800 to 2316) °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 1000) °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	0.2 °C		
(-25 to 120) °C	0.18 °C			
(120 to 1 000) °C	0.28 °C			
(1 000 to 1 372) °C	0.42 °C			
Type L				
(-200 to -100) °C	0.39 °C			
(-100 to 800) °C	0.28 °C			
(800 to 900) °C	0.19 °C			
Type N				
(-200 to -100) °C	0.42 °C			
(-100 to -25) °C	0.24 °C			
(-25 to 120) °C	0.21 °C			
(120 to 410) °C	0.2 °C			
(410 to 1 300) °C	0.29 °C			
Type R				
(0 to 250) °C	0.6 °C			
(250 to 400) °C	0.37 °C			
(400 to 1 000) °C	0.35 °C			
(1 000 to 1 767) °C	0.42 °C			
		Fluke 5520A, Fluke 5522A	Roseville, CA Montreal, Quebec, Canada Mississauga, Ontario, Canada Arlington Heights, IL, Richardson, TX, Colorado Springs, CO, Ft. Wayne, IN	



Electromagnetic - DC/Low Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Electrical Simulation of Thermocouples	Type S (0 to 250) °C	0.5 °C	Fluke 5520A, Fluke 5522A	Roseville, CA Montreal, Quebec, Canada Mississauga, Ontario, Canada Arlington Heights, IL, Richardson, TX, Colorado Springs, CO, Ft. Wayne, IN
	(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		

Electromagnetic - RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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	2.1 % Depth	Agilent 8902A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	(0.01 to 1.3) GHz	1.1 % Depth		
	(1.3 to 26.5) GHz	1.6 % Depth		
Amplitude Modulation – Measure Rate: (0.05 to 10) kHz Rate: (0.05 to 100) kHz	(0.1 to 10) MHz	0.8 % Depth	Agilent E444xA with Opt. 233	Salt Lake City, UT Fort Wayne, IN
	(0.01 to 3) GHz	0.5 % Depth		
	(3 to 26.5) GHz	1.5 % Depth		
	(26.5 to 31.15) GHz	1.9 % Depth		
	(31.5 to 50) GHz	6.1 % Depth		



Electromagnetic - RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada
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	Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN

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 (\pm)]	Reference Standard or Equipment	Locations
Error Vector Magnitude (EVM)	Mod Frequency Span: $f \leq 100\text{kHz}$ $100\text{kHz} \leq f \leq 1\text{MHz}$ $f > 1\text{MHz}$	0.43 % 0.48 % 0.82 %	HP 89441A Vector Signal Analyzer	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
Phase Error	Mod Frequency Span: $f \leq 100\text{kHz}$ $100\text{kHz} \leq f \leq 1\text{MHz}$ $f > 1\text{MHz}$	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 % 0.068 % 0.079 % 0.099 % 0.33 % 0.39 %		
Modulation Accuracy (Rho)	Mod Frequency Span: $f \leq 100\text{kHz}$ $0.9999 \leq \rho \leq 1$ $0.9975 \leq \rho < 0.9999$ $0.9936 \leq \rho < 0.9975$ $0.99 \leq \rho < 0.9936$ $0.978 \leq \rho < 0.99$ $0.96 \leq \rho < 0.978$	$8.6 \text{ E-5 } \rho$ 0.000 43 ρ 0.000 68 ρ 0.000 84 ρ 0.001 2 ρ 0.001 6 ρ		
	Mod Frequency Span: $100 \text{ kHz} \leq f \leq 1 \text{ MHz}$ $0.9999 \leq \rho \leq 1$ $0.9975 \leq \rho < 0.9999$ $0.9936 \leq \rho < 0.9975$ $0.99 \leq \rho < 0.9936$ $0.978 \leq \rho < 0.99$ $0.96 \leq \rho < 0.978$	$9.6 \text{ E-5 } \rho$ 0.000 48 ρ 0.000 76 ρ 0.000 94 ρ 0.001 4 ρ 0.001 8 ρ		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Modulation Accuracy (Rho)	Mod Frequency Span: $f > 1\text{MHz}$ $0.9999 \leq \rho \leq 1$ $0.9975 \leq \rho < 0.9999$ $0.9936 \leq \rho < 0.9975$ $0.99 \leq \rho < 0.9936$ $0.978 \leq \rho < 0.99$ $0.96 \leq \rho < 0.978$	$1.6 \text{ E-}4 \rho$ $0.000 \text{ 82 } \rho$ $0.001 \text{ 3 } \rho$ $0.001 \text{ 6 } \rho$ $0.002 \text{ 4 } \rho$ 0.003ρ	HP 89441A Vector Signal Analyzer	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
Phase Modulation – Measure	(0.15 to 10) MHz Rate: (0.02 to 10) kHz (0.01 to 26.5) GHz Rate: (0.2 to 20) kHz	4.1 % 3.1 %	HP 8902A	
Phase Modulation – Measure	100 kHz to 6.6 GHz Deviations: (0.3 to 7) rad Deviations: > 7 rad (6.6 to 13.2) GHz Deviations: (0.6 to 2) rad (13.2 to 26.5) GHz Deviations: > 2 rad Deviations: (1.2 to 4) rad (26.5 to 31.5) GHz Deviations: > 4 rad Deviations: (1.3 to 4) rad (31.5 to 50) GHz Deviations: > 4 rad Deviations (2.4 to 8) rad Deviations: > 8 rad	3.1 % 1 % 3.1 % 1 % 3.1 % 1 % 3.1 % 1 % 3.1 % 1 %	Keysight E444xA with Opt. 233	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN





Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Distortion Measure	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	HP 8903A/B	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
RF Power - Power Meter Reference	1 mW 50 MHz	0.22 %	Agilent 432A, Agilent 478A (Option H75 or H76)	Roseville, CA
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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
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 (4 to 5) GHz (5 to 6) GHz (6 to 9) GHz (9 to 10) GHz (10 to 11) GHz (11 to 12) GHz (12 to 12.4) GHz (12.4 to 13) GHz	0.57 % 0.67 % 0.49 % 0.46 % 0.45 % 0.4 % 0.5 % 0.51 % 0.5 % 0.51 % 0.6 % 0.62 % 0.71 % 0.74 % 0.72 % 0.68 % 0.73 %	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors	Roseville, CA

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
RF Power Sensors - Calibration Factors	(13 to 14) GHz	0.7 %	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors	Roseville, CA
	(14 to 15) GHz	0.72 %		
	(15 to 16) GHz	0.74 %		
	(16 to 17) GHz	0.82 %		
	(17 to 18) GHz	0.83 %		
	(18 to 19) GHz	0.89 %		
	(19 to 20) GHz	1.2 %		
	(20 to 21) GHz	1.2 %		
	(21 to 22) GHz	1.2 %		
	(22 to 24) GHz	1.2 %		
	(24 to 26) GHz	1.2 %		
	(26 to 26.5) GHz	1.2 %		
	(26.5 to 27) GHz	0.93 %		
	(27 to 28) GHz	0.9 %		
	(28 to 29) GHz	0.88 %		
	(29 to 30) GHz	0.89 %		
	(30 to 32) GHz	0.91 %		
(32 to 34) GHz	0.92 %			
(34 to 35) GHz	0.93 %			
(35 to 36) GHz	0.92 %			
(36 to 37) GHz	0.91 %			



