CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Keysight Technologies, Inc.
10090 Foothills Blvd.
Roseville, CA 95747
(and satellite sites as listed on the scope)

Fulfills the requirements of

ISO/IEC 17025:2017

and national standards

ANSI/NCSL Z540-1-1994 (R2002) and

ANSI/NCSL Z540.3-2006 (R2013)

In the field of

CALIBRATION

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org.

Jason Stine, Vice President

Expiry Date: 16 November 2028
Certificate Number: AC-1498

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. 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 17025:2017

AND

ANSI/NCSL Z540-1-1994 (R2002)

ANSI/NCSL Z540.3-2006 (R2013)

Keysight Technologies, Inc.

10090 Foothills Blvd.
Roseville, CA 95747

Mr. Chris Cox +1 (916) 788-5594 chris_cox@keysight.com
Ms. Bee-Choo Lim +65 6215 7191 bee-choo_lim@keysight.com

CALIBRATION

ISO/IEC 17025 Accreditation Granted: **12 November 2026**

Certificate Number: **AC-1498** Certificate Expiry Date: **16 November 2028**

Services performed at satellite laboratories for the main scope

Customers submitting items to Keysight for calibration will be directed to the appropriate delivery site based on capability, geography and capacity.

Calibration and Measurement Capabilities (CMC) are available at each site. The lowest uncertainties are achieved at the Roseville location. Calibrations are performed at the most suitable site based on customer needs and location and the resultant uncertainties may be higher based on equipment performance.

Site Name	Site Address
Tempe, AZ	1829 West Drake Drive, Suite 101 Tempe, AZ 85283
Plantation, FL	8000 W. Sunrise Boulevard Plantation, FL 33322
Fort Wayne, IN	1200 Airport North Office Park, Unit C/D Fort Wayne, IN 46825
Nashua, NH	22 Cotton Road, Suite 150 Nashua, NH 03063
Greensboro, NC	7907 Piedmont Triad Parkway Greensboro, NC 27409
Bethlehem, PA	2840 Emrick Blvd., Suite A-4 Bethlehem, PA 18020
Richardson, TX	1220 E. Campbell Road Richardson, TX 75081
West Valley City, UT	2550 South Decker Lake Blvd., Suite #3 West Valley City, UT 84119

Site Name	Site Address
Redmond, WA	4729 154th Place NE, Building 87, Room 1437 Redmond, WA 98052
Brazil	Avenida Marcos Penteado de Ulhoa Rodrigues, 939-6º andar Barueri, SP, Brazil
Montreal, Canada	2250 Boul. Alfred Nobel, St. Laurent, Ste 102 Montreal, QC Canada H4S 2C9
Calgary, Canada	4720 14 St N.E. Calgary, AB T2E 6L7, Canada
Ottawa, Canada	350 Terry Fox Drive, Suite 106 Ottawa, ON, Canada K2K 2W5
Mexico	Av. Camino Al ITESO 8900-1B, Col Technological Industrial Park Tlaquepaque, Jalisco, 45609, Mexico
Japan	9-1 Takakura-Cho, Hachioji-shi Tokyo, 192-8550 Japan
South Korea [5]	Singsong Center Bldg. 15F, #57, Yeouinaru-ro, Yeongdeungpo-gu, Seoul, Korea
Singapore	1 Yishun Avenue 7 Singapore 768923
Vietnam	6th Floor, Lot 601, CMC Tower, 11 Duy Tan Alley Cau Giay Ward, Hanoi, Vietnam
India	The Millenia, Second floor, Tower 'D', No. 1&2 Murphy Road, Ulsoor, Bangalore, Karnataka, 560 008, India
Taiwan	No. 20, Kao-Shuang Road Ping-Chen district 32450, Tao-Yuan City, Taiwan R.O.C.
Beijing, China	No.3 Wang Jing Bei Lu Chao Yang District, Beijing, China
Chengdu, China	Chengdu Hi-Tech Industrial Development Zone (South) No. 116 Tian Fu 4th Street, Chengdu, China
Malaysia	Phase 3 Bayan Lepas Free Industrial Zone 11900 Bayan Lepas, Penang, Malaysia

Services performed at satellite laboratories with unique scopes

Site Name	Site Address
El Segundo, CA	700 Lairport Street El Segundo, CA 90245
Kimballton, IA	1346 Yellowwood Road Kimballton, IA 51543
Elk Horn, IA	2012 High Street Elk Horn, IA 51531

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Services performed at main laboratory and satellite locations

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage Ratio - Source and Measure [1]	Up to 5 000 V	7×10^{-9}	Comparison to a DC voltage standard
DC Voltage – Source	(>0 to 10) V	1.1 nV	Comparison to a Programmable Josephson Voltage Standard (PJVS)
DC Voltage – Source	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 V to 1 100) V	7 µV/V + 0.39 µV 4.7 µV/V + 0.62 µV 3.1 µV/V + 2.3 µV 3.1 µV/V + 4.2 µV 4.7 µV/V + 39 µV 6.2 µV/V + 0.39 mV	Direct comparison to a DC voltage standard
DC Voltage – Source	0 V (>0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	20 nV 0.24 µV/V 0.057 µV/V 0.027 µV/V 0.14 µV/V 0.16 µV/V	Comparison to a DC voltage standard and a resistive divider
DC Voltage – Measure	(>0 to 10) V	5.5 nV	Comparison to a Programmable Josephson Voltage Standard (PJVS)
DC Voltage – Measure	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	6.4 µV/V + 0.41 µV 5.9 µV/V + 0.41 µV 5.3 µV/V + 0.91 µV 7.5 µV/V + 41 µV 7.5 µV/V + 0.14 mV	Direct measurement with a Keysight 3458A multimeter
DC Voltage – Measure	(0.25 to 3) kV (3 to 5) kV	110 µV/V 120 µV/V	Comparison to a Keysight 3458A multimeter and a high voltage divider
DC Voltage – Measure (Differential)	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	0.61 µV/V + 0.061 µV 0.37 µV/V + 0.12 µV 0.061 µV/V + 0.61 µV 0.61 µV/V + 0.012 mV 1.8 µV/V + 0.061 mV	Differential measurement with a Keysight 3458A multimeter

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source & Measure	0 A (>0 to 100) nA 100 nA to 1 µA (1 to 10) µA (10 to 100) µA 100 µA to 1 mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 20) A	42 pA 1.2 µA/A 1.1 µA/A 1.2 µA/A 0.2 µA/A 0.26 µA/A 0.23 µA/A 0.2 µA/A 1 µA/A 3.5 µA/A 19 µA/A	Indirect verification with reference resistors and a multimeter
DC Current – Source	(0 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 1.6) A (1.6 to 2.2) A (2.2 to 11) A (11 to 20.5) A	39 µA/A + 5.4 nA 31 µA/A + 6.3 nA 31 µA/A + 39 nA 39 µA/A + 0.62 µA 52 µA/A - 0.74 µA 70 µA/A + 12 µA 110 µA/A - 21 µA 150 µA/A - 92 µA 280 µA/A + 370 µA 0.82 mA/A + 0.89 µA	Comparison to a DC current source
DC Current – Source	10 mA to 1 A (1 to 2) A (2 to 1 000) A	0.41 % of reading 0.29 % of reading 0.2 % of reading	Comparison to DC current source and current coil
DC Current – Measure	0 pA (0.1 to 1.15) pA (1 to 115) pA (10 to 115) pA (0.1 to 1.15) nA (1 to 11.5) nA (10 to 115) nA (0.1 to 1.15) µA (1 to 11.5) µA (1 to 3) A (3 to 20) A	0.49 fA 0.83 mA/A + 0.59 fA 0.92 mA/A + 0.38 fA 0.24 mA/A + 1.4 fA 0.24 mA/A + 21 fA 26 µA/A + 0.25 pA 51 µA/A + 0.54 pA 20 µA/A + 1.7 pA 13 µA/A + 28 pA 17 µA/A + 0.12 mA 0.22 mA/A + 0.29 mA	Indirect verification with a Keysight 3458A multimeter and reference resistors