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
RF Power Sensors - Calibration Factors	(37 to 38) GHz	0.90 %	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors	Roseville, CA
	(38 to 39) GHz	0.89 %		
	(39 to 40) GHz	0.88 %		
	(40 to 41) GHz	0.91 %		
	(41 to 42) GHz	1.1 %		
	(42 to 43) GHz	1.1 %		
	(43 to 44) GHz	1.1 %		
	(44 to 45) GHz	1.1 %		
	(45 to 46) GHz	1.2 %		
	(46 to 47) GHz	1.1 %		
	(47 to 48) GHz	1.1 %		
	(48 to 49) GHz	1.1 %		
	(49 to 50) GHz	1.1 %		
	(50 to 51) GHz	1.1 %		
(51 to 52) GHz	4.6 %			
(52 to 53) GHz	4.4 %			
RF Power Sensors - Calibration Factors	(53 to 54) GHz	4.1 %	Coaxial Thermistor/ Thermocouple or Waveguide Thermistor/ Thermocouple or Diode Power Sensors	Roseville, CA
	(54 to 55) GHz	3.8 %		
	(55 to 56) GHz	3.7 %		
	(56 to 57) GHz	3.8 %		
	(57 to 58) GHz	4.2 %		
	(58 to 59) GHz	4.5 %		
	(59 to 60) GHz	4.7 %		
	(60 to 61) GHz	4.8 %		
	(61 to 62) GHz	4.6 %		
	(62 to 63) GHz	4.4 %		
	(63 to 64) GHz	4.2 %		
	(64 to 65) GHz	4.1 %		
	(65 to 66) GHz	4.1 %		
	(66 to 67) GHz	4.2 %		
67 GHz	4.4 %			
50 MHz	0.3 %			





Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
RF Power Sensors Cal Factors	10 MHz	0.58 %	Keysight PNA-X 2.4, 3.5 mm Calibration Kits Reference Power Sensors	Montreal, QC Canada
	30 MHz	0.54 %		
	50 MHz	0.41 %		
	100 MHz	0.51 %		
	300 MHz to 3 GHz	0.6 %		
	4 GHz	0.61 %		
	5 GHz	0.67 %		
	(6 to 7) GHz	0.68 %		
	8 GHz	0.7 %		
	9 GHz	0.79 %		
	10 GHz	0.82 %		
	11 GHz	0.79 %		
	12 GHz	0.76 %		
	12.4 GHz	0.8 %		
	(13 to 15) GHz	0.79 %		
	16 GHz	0.87 %		
	17 GHz	0.91 %		
	18 GHz	0.97 %		
	(19 to 26) GHz	1.5 %		
	26.5 GHz	1.6 %		
27 GHz	1.7 %			
(28 to 29) GHz	1.8 %			
30 GHz	1.7 %			
(31 to 32) GHz	1.8 %			
33 GHz	1.7 %			
(34 to 40) GHz	1.8 %			
41 GHz	2.4 %			
(42 to 44) GHz	2.5 %			
(45 to 47) GHz	2.6 %			
(48 to 50) GHz	2.5 %			
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	Roseville, CA
	-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		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
RF Absolute Power - Source	$0.02 \text{ V} \leq V < 7 \text{ V}$		Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	$f < 10 \text{ MHz}$	0.082 dB		
	$10 \text{ MHz} \leq f \leq 50 \text{ MHz}$	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		