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 (1 to 3) 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 1.4 mA/A + 0.74 mA	Direct measurement with a Keysight multimeter
DC Current – Measure	(0.10 to 1) A (1 to 100) A (100 to 500) A (500 to 1 000) A	73 µA/A + 1.3 µA 74 µA/A - 0.021 µA 58 µA/A + 180 µA 140 µA/A + 0.42 mA	Indirect verification with a DC current shunt and a Keysight 3458A multimeter
DC Current – Measure	(5 to 10) A (10 to 30) A (30 to 36) A (36 to 45) A (45 to 60) A (60 to 90) A (90 to 180) A (180 to 340) A (340 to 510) A (510 to 1 000) A (1 000 to 2 000) A	93 µA/A + 0.39 mA 140 µA/A 94 µA/A + 1.5 mA 92 µA/A + 1.9 mA 93 µA/A + 2.6 mA 91 µA/A + 4 mA 87 µA/A + 8.5 mA 200 µA/A 180 µA/A + 8.8 mA 180 µA/A + 18 mA 150 µA/A + 26 mA	Comparison to a DC current transducer and a Keysight 3458A multimeter
DC Current – Measure (Differential)	(10 to 100) µA 100 µA to 1 mA	24 µA/A + 0.97 nA 24 µA/A + 6.1 nA	Differential measurement with a multimeter
DC Current – Measure (Differential)	1 mA to 10 mA 10 mA to 100 mA 100 mA to 1.0 A 1 A to 10 A 10 A to 30 A 30 A to 50 A 50 A to 100 A 100 A to 300 A 300 A to 500 A 500 A to 1 000 A	0.61 µA/A + 6.1 nA 0.061 µA/A + 6 nA 0.061 µA/A + 61 nA 0.061 µA/A + 1 µA 0.061 µA/A + 6.1 µA 0.061 µA/A + 12 µA 0.37 µA/A + 12 µA 0.37 µA/A + 0.12 mA 0.37 µA/A + 0.24 mA 0.61 µA/A + 0.61 mA	Differential measurement with a multimeter and a resistive shunt
AC Voltage Ratio [1]	400 Hz to 1 kHz Ratio (0.001 to 1)	4×10^{-6}	Comparison to a ratio transformer

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current (Relative) [1]	100 kHz to 100 MHz Ratio (0.7 to 1.1)	0.058	Comparison to an oscilloscope
AC Current – Source	1 kHz 10 µA 100 µA 1 mA 10 mA 100 mA 1 A	 3 nA 2.5 nA 32 nA 330 nA 3.3 µA 38 µA	Comparison to a multifunction calibrator and a Keysight 3458A multimeter
AC Current - Measure	(45 to 100) Hz (5 to 10) A (10 to 60) A (60 to 90) A (90 to 180) A (180 to 240) A (240 to 360) A (360 to 700) A	 0.82 mA/A + 1.5 mA 1 mA/A 0.78 mA/A + 18 mA 0.78 mA/A + 37 mA 1 mA/A + 0.12 A 1 mA/A + 0.18 A 1 mA/A + 0.36 A	Comparison to an AC current transducer and a Keysight 3458A multimeter
DC Resistance – Source	1 Ω 1.9 Ω (10, 19) Ω (100, 190) Ω (1, 1.9, 10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	86 µΩ/Ω 85 µΩ/Ω 21 µΩ/Ω 9.3 µΩ/Ω 6.2 µΩ/Ω 7.8 µΩ/Ω 9.3 µΩ/Ω 12 µΩ/Ω 16 µΩ/Ω 36 µΩ/Ω 43 µΩ/Ω 93 µΩ/Ω	Comparison to a multifunction calibrator

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC 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 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 110 μΩ/Ω + 0.2 kΩ 210 μΩ/Ω + 2 kΩ 410 μΩ/Ω + 2.8 kΩ 2.5 mΩ/Ω + 83 kΩ 12 mΩ/Ω + 0.4 MΩ	Comparison to a multiproduct calibrator
DC Resistance – Source and Measure	Short (>0 to 100) mΩ 100 mΩ 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 1 GΩ 10 GΩ 100 GΩ	0.02 μΩ 0.064 μΩ/Ω 0.065 μΩ/Ω 0.082 μΩ/Ω 0.096 μΩ/Ω 0.095 μΩ/Ω 0.17 μΩ/Ω 0.35 μΩ/Ω 0.69 μΩ/Ω 4.1 μΩ/Ω 41 μΩ/Ω 46 μΩ/Ω 52 μΩ/Ω	Comparison to reference resistors, a resistance bridge and a high resistance meter
DC Resistance – Source and Measure	0 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ	7.6 μΩ 13 μΩ 76 μΩ 0.4 mΩ 4.5 mΩ 42 mΩ 0.88 Ω 22 Ω 1.3 kΩ	Comparison to a multifunction calibrator and a Keysight 3458A multimeter

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance - Measure	(0 to 12) Ω (12 to 100) Ω (0.1 to 1.2) kΩ (1.2 to 12) kΩ (12 to 120) kΩ (0.12 to 1.2) MΩ (1.2 to 12) MΩ (12 to 120) MΩ (0.12 to 1.2) GΩ	20 μΩ/Ω + 79 μΩ 15 μΩ/Ω + 0.79 mΩ 13 μΩ/Ω + 0.79 mΩ 13 μΩ/Ω + 7.8 mΩ 13 μΩ/Ω + 78 mΩ 17 μΩ/Ω + 2.6 Ω 61 μΩ/Ω + 0.12 kΩ 0.58 mΩ/Ω + 3.6 kΩ 5.7 mΩ/Ω + 0.26 MΩ	Comparison to a Keysight 3458A multimeter
Capacitance – Source	(0.19 to 3.29) nF (3.3 to 10.99) nF (11 to 109.99) nF (110 to 329.99) nF (0.33 to 1.099) μF (1.1 to 3.299) μF (3.3 to 10.99) μF (11 to 32.99) μF (33 to 109.99) μF (110 to 329.99) μF (0.33 to 1.099) mF (1.1 to 3.299) mF (3.3 to 10.99) mF (11 to 32.99) mF (33 to 110) mF	3.1 mF/F + 7.7 pF 1.4 mF/F + 8.2 pF 1.4 mF/F + 80 pF 1.5 mF/F + 0.24 nF 1.4 mF/F + 0.82 nF 1.5 mF/F + 2.4 nF 1.4 mF/F + 8.1 nF 2.4 mF/F + 24 nF 2.6 mF/F + 83 nF 2.7 mF/F + 0.24 μF 2.6 mF/F + 0.82 μF 2.7 mF/F + 2.4 μF 3.3 mF/F + 5.2 μF 5.5 mF/F + 24 μF 7.9 mF/F + 79 μF	Comparison to a multiproduct calibrator
Capacitance – Source	1 kHz 1 pF 10 pF 100 pF 1 nF 10 nF 100 nF 1 μF	 11 μF/F 5.4 μF/F 1.9 μF/F 8.8 μF/F 27 μF/F 34 μF/F 43 μF/F	Comparison to reference capacitors and a ratio transformer
Capacitance - Source	< 1 pF 1 MHz 100 kHz 10 kHz	 0.067 pF 0.64 pF 0.76 pF	Comparison to reference resistors

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance - Measure	DC		Comparison to an LCR meter, DC current source and a Keysight 3458A multimeter
	0.2 mF	48 nF	
	0.3 mF	59 nF	
	0.33 mF	61 nF	
	0.7 mF	0.11 µF	
	1.09 mF	0.16 µF	
	1.1 mF	0.16 µF	
	2 mF	0.29 µF	
	3 mF	0.43 µF	
	3.3 mF	0.44 µF	
	10.9 mF	1.6 µF	
	20 mF	2.7 µF	
	30 mF	4.1 µF	
	33 mF	4.5 µF	
	110 mF	16 µF	
	(50, 100) Hz, 1 kHz		
	(0.19 to 1.2) nF	0.98 mF/F + 0.12 pF	
	(2 to 12) nF	0.9 mF/F + 0.23 pF	
	(20 to 120) nF	0.91 mF/F + 0.88 pF	
	(0.2 to 1.09) µF	0.91 mF/F + 8.1 pF	
	(2 to 12) µF	0.91 mF/F + 95 pF	
	20 µF	20 nF	
	30 µF	30 nF	
	33 µF	51 nF	
	70 µF	120 nF	
	109 µF	250 nF	
	0.12 mF	280 nF	
Capacitance - Measure	1 kHz		Comparison to a capacitance bridge
	1 pF to 40 nF	3 µF/F	
	(40 to 100) nF	4 µF/F	
	(100 to 400) nF	5 µF/F	
	400 nF to 1.2 µF	8 µF/F	
Charge - Measure	DC		Comparison to reference capacitors and a Keysight 3458A multimeter
	(0 to 0.2) nC	0.079 pC	
	(0.2 to 2.0) nC	0.78 pC	
	(2 to 20) nC	4.5 pC	
	(20 to 200) nC	0.043 nC	
	(0.2 to 2) µC	0.43 nC	

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dissipation Factor – Measure [1]	>0 to 1 1 kHz 1 pF to 1 nF (1 to 10) nF (10 to 40) nF (40 to 70) nF (70 to 100) nF (100 to 200) nF (200 to 300) nF (300 to 400) nF (400 to 500) nF (500 to 600) nF (600 to 700) nF (700 to 800) nF (800 to 900) nF 900 nF to 1 µF (1 to 1.2) µF	 0.000 003 0.000 005 0.000 01 0.000 015 0.000 02 0.000 04 0.000 055 0.000 075 0.000 095 0.000 11 0.000 13 0.000 15 0.000 16 0.000 18 0.000 21	Comparison to a capacitance bridge
Inductance – Measure	1 MHz 0.1 Ω 1 Ω 10 Ω 100 Ω	 1 nH 0.3 nH 1 nH 7 nH	Comparison to a reference RL standard and an LCR Meter
Reactance – Measure	10 Ω 1 MHz (2, 3) MHz 4 MHz 5 MHz 10 MHz 13 MHz 100 Ω (1, 2, 3, 4, 5) MHz 10 MHz 13 MHz	 4 mΩ 5 mΩ 6 mΩ 7 mΩ 20 mΩ 40 mΩ 40 mΩ 80 mΩ 90 mΩ	Comparison to reference RL, capacitance standards and an LCR Meter
Phase Angle	(40 to 100) Hz (-180 to +180)°	 0.046°	Comparison to a Power Analyzer, current transducer
Power	(40 to 100) Hz 0 W (5 to 25) kW (25 to 50) kW	 0.80 W 2 mW/W - 0.16 W 1.4 mW/W + 29 W	Comparison to a Power Analyzer, current transducer

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Susceptance – Measure	1 kΩ 100 kHz (1, 2, 3, 4, 5) MHz (10, 13) MHz 10 kΩ (0.1, 1) MHz 100 kΩ (0.1, 1) MHz	 0.4 µS 0.4 µS 0.7 µS 0.04 µS 4 nS	Comparison to reference RL, capacitance standards and an LCR Meter
Temperature – Source [3] (simulation)	(-200 to -150) °C (-150 to 0) °C (0 to 51.6) °C (51.6 to 200) °C (200 to 525) °C (525 to 600) °C	1.33×10^{-5} T + 0.003 6 °C 1.5×10^{-5} T + 0.003 8 °C 1.6×10^{-5} T + 0.003 8 °C 1.6×10^{-5} T + 0.005 3 °C 1.7×10^{-5} T + 0.005 1 °C 1.9 10^{-5} T + 0.004 1 °C	Comparison to fixed resistors
Temperature – Source (stimulation)	(-210 to -200) °C (-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 760) °C (760 to 800) °C (800 to 1 200) °C (1 200 to 1 372) °C	0.22 °C 0.039 °C 0.055 °C 0.07 °C 0.078 °C 0.093 °C 0.14 °C 0.18 °C 0.19 °C 0.32 °C	Comparison to a resistance or voltage generator

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC DC Difference - Measure										
Reference Standard, Method, and/or Equipment	Comparison to an AC DC transfer standard										
Expanded Uncertainty of Measurement (+/-)											
Range	0.5 V	1 V	3 V	6 V	10 V	20 V	100 V	300 V	500 V	700 V	1 000 V
10 Hz	15 µV/V	6.3 µV/V	8.2 µV/V	57 µV/V	8.2 µV/V	-	6.9 µV/V	-	-	-	-
20 Hz	11 µV/V	4.5 µV/V	-	-	5.1 µV/V	-	7.6 µV/V	-	-	-	-
40 Hz	11 µV/V	3.8 µV/V	-	--	3.9 µV/V	-	6.3 µV/V	6.3 µV/V	9.2 µV/V	10 µV/V	10 µV/V
100 Hz	12 µV/V	2.7 µV/V	3.1 µV/V	25 µV/V	3.1 µV/V	-	6.8 µV/V	6.4 µV/V	9.2 µV/V	9.3 µV/V	10 µV/V
1 kHz	4.6 µV/V	3.1 µV/V	3.1 µV/V	2.9 µV/V	3.4 µV/V	3.5 µV/V	4 µV/V	6.6 µV/V	9.2 µV/V	9.9 µV/V	10 µV/V