	$10 \text{ mV} < V \leq 100 \text{ mV}$			
	$20 \text{ Hz} \leq f \leq 40 \text{ Hz}$	0.029 mV		
	$40 \text{ Hz} \leq f \leq 1 \text{ kHz}$	0.028 mV		
	$1 \text{ kHz} < f \leq 20 \text{ kHz}$	0.032 mV		
$20 \text{ kHz} < f \leq 50 \text{ kHz}$	0.045 mV			
$50 \text{ kHz} < f \leq 100 \text{ kHz}$	0.08 mV			
$100 \text{ kHz} < f \leq 300 \text{ kHz}$	0.3 mV			
RF Absolute Power - Source	$100 \text{ mV} < V \leq 1 \text{ V}$		Function Generator and DVM Agilent 33250A, Agilent 33120A, Agilent 3458A	
	$20 \text{ Hz} \leq f \leq 1 \text{ kHz}$	0.7 mV		
	$1 \text{ kHz} < f \leq 20 \text{ kHz}$	0.72 mV		
	$20 \text{ kHz} < f \leq 50 \text{ kHz}$	0.79 mV		
	$50 \text{ kHz} < f \leq 100 \text{ kHz}$	1.3 mV		
	$100 \text{ kHz} < f \leq 300 \text{ kHz}$	3.7 mV		
	$1 \text{ V} < V \leq 3.5 \text{ V}$			
	$20 \text{ Hz} \leq f \leq 40 \text{ Hz}$	2.2 mV		
	$40 \text{ Hz} \leq f \leq 1 \text{ kHz}$	2.1 mV		
	$1 \text{ kHz} < f \leq 20 \text{ kHz}$	2.2 mV		
	$20 \text{ kHz} < f \leq 50 \text{ kHz}$	2.5 mV		
	$50 \text{ kHz} < f \leq 100 \text{ kHz}$	4 mV		
	$100 \text{ kHz} < f \leq 300 \text{ kHz}$	13 mV		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
RF Absolute Power - Source	7dBm \geq P \geq 0 dBm		Signal Source PSG, ESG	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	0.3 MHz \leq f \leq 1.1 GHz	0.49 dB		
	1.1 GHz \leq f \leq 2.985 GHz	0.58 dB		
	2.985 GHz $<$ f \leq 4 GHz	0.69 dB		
	4 GHz $<$ f \leq 6 GHz	0.79 dB		
	0 dBm $>$ P \geq -25 dBm			
	0.3 MHz \leq f \leq 1.1 GHz	0.49 dB		
	1.1 GHz \leq f \leq 2.985 GHz	0.59 dB		
	2.985 GHz $<$ f \leq 4 GHz	0.69 dB		
	4 GHz $<$ f \leq 6 GHz	0.8 dB		
	-25 dBm $>$ P \geq -70 dBm			
	0.3 MHz \leq f \leq 1.1 GHz	0.50 dB		
	1.1 GHz \leq f \leq 2.985 GHz	0.59 dB		
	2.985 GHz $<$ f \leq 4 GHz	0.69 dB		
	4 GHz $<$ f \leq 6 GHz	0.8 dB		
	-70 dBm $>$ P \geq -95 dBm			
0.3 MHz \leq f \leq 1.1 GHz	0.5 dB			
1.1 GHz \leq f \leq 2.985 GHz	0.6 dB			
2.985 GHz $<$ f \leq 4 GHz	0.7 dB			
4 GHz $<$ f \leq 6 GHz	0.8 dB			
-95 dBm $>$ P \geq -125 dBm				
0.3 MHz \leq f \leq 1.1 GHz	0.51 dB			
1.1 GHz \leq f \leq 2.985 GHz	0.6 dB			
2.985 GHz $<$ f \leq 4 GHz	0.7 dB			
4 GHz $<$ f \leq 6 GHz	1.5 dB			