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC DC Difference - Measure										
Reference Standard, Method, and/or Equipment	Comparison to an AC DC transfer standard										
Expanded Uncertainty of Measurement (+/-)											
Range	0.5 V	1 V	3 V	6 V	10 V	20 V	100 V	300 V	500 V	700 V	1 000 V
10 kHz	6 µV/V	3.5 µV/V	3.5 µV/V	34 µV/V	3 µV/V	-	4.3 µV/V	6.9 µV/V	9.4 µV/V	10 µV/V	11 µV/V
20 kHz	7.4 µV/V	3.5 µV/V	3.5 µV/V		2.7 µV/V	-	3.7 µV/V	5.6 µV/V	9.9 µV/V	10 µV/V	10 µV/V
30 kHz	8.5 µV/V	3.1 µV/V	4.5 µV/V	25 µV/V	2.7 µV/V	-	3.9 µV/V	7.3 µV/V	11 µV/V	12 µV/V	12 µV/V
50 kHz	8.2 µV/V	4.3 µV/V	-	-	4 µV/V	-	6.7 µV/V	8.7 µV/V	14 µV/V	16 µV/V	-
100 kHz	9.4 µV/V	4.6 µV/V	4.7 µV/V	32 µV/V	5.2 µV/V	-	7.3 µV/V	15 µV/V	25 µV/V	23 µV/V	-
200 kHz	21 µV/V	7.9 µV/V	-	-	7.6 µV/V	-	13 µV/V	-	-	-	-
300 kHz	21 µV/V	7.7 µV/V	7.5 µV/V	35 µV/V	7.6 µV/V	-	-	-	-	-	-
500 kHz	25 µV/V	11 µV/V	-	-	11 µV/V	-	-	-	-	-	-
1 MHz	33 µV/V	18 µV/V	17 µV/V	52 µV/V	18 µV/V	-	-	-	-	-	-
3 MHz	0.11 mV/V	0.11 mV/V	0.11 mV/V	0.11 mV/V	-	-	-	-	-	-	-
8 MHz	0.32 mV/V	0.32 mV/V	0.32 mV/V	0.32 mV/V	-	-	-	-	-	-	-
10 MHz	0.35 mV/V	0.35 mV/V	0.35 mV/V	0.35 mV/V	-	-	-	-	-	-	-
20 MHz	0.58 mV/V	0.58 mV/V	0.58 mV/V	0.58 mV/V	-	-	-	-	-	-	-
30 MHz	0.73 mV/V	0.73 mV/V	0.73 mV/V	0.73 mV/V	-	-	-	-	-	-	-
50 MHz	1.6 mV/V	1.6 mV/V	1.6 mV/V	1.6 mV/V	-	-	-	-	-	-	-
70 MHz	2.8 mV/V	2.8 mV/V	2.8 mV/V	2.8 mV/V	-	-	-	-	-	-	-
80 MHz	3 mV/V	3 mV/V	3 mV/V	3 mV/V	-	-	-	-	-	-	-
100 MHz	3.6 mV/V	3.6 mV/V	3.6 mV/V	3.6 mV/V	-	-	-	-	-	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC DC Difference - Measure									
Reference Standard, Method, and/or Equipment	Comparison to an AC DC transfer standard and a ratio transformer									
Expanded Uncertainty of Measurement (+/-)										
Range	200 mV	600 mV	1 V	2 V	6 V	20 V	60 V	200 V	600 V	1 000 V
10 Hz	31 µV/V	14 µV/V	12 µV/V	33 µV/V	25 µV/V	22 µV/V	14 µV/V	23 µV/V	-	-
20 Hz	22 µV/V	12 µV/V	13 µV/V	4.2 µV/V	4.6 µV/V	10 µV/V	8.5 µV/V	15 µV/V	-	-
40 Hz	13 µV/V	11 µV/V	3.2 µV/V	2.4 µV/V	3.2 µV/V	6.3 µV/V	10 µV/V	12 µV/V	12 µV/V	12 µV/V
1 kHz	9.8 µV/V	5.4 µV/V	3 µV/V	5.8 µV/V	6.5 µV/V	6.8 µV/V	11 µV/V	11 µV/V	12 µV/V	12 µV/V
20 kHz	9.7 µV/V	5.8 µV/V	2.8 µV/V	2.7 µV/V	2.3 µV/V	6.3 µV/V	6.2 µV/V	11 µV/V	11 µV/V	11 µV/V

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC DC Difference - Measure									
Reference Standard, Method, and/or Equipment	Comparison to an AC DC transfer standard and a ratio transformer									
Expanded Uncertainty of Measurement (+/-)										
Range	200 mV	600 mV	1 V	2 V	6 V	20 V	60 V	200 V	600 V	1 000 V
50 kHz	10 µV/V	5.8 µV/V	3 µV/V	2.8 µV/V	2.4 µV/V	6.1 µV/V	6.3 µV/V	11 µV/V	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage Flatness - Measure							
Reference Standard, Method, and/or Equipment	Comparison to a Thermal Voltage Convertor, reference attenuators							
Expanded Uncertainty of Measurement (+/-)								
Range	(0.6 to 2.2) mV	(1.9 to 7) mV	(6 to 22) mV	(19 to 70) mV	(60 to 220) mV	(190 to 700) mV	(0.6 to 2.2) V	(1.9 to 7) V
(10 to 20) Hz	77 µV/V	72 µV/V	71 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V
(20 to 50) Hz	75 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V
(50 to 100) Hz	78 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V	70 µV/V
(0.1 to 1) kHz	41 µV/V	45 µV/V	43 µV/V	41 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V
(1 to 20) kHz	45 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V
(20 to 50) kHz	47 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V
(50 to 100) kHz	45 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V	40 µV/V
(100 to 200) kHz	56 µV/V	50 µV/V	50 µV/V	50 µV/V	50 µV/V	50 µV/V	50 µV/V	50 µV/V
(200 to 300) kHz	68 µV/V	62 µV/V	61 µV/V	60 µV/V	60 µV/V	60 µV/V	60 µV/V	60 µV/V
(300 to 500) kHz	66 µV/V	65 µV/V	62 µV/V	62 µV/V	61 µV/V	60 µV/V	60 µV/V	60 µV/V
(0.5 to 1) MHz	93 µV/V	90 µV/V	85 µV/V	84 µV/V	83 µV/V	81 µV/V	80 µV/V	80 µV/V
(1 to 2) MHz	0.12 mV/V	0.11 mV/V	99 µV/V	94 µV/V	90 µV/V	85 µV/V	80 µV/V	81 µV/V
(2 to 3) MHz	0.27 mV/V	0.26 mV/V	0.24 mV/V	0.23 mV/V	0.22 mV/V	0.21 mV/V	0.21 mV/V	0.21 mV/V
(3 to 4) MHz	0.33 mV/V	0.32 mV/V	0.27 mV/V	0.25 mV/V	0.24 mV/V	0.22 mV/V	0.21 mV/V	0.21 mV/V
(4 to 8) MHz	0.48 mV/V	0.46 mV/V	0.4 mV/V	0.38 mV/V	0.36 mV/V	0.35 mV/V	0.33 mV/V	0.33 mV/V
(8 to 10) MHz	0.77 mV/V	0.74 mV/V	0.57 mV/V	0.52 mV/V	0.46 mV/V	0.4 mV/V	0.33 mV/V	0.33 mV/V
(10 to 15) MHz	0.95 mV/V	0.9 mV/V	0.68 mV/V	0.61 mV/V	0.54 mV/V	0.46 mV/V	0.36 mV/V	0.36 mV/V
(15 to 20) MHz	1 mV/V	1 mV/V	0.83 mV/V	0.78 mV/V	0.72 mV/V	0.66 mV/V	0.6 mV/V	0.6 mV/V
(20 to 26) MHz	1 mV/V	1 mV/V	0.83 mV/V	0.78 mV/V	0.72 mV/V	0.66 mV/V	0.6 mV/V	0.6 mV/V
(26 to 30) MHz	1.2 mV/V	1.1 mV/V	1 mV/V	0.97 mV/V	0.92 mV/V	0.88 mV/V	0.83 mV/V	0.83 mV/V
(30 to 35) MHz	2 mV/V	1.7 mV/V	1.7 mV/V	1.4 mV/V	1.3 mV/V	1.1 mV/V	1.1 mV/V	1.1 mV/V

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage Flatness - Measure							
Reference Standard, Method, and/or Equipment	Comparison to a Thermal Voltage Convertor, reference attenuators							
Expanded Uncertainty of Measurement (+/-)								
Range	(0.6 to 2.2) mV	(1.9 to 7) mV	(6 to 22) mV	(19 to 70) mV	(60 to 220) mV	(190 to 700) mV	(0.6 to 2.2) V	(1.9 to 7) V
(35 to 40) MHz	2.2 mV/V	1.9 mV/V	1.9 mV/V	1.5 mV/V	1.4 mV/V	1.2 mV/V	1.2 mV/V	1.2 mV/V
(45 to 50) MHz	2.4 mV/V	2.1 mV/V	2.1 mV/V	1.7 mV/V	1.6 mV/V	1.3 mV/V	1.3 mV/V	1.3 mV/V