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Thermal Noise – Source ENR	5 dB, 15 dB, or 21 dB		HP 346B opt. 002 346B/N4001A opt. 001 346B opt. 004 346C/N4002A	Roseville, CA
	0.01 GHz	0.06 dB		
	0.1 GHz	0.06 dB		
	1 GHz	0.11 dB		
	2 GHz	0.07 dB		
	3 GHz	0.07 dB		
	4 GHz	0.06 dB		
	5 GHz	0.06 dB		
	6 GHz	0.06 dB		
	7 GHz	0.06 dB		
	8 GHz	0.07 dB		
	9 GHz	0.06 dB		
	10 GHz	0.09 dB		
	11 GHz	0.07 dB		
	12 GHz	0.07 dB		
	13 GHz	0.07 dB		
	14 GHz	0.06 dB		
	15 GHz	0.06 dB		
	16 GHz	0.06 dB		
	17 GHz	0.07 dB		
18 GHz	0.06 dB			
19 GHz	0.13 dB			
20 GHz	0.14 dB			
21 GHz	0.14 dB			
22 GHz	0.16 dB			
23 GHz	0.17 dB			
24 GHz	0.14 dB			
25 GHz	0.13 dB			
26 GHz	0.15 dB			
26.5 GHz	0.15 dB			
Thermal Noise - Source ENR (14 to 16) dB	10 MHz to 18 GHz		HP 346B w/ APC- 3.5	Roseville, CA
	SWR 1.25:1	0.21 dB		
	(18 to 26.5) GHz SWR 1.35:1	0.22 dB		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Phase Noise for Signal Analyzers Carrier 1 GHz Offsets: 0.1 kHz	Phase Noise Measurement dBc/Hz			
	-84 \geq PN \leq -94	1.1 dB		
	-94 < PN \leq -95	1.2 dB		
	-95 < PN \leq -98	1.4 dB		
	-98 < PN \leq -100	1.8 dB		
	-100 < PN \leq -102	2.4 dB		
	-102 < PN \leq -105	3.4 dB		
1 kHz	-78 \geq PN \leq -115	0.75 dB		
	-115 < PN \leq -121	0.82 dB		
	-121 < PN \leq -123	0.91 dB		
	-123 < PN \leq -125	1.1 dB		
	-125 < PN \leq -129	1.9 dB		
	-129 < PN \leq -130	2.1 dB		
	-130 < PN \leq -133	3.3 dB	Wenzel 500-13438C	Roseville, CA Salt Lake City, UT Fort Wayne, IN
10 kHz	-90 \geq PN \leq -129	0.43 dB		
	-129 < PN \leq -132	0.45 dB		
	-132 < PN \leq -135	0.54 dB		
	-135 < PN \leq -138	0.74 dB		
	-138 < PN \leq -142	1.2 dB		
	-142 < PN \leq -145	2.1 dB		
30 kHz	-106 \geq PN \leq -112	0.56 dB		
	-112 < PN \leq -132	0.57 dB		
	-132 < PN \leq -134	0.59 dB		
	-134 < PN \leq -137	0.65 dB		
	-137 < PN \leq -140	0.82 dB		
	-140 < PN \leq -143	1.3 dB		
	-143 < PN \leq -144	1.5 dB		
	-144 < PN \leq -147	2.1 dB		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Phase Noise for Signal Analyzers Carrier 1 GHz Offsets:	Phase Noise Measurement dBc/Hz			
	-102 \geq PN \leq -131	0.55 dB	Wenzel 500-13438C	Roseville, CA Salt Lake City, UT Fort Wayne, IN
	-131 < PN \leq -132	0.56 dB		
	-132 < PN \leq -136	0.58 dB		
	-136 < PN \leq -139	0.64 dB		
100 kHz	-139 < PN \leq -142	0.81 dB		
	-142 < PN \leq -145	1.3 dB		
	-145 < PN \leq -146	1.5 dB		
	-146 < PN \leq -149	2.1 dB		
	-120 \geq PN \leq -139	0.55 dB		
	-139 < PN \leq -142	0.56 dB		
	-142 < PN \leq -145	0.58 dB		
	-143 < PN \leq -148	0.64 dB		
1 MHz	-148 < PN \leq -150	0.74 dB		
	-150 < PN \leq -152	0.93 dB		
	-152 < PN \leq -155	1.5 dB		
	-155 < PN \leq -158	2.1 dB		
Phase Noise for Signal Analyzers Carrier 1 GHz Offsets	-131 \geq PN \leq -136	0.69 dB	Wenzel 500-13438C	Roseville, CA Salt Lake City, UT Fort Wayne, IN
	-136 < PN \leq -156	0.79 dB		
9.9 and 10 MHz	Phase Noise Measurement dBc/Hz			
	-156 < PN \leq -158	0.91 dB		
	-158 < PN \leq -159	1 dB		
	-159 < PN \leq -162	1.5 dB		
	-162 < PN \leq -165	2.1 dB		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
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	Roseville, CA Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
Pulse - Source Transition Time	<100 ps	0.13 ns	HP 8133A	Roseville, CA Arlington Heights, IL Salt Lake City, UT Fort Wayne, IN
Width	150 ps to 10 ns (10 to 100) ns 100 μ s 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 μ s (0.012 * Width) + 2 ns (0.012*Width) +0.19 μ s	HP 8161A	
RMS Jitter - Period, Delay and Width	33 MHz to 3 GHz	10 ps	HP 8133A	