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Source and Measure				
Reference Standard, Method, and/or Equipment	Comparison to an AC source and a voltage divider				
Expanded Uncertainty of Measurement (+/-)					
Range	(0.6 to 2.2) mV	(1.9 to 7) mV	(6 to 22) mV	(19 to 70) mV	(60 to 220) mV
(10 to 20) Hz	15 µV/V	5.2 µV/V	4.2 µV/V	3.6 µV/V	3.4 µV/V
(20 to 45) Hz	14 µV/V	4 µV/V	4.2 µV/V	3.5 µV/V	3.3 µV/V
(45 to 100) Hz	13 µV/V	5.4 µV/V	4 µV/V	3.4 µV/V	3.4 µV/V
(0.1 to 1) kHz	19 µV/V	4.5 µV/V	4.2 µV/V	3.4 µV/V	10 µV/V
(1 to 20) kHz	22 µV/V	11 µV/V	11 µV/V	10 µV/V	5.3 µV/V
(20 to 50) kHz	46 µV/V	6.6 µV/V	5.8 µV/V	5.4 µV/V	5.4 µV/V
(50 to 100) kHz	45 µV/V	6.1 µV/V	5 µV/V	5.4 µV/V	5.4 µV/V
(100 to 200) kHz	46 µV/V	5.3 µV/V	4.8 µV/V	7.4 µV/V	7.4 µV/V
(200 to 300) kHz	35 µV/V	10 µV/V	9 µV/V	7.8 µV/V	7.8 µV/V
(300 to 500) kHz	58 µV/V	22 µV/V	21 µV/V	25 µV/V	25 µV/V
(0.5 to 1) MHz	328 µV/V	114 µV/V	114 µV/V	49 µV/V	49 µV/V

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Measure														
Reference Standard, Method, and/or Equipment	Comparison to an AC DC transfer standard														
Expanded Uncertainty of Measurement (+/-)															
Range	10 Hz	20 Hz	40 Hz	45 Hz	100 Hz	1 kHz	10 kHz	20 kHz	30 kHz	50 kHz	100 kHz	200 kHz	300 kHz	500 kHz	1 MHz
60 mV	49 µV/V	38 µV/V	37 µV/V	-	-	40 µV/V	-	37 µV/V	-	26 µV/V	38 µV/V	-	81 µV/V	81 µV/V	81 µV/V
200 mV	27 µV/V	20 µV/V	11 µV/V	-	-	7 µV/V	-	7 µV/V	-	8 µV/V	9 µV/V	-	30 µV/V	30 µV/V	47 µV/V
300 mV	15 µV/V	13 µV/V	12 µV/V	12 µV/V	13 µV/V	6.8 µV/V	9.5 µV/V	9.5 µV/V	10 µV/V	10 µV/V	10 µV/V	21 µV/V	21 µV/V	26 µV/V	35 µV/V
500 mV	-	-	-	-	-	6.8 µV/V	-	-	-	-	-	-	-	-	-
600 mV	13 µV/V	12 µV/V	11 µV/V	-	-	5.8 µV/V	-	6 µV/V	-	5.8 µV/V	8.6 µV/V	-	30 µV/V	30 µV/V	45 µV/V
1 V	3.1 µV/V	2.2 µV/V	1.6 µV/V	1.6 µV/V	1.6 µV/V	1.6 µV/V	1.3 µV/V	1.7 µV/V	1.4 µV/V	1.9 µV/V	4.1 µV/V	5.1 µV/V	5.1 µV/V	9.1 µV/V	9.1 µV/V
2 V	28 µV/V	5.6 µV/V	4.7 µV/V	-	-	5.8 µV/V	-	3.1 µV/V	-	5.9 µV/V	6.1 µV/V	-	11 µV/V	10 µV/V	16 µV/V
3 V	-	-	-	-	-	1.7 µV/V	-	-	-	-	5.1 µV/V	-	-	-	-
6 V	20 µV/V	5.7 µV/V	4.1 µV/V	-	-	1.5 µV/V	-	3.4 µV/V	-	2.8 µV/V	5.2 µV/V	-	10 µV/V	10 µV/V	19 µV/V
10 V	2.5 µV/V	2.2 µV/V	1.8 µV/V	1.8 µV/V	1.6 µV/V	1.7 µV/V	1.6 µV/V	1.4 µV/V	1.5 µV/V	1.6 µV/V	4.1 µV/V	5.1 µV/V	5.1 µV/V	9.1 µV/V	9.1 µV/V
20 V	17 µV/V	9.9 µV/V	6.9 µV/V	-	-	7.8 µV/V	-	6.3 µV/V	-	6.3 µV/V	7.1 µV/V	-	12 µV/V	12 µV/V	25 µV/V
60 V	13 µV/V	8 µV/V	8.1 µV/V	-	-	9.9 µV/V	-	6.5 µV/V	-	6.6 µV/V	12 µV/V	-	14 µV/V	-	-
100 V	-	-	-	-	-	-	-	-	-	-	-	-	7.1 µV/V	-	-
200 V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	5.1 µV/V	8.1 µV/V	10 µV/V	-	-	-
300 V	22 µV/V	15 µV/V	12 µV/V	-	-	12 µV/V	-	11 µV/V	-	11 µV/V	11 µV/V	-	-	-	-
500 V	-	-	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	12 µV/V	-	-	-	-
600 V	-	-	9.1 µV/V	9.1 µV/V	9.1 µV/V	9.1 µV/V	9.1 µV/V	9.1 µV/V	9.1 µV/V	11 µV/V	18 µV/V	-	-	-	-
700 V	-	-	12 µV/V	-	-	12 µV/V	-	11 µV/V	-	11 µV/V	35 µV/V	-	-	-	-
1 000 V	-	-	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	6.1 µV/V	12 µV/V	-	-	-	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Source							
Reference Standard, Method, and/or Equipment	Comparison to a characterized AC voltage source							
Expanded Uncertainty of Measurement (+/-)								
Range	10 mV	100 mV	1 V	3 V	10 V	100 V	700 V	1 000 V
10 Hz	0.69 µV	1.7 µV	-	-	76 µV	-	-	-
20 Hz	0.51 µV	1.8 µV	-	-	45 µV	-	-	-
40 Hz	-	-	-	-	35 µV	-	-	-
200 Hz	-	-	-	-	24 µV	-	-	-
500 Hz	-	-	-	-	25 µV	-	-	-
1 kHz	70 nV	0.36 µV	2.6 µV	-	26 µV	0.42 mV	6.5 mV	16 mV
10 kHz	-	-	-	-	26 µV	-	7 mV	11 mV
20 kHz	76 nV	0.31 µV	2.8 µV	-	25 µV	0.35 mV	-	22 mV
50 kHz	-	-	3.7 µV	-	36 µV	0.67 mV	-	-
100 kHz	62 nV	0.34 µV	4.6 µV	13 µV	44 µV	0.8 mV	-	-
300 kHz	0.17 µV	0.7 µV	8 µV	-	73 µV	-	-	-
500 kHz	-	-	11 µV	-	0.11 mV	-	-	-
1 MHz	1.15 µV	2.7 µV	20 µV	-	0.19 mV	-	-	-
2 MHz	-	-	-	2.1 mV		-	-	-
4 MHz	10 µV	0.1 mV	1 mV	3.2 mV		-	-	-
8 MHz	-	0.16 mV	1.6 mV	4.8 mV		-	-	-
10 MHz	-	0.18 mV	1.8 mV	5.5 mV		-	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC voltage source								
Expanded Uncertainty of Measurement (+/-)									
Range	(>0 to 2.2) mV	(2.2 to 22) mV	(22 to 220) mV	(0.22 to 2.2) V	(2.2 to 22) V	(22 to 220) V	(220 to 250) V	(220 to 1 100) V	(220 to 750) V
(10 to 15) Hz	230 µV/V + 3.9 µV	230 µV/V + 3.9 µV	230 µV/V + 12 µV	230 µV/V + 39 µV	230 µV/V + 390 µV	230 µV/V + 3.9 mV	-	-	-
(15 to 20) Hz	230 µV/V + 3.9 µV	230 µV/V + 3.9 µV	230 µV/V + 12 µV	230 µV/V + 39 µV	230 µV/V + 390 µV	230 µV/V + 3.9 mV	280 µV/V + 16 mV	-	-
(20 to 40) Hz	89 µV/V + 3.9 µV	89 µV/V + 3.9 µV	89 µV/V + 6.2 µV	85 µV/V + 16 µV	85 µV/V + 160 µV	85 µV/V + 1.6 mV	280 µV/V + 16 mV	-	-
(40 to 50) Hz	77 µV/V + 3.9 µV	77 µV/V + 3.9 µV	54 µV/V + 6.2 µV	37 µV/V + 7.8 µV	37 µV/V + 54 µV	50 µV/V + 0.54 mV	-	70 µV/V + 3.1 mV	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC voltage source								
Expanded Uncertainty of Measurement (+/-)									
Range	(>0 to 2.2) mV	(2.2 to 22) mV	(22 to 220) mV	(0.22 to 2.2) V	(2.2 to 22) V	(22 to 220) V	(220 to 250) V	(220 to 1 100) V	(220 to 750) V
50 Hz to 1 kHz	77 µV/V + 3.9 µV	77 µV/V + 3.9 µV	54 µV/V + 6.2 µV	37 µV/V + 7.8 µV	37 µV/V + 54 µV	50 µV/V + 0.54 mV	-	66 µV/V + 3.1 mV	-
(1 to 20) kHz	77 µV/V + 3.9 µV	77 µV/V + 3.9 µV	54 µV/V + 6.2 µV	37 µV/V + 7.8 µV	37 µV/V + 54 µV	50 µV/V + 0.54 mV	-	130 µV/V + 4.7 mV	-
(20 to 30) kHz	190 µV/V + 3.9 µV	190 µV/V + 3.9 µV	120 µV/V + 6.2 µV	62 µV/V + 9.3 µV	62 µV/V + 93 µV	78 µV/V + 0.93 mV	-	470 µV/V + 8.5 mV	-
(30 to 50) kHz	190 µV/V + 3.9 µV	190 µV/V + 3.9 µV	120 µV/V + 6.2 µV	62 µV/V + 9.3 µV	62 µV/V + 93 µV	78 µV/V + 0.93 mV	-	-	470 µV/V + 8.5 mV
(50 to 100) kHz	460 µV/V + 4.7 µV	470 µV/V + 4.7 µV	310 µV/V + 16 µV	78 µV/V + 31 µV	78 µV/V + 190 µV	140 µV/V + 2.3 mV	-	-	1.8 mV/V + 35 mV
Range	(>0 to 2.2) mV	(2.2 to 22) mV	(22 to 220) mV	(0.22 to 2.2) V	(2.2 to 22) V	(22 to 2.2e7/f) V	(220 to 250) V	(220 to 1 100) V	(220 to 250) V
(100 to 300) kHz	1 mV/V + 9.3 µV	1 mV/V + 9.3 µV	620 µV/V + 19 µV	310 µV/V + 78 µV	230 µV/V + 620 µV	850 µV/V + 16 mV	-	-	-
(300 to 500) kHz	1.3 mV/V + 19 µV	1.3 mV/V + 19 µV	1.3 mV/V + 23 µV	930 µV/V + 190 µV	930 µV/V + 1.9 mV	4.2 mV/V + 39 mV	-	-	-
500 kHz to 1 MHz	2.6 mV/V + 19 µV	2.6 mV/V 19 µV	2.6 mV/V + 47 µV	1.6 mV/V + 310 µV	1.4 mV/V + 3.1 mV	7.8 mV/V + 78 mV	-	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Measure					
Reference Standard, Method, and/or Equipment	Comparison to a Keysight 3458A multimeter					
Expanded Uncertainty of Measurement (+/-)						
Range	(>0 to 10 mV)	(10 to 120) mV	(0.12 to 1.2) V	(1.2 to 12) V	(12 to 120) V	(120 to 700) V
(1 to 40) Hz	0.35 mV/V + 3.4 µV	83 µV/V + 4.6 µV	83 µV/V + 46 µV	83 µV/V + 0.46 mV	0.23 mV/V + 4.6 mV	0.46 mV/V + 46 mV
40 Hz to 1 kHz	0.23 mV/V + 1.3 µV	83 µV/V + 2.3 µV	83 µV/V + 23 µV	83 µV/V + 0.23 mV	0.23 mV/V + 2.3 mV	0.46 mV/V + 23 mV
(1 to 20) kHz	0.34 mV/V + 1.3 µV	0.16 mV/V + 2.3 µV	0.16 mV/V + 23 µV	0.16 mV/V + 0.23 mV	0.23 mV/V + 2.3 mV	0.7 mV/V + 23 mV
(20 to 50) kHz	1.1 mV/V + 1.3 µ/V	0.34 mV/V + 2.3 µV	0.34 mV/V + 23 µV	0.34 mV/V + 0.23 mV	0.4 mV/V + 2.3 mV	1.4 mV/V + 23 mV
(50 to 100) kHz	5.7 mV/V + 1.2 µV	0.92 mV/V + 2.3 µV	0.92 mV/V + 23 µV	0.92 mV/V + 0.23 mV	1.4 mV/V + 2.3 mV	3.5 mV/V + 23 mV
(100 to 300) kHz	46 mV/V + 2.3 µV	3.4 mV/V + 12 µV	3.4 mV/V + 0.11 mV	3.4 mV/V + 1.2 mV	4.6 mV/V + 11 mV	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Voltage - Measure					
Reference Standard, Method, and/or Equipment	Comparison to a Keysight 3458A multimeter					
Expanded Uncertainty of Measurement (+/-)						
Range	(>0 to 10 mV)	(10 to 120) mV	(0.12 to 1.2) V	(1.2 to 12) V	(12 to 120) V	(120 to 700) V
300 kHz to 1 MHz	14 mV/V + 5.8 µV	11 mV/V + 12 µV	11 mV/V + 0.12 mV	11 mV/V + 1.2 mV	17 mV/V + 11 mV	-
(1 to 2) MHz	81 mV/V + 8.1 µV	17 mV/V + 12 µV	17 mV/V + 0.12 mV	17 mV/V + 1.2 mV	-	-
(2 to 4) MHz	82 mV/V + 8.1 µV	46 mV/V + 81 µV	46 mV/V + 0.81 mV	46 mV/V + 8.1 mV	-	-
(4 to 8) MHz	230 mV/V + 9.2 µV	46 mV/V + 92 µV	46 mV/V + 0.92 mV	46 mV/V + 9.2 mV	-	-
(8 to 10) MHz	-	170 mV/V + 120 µV	170 mV/V + 1.2 mV	170 mV/V + 12 mV	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC source								
Expanded Uncertainty of Measurement (+/-)									
Range	(10 to 20) Hz	(20 to 30) Hz	(30 to 40) Hz	(40 to 45) Hz	(45 to 100) Hz	(0.1 to 1) kHz	(1 to 5) kHz	(5 to 10) kHz	(10 to 30) kHz
(>0 to 220) µA	230 µA/A + 16 nA	160 µA/A + 9.3 nA	160 µA/A + 9.3 nA	93 µA/A + 7.8 nA	93 µA/A + 7.8 nA	93 µA/A + 7.8 nA	270 µA/A + 12 nA	1 mA/A + 62 nA	13 mA/A + 0.33 µA
(220 to 330) µA	230 µA/A + 39 nA	160 µA/A + 31 nA	160 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	190 µA/A + 100 nA	1 mA/A + 620 nA	13 mA/A + 0.33 µA
(0.33 to 2.2) mA	230 µA/A + 39 nA	160 µA/A + 31 nA	160 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	190 µA/A + 100 nA	1 mA/A + 620 nA	8.2 mA/A + 0.49 µA
(2.2 to 3.3) mA	230 µA/A + 390 nA	160 µA/A + 310 nA	160 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	190 µA/A +540 nA	1 mA/A + 4.7 µA	8.2 mA/A + 0.49 µA
(3.3 to 22) mA	230 µA/A + 390 nA	160 µA/A + 310 nA	160 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	190 µA/A +540 nA	1 mA/A + 4.7 µA	3.3 mA/A + 3.3 µA
(22 to 33) mA	230 µA/A + 3.9 µA	160 µA/A + 3.1 µA	160 µA/A + 3.1 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	190 µA/A +3.1 µA	1 mA/A + 9.3 µA	3.3 mA/A + 3.3 µA
(33 to 220) mA	230 µA/A + 3.9 µA	160 µA/A + 3.1 µA	160 µA/A + 3.1 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	190 µA/A +3.1 µA	1 mA/A + 9.3 µA	3.3 mA/A + 0.16 mA
(220 to 330) mA	1.5 mA/A + 16 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	390 µA/A +78 µA	6.2 mA/A + 160 µA	3.3 mA/A + 0.16 mA
(0.33 to 2.2) A	1.5 mA/A + 82 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	390 µA/A +78 µA	6.2 mA/A + 160 µA	-
(2.2 to 3) A	1.5 mA/A + 82 µA	1.5 mA/A + 82 µA	1.5 mA/A + 82 µA	360 µA/A + 130 µA	360 µA/A + 130 µA	360 µA/A + 130 µA	740 µA/A +290 µA	2.8 mA/A + 580 µA	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC source								
Expanded Uncertainty of Measurement (+/-)									
Range	(10 to 20) Hz	(20 to 30) Hz	(30 to 40) Hz	(40 to 45) Hz	(45 to 100) Hz	(0.1 to 1) kHz	(1 to 5) kHz	(5 to 10) kHz	(10 to 30) kHz
(3 to 11) A	-	-	-	360 µA/A + 130 µA	360 µA/A + 130 µA	360 µA/A + 130 µA	740 µA/A +290 µA	2.8 mA/A + 580 µA	-
(11 to 20.5) A	-	-	-	-	0.98 mA/A + 4.1 mA	1.2 mA/A + 4.1 mA	25 mA/A + 4.1 mA	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Measure										
Reference Standard, Method, and/or Equipment	Comparison to an AC measurement standard, source and reference current shunts										
Expanded Uncertainty of Measurement (+/-)											
Range	10 Hz	20 Hz	40 Hz	50 Hz	60 Hz	400 Hz	500 Hz	1 kHz	3 kHz	5 kHz	10 kHz
10 µA	0.5 nA	0.71 nA	-	0.48 nA	-	-	-	0.44 nA	-	-	-
100 µA	4.6 nA	4.5 nA	-	4.5 nA	-	-	-	4.5 nA		4.6 nA	4.6 nA
1 mA	39 nA	39 nA	-	39 nA	-	-	-	39 nA		40 nA	38 nA
10 mA	0.25 µA	0.25 µA	-	0.24 µA	-	-	-	0.24 µA		0.25 µA	0.25 µA
100 mA	4.7 µA	4.7 µA	-	4.7 µA	-	-	-	4.7 µA		4.7 µA	4.3 µA
1 A	36 µA	36 µA	-	36 µA	-	-	-	36 µA		37 µA	41 µA
2.5 A	-	-	-	-	0.6 mA		1.1 mA	-	-	-	-
5 A	-	-	-	-	1.1 mA		2.4 mA	-	-	-	-
10 A	-	-	0.55 mA	-	4.9 mA	0.55 mA	4.9 mA	0.48 mA	0.71 mA	0.61 mA	0.49 mA
20 A	-	-	-	-	9.5 mA	-	9.5 mA	-	-	-	-
40 A	-	-	-	-	19 mA	-	19 mA	-	-	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Measure									
Reference Standard, Method, and/or Equipment	Comparison to an AC measurement standard, source and reference current shunts									
Expanded Uncertainty of Measurement (+/-)										
Range	10 Hz	20 Hz	40 Hz	45 Hz	65 Hz	500 Hz	1 kHz	5 kHz	10 kHz	30 kHz
20 µA	-	-	-	-	-	-	2.7 nA	-	2.7 nA	-