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Phase Noise for Signal Sources ($L_{REF} - L_{DUT}$) \geq 10dB Offset Frequency \leq 100 kHz \leq 100 kHz \leq 1 MHz \leq 10 MHz $<$ 100 MHz 10dB $>$ ($L_{REF} - L_{DUT}$) \geq 5dB Offset Frequency \leq 100 kHz \leq 100 kHz \leq 1 MHz \leq 10 MHz $<$ 100 MHz 5dB $>$ ($L_{REF} - L_{DUT}$) \geq 3dB Offset Frequency \leq 100 kHz \leq 100 kHz \leq 1 MHz \leq 10 MHz $<$ 100 MHz 3dB $>$ ($L_{REF} - L_{DUT}$) \geq 0dB Offset Frequency \leq 100 kHz \leq 100 kHz \leq 1 MHz \leq 10 MHz $<$ 100 MHz	\leq 100 MHz 100 MHz $<$ f \leq 26.5 GHz 50 kHz $<$ f \leq 26.5 GHz 50 kHz $<$ f \leq 26.5 GHz \leq 100 MHz 100 MHz $<$ f \leq 26.5 MHz 50 kHz $<$ f \leq 26.5 GHz 50 kHz $<$ f \leq 26.5 GHz \leq 100 MHz 100 MHz $<$ f \leq 26.5G Hz 50 kHz $<$ f \leq 26.5 GHz 50 kHz $<$ f \leq 26.5 GHz \leq 100 MHz 100 MHz $<$ f \leq 26.5 GHz 50 kHz $<$ f \leq 26.5 GHz 50 kHz $<$ f \leq 26.5 GHz	\pm 2.3 dB \pm 2.3 dB \pm 2.3 dB \pm 4.6 dB \pm 4.6 dB \pm 2.8 dB \pm 2.9 dB \pm 2.9 dB \pm 5.2 dB \pm 5.3 dB \pm 3.2 dB \pm 3.3 dB \pm 3.3 dB \pm 5.4 dB \pm 5.5 dB \pm 4.3 dB \pm 4.3 dB \pm 4.3 dB \pm 6.1 dB \pm 6.2 dB	Keysight E5500 System	Roseville, CA Colorado Springs, Co Arlington Heights, IL Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Phase Noise for Signal Sources Offset Frequency	$3 \text{ dB} > (L_{\text{REF}} - L_{\text{DUT}}) \geq 0 \text{ dB}$			
$\leq 100 \text{ kHz}$	$\leq 100 \text{ MHz}$	$\pm 4.3 \text{ dB}$	Keysight E5500 System	Roseville, CA Colorado Springs, Co Arlington Heights, IL Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
$\leq 100 \text{ kHz}$	$100 \text{ MHz} < f \leq 255 \text{ MHz}$	$\pm 4.6 \text{ dB}$		
$\leq 100 \text{ kHz}$	$255 \text{ MHz} < f \leq 600 \text{ MHz}$	$\pm 4.6 \text{ dB}$		
$\leq 100 \text{ kHz}$	$600 \text{ MHz} < f \leq 1.8 \text{ GHz}$	$\pm 4.5 \text{ dB}$		
$\leq 100 \text{ kHz}$	$1.8 \text{ GHz} < f \leq 3.2 \text{ GHz}$	$\pm 4.5 \text{ dB}$		
$\leq 100 \text{ kHz}$	$3.2 \text{ GHz} < f \leq 10 \text{ GHz}$	$\pm 4.8 \text{ dB}$		
$\leq 100 \text{ kHz}$	$10 \text{ GHz} < f \leq 20 \text{ GHz}$	$\pm 4.8 \text{ dB}$		
$\leq 100 \text{ kHz}$	$20 \text{ GHz} < f \leq 26.5 \text{ GHz}$	$\pm 4.5 \text{ dB}$		
$\leq 1 \text{ MHz}$	$50 \text{ kHz} < f \leq 26.5 \text{ GHz}$	$\pm 4.7 \text{ dB}$		
$\leq 10 \text{ MHz}$	$50 \text{ kHz} < f \leq 26.5 \text{ GHz}$	$\pm 6.2 \text{ dB}$		
$< 100 \text{ MHz}$	$50 \text{ kHz} < f \leq 26.5 \text{ GHz}$	$\pm 6.2 \text{ dB}$		

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
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 23 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 0.08 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 0.1 dB	HP 346A/B/C, 346C K01, R347B, Q347B	Roseville, CA

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Thermal Noise - Measure	(5 to 22) dB		HP 346A/B/C, 346C K01, R347B, Q347B	Roseville, CA
	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			

Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
CISPR 16 Pulse Response Quasi-Peak Detector Response Band A Band B Band C Band D Quasi-Peak to Peak Detector Relative Response Ratio Band A Bands B, C, D Quasi-Peak to Average Detector Relative Response Ratio Band A Band B Band C, D Quasi-Peak	(1 to 100) Hz (1 to 20) Hz (1 to 20) Hz (1 to 20) Hz 25 Hz 100 Hz 25 Hz 500 Hz 5 kHz	0.23 dB 0.23 dB 0.3 dB 0.3 dB 0.21 dB 0.21 dB 0.21 dB 0.21 dB 0.21 dB	IGUU 2916	Roseville, CA
CISPR 16 Pulse Response Absolute Amplitude Band A Band B Band C Quasi-Peak to RMS Relative Band A Band B, C, D	25 Hz 100 Hz 100 Hz 25 Hz 100 Hz	0.35 dB 0.35 dB 0.51 dB 0.21 dB 0.21 dB	Keysight E4419B and E9304A	Roseville, CA



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations	
Attenuation - Source Coaxial, 1 dB Steps (0 to 11) dB	0 dB 50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB	HP 8496G w/ Type- N(f)	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN	
	1 dB 50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	2 dB 50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	3 dB 50 MHz to 2 GHz (2 to 4) GHz	0.03 dB 0.03 dB			
	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			HP 8496G w/ Type- N(f)



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Attenuation – Source Coaxial, 10 dB Steps	0 dB		HP 8496G With Type-N(f)	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	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		
	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		
	40 dB			
	50 MHz to 2 GHz (2 to 4) GHz	0.06 dB 0.05 dB		
	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			



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
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	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada Salt Lake City, UT Fort Wayne, IN
	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		
	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		
	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		



Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Attenuation - Measure 20 Hz to 50 MHz	1 dB steps (1 to 3) dB (4 to 11) dB 12 dB	0.003 dB 0.003 dB 0.003 dB	ESI PRT 73 35670A	Roseville, CA
>50 MHz to 1 GHz	1 dB steps (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 10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	0.003 dB 0.004 dB 0.004 dB 0.007 dB 0.009 dB 0.01 dB 0.02 dB 0.02 dB 0.02 dB 0.03 dB 0.04 dB		
	>50 MHz to 1 GHz 10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	0.005 dB 0.007 dB 0.009 dB 0.02 dB 0.02 dB 0.02 dB 0.03 dB 0.04 dB 0.04 dB 0.06 dB 0.07 dB		

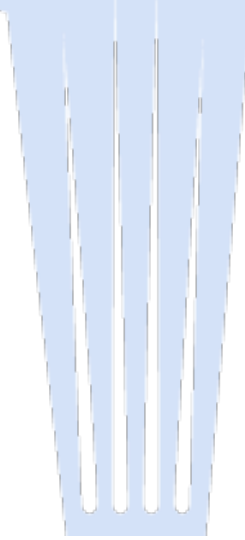


Electromagnetic RF/Microwave

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (\pm)]	Reference Standard or Equipment	Locations
Attenuation - Measure 10 dB steps	>1 GHz to 2 GHz		ESI PRT 73 35670A	Roseville, CA
	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	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

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Torque	8 in·lbf 12 in·lbf	0.10 in·lbf 0.13 in·lbf	Mountz EZ50I	Roseville, CA
Pressure	(70 to 110) kPa	0.02 kPa	DH Instruments RPM4	Roseville, CA

Optical Radiation

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Laser Optical Power - Measure	(80 to 1 000) μW (488 to 788) nm	5.9% * Output Power	Laser Power Meter Vega Photodiode PD300-1W	Roseville, CA
Laser Wavelength - Measure	633 nm	5.1 x 10 ⁻⁶ nm	HP 5517B/5508A	Roseville, CA
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	Roseville, CA
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, Agilent 81623B, Agilent 81626B	Roseville, CA