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Parameter/Equipment	AC Current - Measure									
Reference Standard, Method, and/or Equipment	Comparison to an AC measurement standard, source and reference current shunts									
Expanded Uncertainty of Measurement (+/-)										
Range	10 Hz	20 Hz	40 Hz	45 Hz	65 Hz	500 Hz	1 kHz	5 kHz	10 kHz	30 kHz
33 µA	-	-	-	-	-	-	4.9 nA	-	10 nA	8.3 nA
190 µA	-	-	-	9.8 nA	-	-	9.7 nA	9.7 nA	9.7 nA	14 nA
200 µA	34 nA	15 nA	7.8 nA	-	-	-	7.7 nA	7.6 nA	7.8 nA	-
329 µA	56 nA	-	-	15 nA			15 nA	15 nA	15 nA	19 nA
330 µA	-	-	-	-	-	-	20 nA	19 nA	-	21 nA
1.9 mA	-	-	-	-	-	-	85 nA	85 nA	85 nA	130 nA
2 mA	350 nA	150 nA	87 nA	-	--		87 nA	88 nA	88 nA	-
3.29 mA	560 nA	-	-	130 nA	-	-	130 nA	130 nA	130 nA	170 nA
3.3 mA	-	-	-	-	-	-	180 nA	140 nA	140 nA	240 nA
19 mA	-	-	-	-	-	-	580 nA	-	590 nA	830 nA
20 mA	3.2 µA	1.1 µA	0.6 µA	-	-	-	0.6 µA	0.6 µA	0.6 µA	-
32.9 mA	5.6 µA			1.3 µA	-	-	1.3 µA	1.3 µA	1.3 µA	1.7 µA
33 mA	-	-	-	-	-	-	1.5 µA	1.7 µA	-	2 µA
190 mA	-	-	-	-	-	-	6 µA	6.1 µA	-	8.6 µA
200 mA	32 µA	11 µA	6.3 µA	-	-	-	6.3 µA	6.4 µA	6.3 µA	-
329 mA	56 µA	-	-	16 µA	-	-	16 µA	16 µA	16 µA	20 µA
330 mA	-	-	-	-	-	-	18 µA	17 µA	46 µA	-
1.09 A	170 µA	-	-	36 µA	-	-	35 µA	35 µA	140 µA	-
2 A	-	0.15 mA	-	-	-	-	0.1 mA	0.1 mA	0.13 mA	-
2.19 A	-	-	-	0.11 mA	-	-	0.11 mA	0.11 mA	-	-
2.2 A	-	-	-	-	-	0.11 mA	0.11 mA	-	-	-
2.99 A	0.51 mA	-	-	0.14 mA	-	-	0.14 mA	0.14 mA	0.14 mA	-
3 A			0.14 mA	-	-	-	0.14 mA	0.14 mA	0.14 mA	-
3.3 A	-	-	-	-	-	0.23 mA	0.23 mA	0.17 mA	-	-
10 A	-	-	0.84 mA	-	-	-	0.86 mA	0.88 mA	0.89 mA	-
10.9 A	-	-	-	0.89 mA	0.88 mA	0.88 mA	0.89 mA	0.93 mA	-	-
11 A	-	-	-	0.89 mA	0.88 mA	0.88 mA	0.89 mA	0.93 mA	-	-
20 A	-	-	-	1.4 mA	0.88 mA	0.92 mA	0.91 mA	1.1 mA	-	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Measure			
Reference Standard, Method, and/or Equipment	Comparison to a Keysight 3458A multimeter			
Expanded Uncertainty of Measurement (+/-)				
Range	(10 to 20) Hz	(20 to 45) Hz	(45 to 100) Hz	(0.1 to 5) kHz
(>0 to 120) µA	4.6 mA/A + 34 nA	1.7 mA/A + 34 nA	0.69 mA/A + 34 nA	0.69 mA/A + 34 nA
(0.1 to 1.2) mA	4.6 mA/A + 0.23 µA	1.7 mA/A + 0.23 µA	0.69 mA/A + 0.23 µA	0.35 mA/A + 0.23 µA
(1 to 12) mA	4.6 mA/A + 2.3 µA	1.7 mA/A + 2.3 µA	0.69 mA/A + 2.3 µA	0.35 mA/A + 2.3 µA
(10 to 120) mA	4.6 mA/A + 23 µA	1.7 mA/A + 23 µA	0.69 mA/A + 23 µA	0.35 mA/A + 23 µA
(0.12 to 1.05) A	4.6 mA/A + 0.23 mA	1.8 mA/A + 0.23 mA	0.93 mA/A + 0.23 mA	1.1 mA/A + 0.23 mA