Optical Radiation

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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	Roseville, CA
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	Roseville, CA
Optical Wavelength - Measure	1 310 nm 1 530 nm 1 550 nm 600 nm ≤ λ ≤ 1 800 nm	0.46 pm 0.53 pm 0.52 pm 0.48 x 10 ⁻⁶ * λ	Burleigh WA-1500	Roseville, CA
Optical Wavelength - Source	600 nm ≤ λ ≤ 1 800 nm	0.42 x 10 ⁻⁶ * λ	81520A, 81623B, 81626B	Roseville, CA
Optical Attenuation - Measure Optical Fixed Attenuators of Fiber Coils 850 nm 1 310 nm 1 550 nm	(0 to -60) dB	0.08 dB 0.07 dB 0.07 dB	81520A, 81623B, 81626B	Roseville, CA



Optical Radiation

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Optical Attenuation - Measure Optical Step Attenuators 850 nm	Insertion Loss (0 dB) (1 to -60) dB	0.08 dB 0.07 dB	81520A, 81623B, 81626B	Roseville, CA
1 310 nm	Insertion Loss (0 dB) (1 to -60) dB	0.07 dB 0.06 dB		
1 550 nm	Insertion Loss (0 dB) (1 to -60) dB	0.07 dB 0.06 dB		

Thermodynamic

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Temperature	(-1 to 41) °C	0.01 °C	Hart Scientific 1529 and 5610	Roseville, CA
Humidity	(10 to 90) %RH	2 %RH	Thunder Scientific 1200 Humidity Generator	Roseville, CA

Time & Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
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, includes transition time; Δt is the time interval in seconds.	Roseville, CA



Time & Frequency

Parameter/ Equipment	Range	Calibration and Measurement Capability [Expressed as Uncertainty (±)]	Reference Standard or Equipment	Locations
Time Interval - Measure	10 ns to 10 s	2.9 ns	HP 5334B connected to Time base (HP 5071A or Datum 8040)	Roseville, CA Arlington Heights, IL Roseville, CA Montreal, Quebec, Canada Mississauga, Ontario, Canada
Frequency - Source	5 MHz, 10 MHz	16 pHz/Hz	HP 5071A Cesium Beam Frequency Standard, 2½ day avg, GPS disciplined	Roseville, CA
Frequency - Source	5 MHz, 10 MHz	50 pHz/Hz	Datum 8040	Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada
Frequency - Measure	1 Hz to 40 GHz	50 pHz/Hz	HP 53132A, HP 5352B	Roseville, CA Colorado Springs, CO Arlington Heights, IL Richardson, TX Montreal, Quebec, Canada Mississauga, Ontario, Canada

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. This organization maintains satellite sites at:
 - a. 1900 Garden of the Gods Road, Colorado Springs, CO 80907-3417. Contact: Johnny Booth, Phone: 321-431-6849.
 - b. 720 West Algonquin, Arlington Heights, IL 60005. Contact: Mike Helwig, Phone: 916-788-5485.
 - c. 1220 E. Campbell Road, Richardson, TX 75081. Contact: Mike Helwig, Phone: 916-788-5485.
 - d. 2250 Boul. Alfred Nobel, St. Laurent, Montreal, Canada PQ H4S 2C9. Contact: Scott Arrants, Phone: 514-832-2836.
 - e. 6535 Millcreek Drive, Unit 41, Mississauga, Ontario, Canada L5N 5M4. Contact: Scott Arrants, Phone: 514-832-2836.
 - f. 2550 South Decker Lake Blvd, Unit #3, West Valley City, UT 84119. Contact: Scott Arrants, Phone: 916-788-5540.
 - g. 1200 C/D Airport North Office Park, Fort Wayne, IN 46825 Contact: Scott Arrants, Phone: 916-788-5540.
3. Contact the laboratory for information on methods used.
4. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1498.



Vice President