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Measure							
Reference Standard, Method, and/or Equipment	Comparison to an AC source and a current coil							
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)								
Range	(10 to 20) Hz	(20 to 45) Hz	(45 to 65) Hz	(45 to 100) Hz	45 Hz to 1 kHz	(65 to 400) Hz	(0.1 to 1) kHz	(1 to 5) kHz
(0.1 to 1) mA	0.13 % + 0.43 µA	0.078 % + 0.47 µA	-	-	0.058 % + 0.5 µA	-	-	0.13 % + 0.53 µA
(1 to 3) mA	0.15 % + 0.25 µA	0.095 % + 0.35 µA	-	-	0.075 % + 0.35 µA	-	-	0.15 % + 0.35 µA
(3 to 10) mA	0.11 % + 5 µA	0.063 % + 4.4 µA	-	-	0.02 % + 5.3 µA	-	-	0.05 % + 5 µA
(10 to 30) mA	0.14 % + 3 µA	0.063 % + 4.4 µA	-	-	0.02 % + 5.3 µA	-	-	0.050 % + 5 µA
(30 to 300) mA	0.12 % + 48 µA	0.063 % + 44 µA	-	-	0.02 % + 54 µA	-	-	0.077 % + 58 µA
(0.3 to 1) A	0.15 % + 86 µA	0.12 % + 0.40 mA	-	-	0.02 % + 0.52 mA	-	-	0.46 % + 1 mA
(1 to 2.5) A	0.67 % - 0.5 mA	0.46 % - 0.5 mA	-	0.1 %	-	-	0.14 %	0.56 % + 0.75 mA
(2.5 to 3) A	-	-	-	0.1 %	-	-	0.14 %	2.3 % + 5 mA
(3 to 10) A	-	-	-	0.034 % + 5.1 mA	-	-	0.058 % + 5.2 mA	2.3 % + 5 mA
(10 to 20) A	-	-	-	0.15 % - 6.8 mA	-	-	0.18 % - 7 mA	2.3 % + 5 mA
(20 to 30)A	-	-	0.24 % + 23 mA	-	-	0.58 % + 34 mA	-	-
(30 to 150) A	-	-	0.21 % + 44 mA	-	-	0.63 % + 25 mA	-	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Current - Measure							
Reference Standard, Method, and/or Equipment	Comparison to an AC source and a current coil							
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)								
Range	(10 to 20) Hz	(20 to 45) Hz	(45 to 65) Hz	(45 to 100) Hz	45 Hz to 1 kHz	(65 to 400) Hz	(0.1 to 1) kHz	(1 to 5) kHz
(150 to 300) A	-	-	0.23 % + 94 mA	-	-	0.64 % + 71 mA	-	-
(300 to 1 020) A	-	-	0.25 % + 0.19 A	-	-	0.64 % + 60 mA	-	-

Electrical - DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Resistance - Source and Measure						
Reference Standard, Method, and/or Equipment	Comparison to reference resistors, shunts and an AC source						
Expanded Uncertainty of Measurement (+/-)							
Range	(>0 to 1) mΩ	(1 to 10) mΩ	(10 to 100) mΩ	(1 to 10) Ω	(10 to 100) Ω	(0.1 to 1) kΩ	1 kΩ
10 Hz	-	-	46 μΩ/Ω	29 μΩ/Ω	30 μΩ/Ω	53 μΩ/Ω	80 μΩ/Ω
20 Hz	-	-	30 μΩ/Ω	30 μΩ/Ω	26 μΩ/Ω	43 μΩ/Ω	54 μΩ/Ω
30 Hz	-	-	34 μΩ/Ω	29 μΩ/Ω	26 μΩ/Ω	38 μΩ/Ω	51 μΩ/Ω
40 Hz	287 μΩ/Ω	135 μΩ/Ω	-	-	-	-	-
45 Hz	-	-	58 μΩ/Ω	-	-	-	-
50 Hz	-	-	33 μΩ/Ω	27 μΩ/Ω	28 μΩ/Ω	38 μΩ/Ω	51 μΩ/Ω
60 Hz	-	82 μΩ/Ω	55 μΩ/Ω	-	-	-	-
100 Hz	-	-	34 μΩ/Ω	28 μΩ/Ω	26 μΩ/Ω	37 μΩ/Ω	50 μΩ/Ω
300 Hz	-	-	30 μΩ/Ω	26 μΩ/Ω	28 μΩ/Ω	37 μΩ/Ω	51 μΩ/Ω
400 Hz	285 μΩ/Ω	118 μΩ/Ω	-	-	-	-	-
500 Hz	-	82 μΩ/Ω	-	-	-	-	-
1 kHz	37 μΩ/Ω	35 μΩ/Ω	29 μΩ/Ω	26 μΩ/Ω	28 μΩ/Ω	35 μΩ/Ω	46 μΩ/Ω
3 kHz	282 μΩ/Ω	89 μΩ/Ω	30 μΩ/Ω	28 μΩ/Ω	26 μΩ/Ω	25 μΩ/Ω	47 μΩ/Ω
5 kHz	287 μΩ/Ω	85 μΩ/Ω	29 μΩ/Ω	29 μΩ/Ω	27 μΩ/Ω	37 μΩ/Ω	50 μΩ/Ω
10 kHz	284 μΩ/Ω	87 μΩ/Ω	33 μΩ/Ω	29 μΩ/Ω	28 μΩ/Ω	37 μΩ/Ω	49 μΩ/Ω

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Resistance - Source and Measure				
Reference Standard, Method, and/or Equipment	Comparison to reference resistors and an LCR meter				
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)					
Range	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
100 kHz	-	-	0.022 %	0.02 %	0.026 %
1 MHz	0.028 %	0.023 %	0.019 %	0.025 %	0.03 %
2 MHz	0.042 %	0.031 %	0.028 %	-	-
3 MHz	0.054 %	0.05 %	0.03 %	-	-
4 MHz	0.062 %	0.035 %	0.031 %	-	-
5 MHz	0.091 %	0.048 %	0.041 %	-	-
10 MHz	0.32 %	0.16 %	0.14 %	-	-
13 MHz	0.51 %	0.25 %	0.23 %	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Resistance – Source								
Reference Standard, Method, and/or Equipment	Comparison to reference resistors								
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)									
Range	1 mΩ	10 mΩ	100 mΩ	1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
20 Hz	-	-	-	-	0.036 %	0.003 2 %	0.0038 %	0.023 %	0.09 %
100 Hz	-	-	0.03 %	-	0.036 %	0.044 %	0.049 %	0.023 %	0.09 %
120 Hz	-	-	-	0.014 %	0.003 1 %	0.043 %	0.033 %	0.023 %	0.09 %
125 Hz	-	-	-	-	0.094 %	0.002 7 %	0.003 7 %	0.023 %	0.09 %
1 kHz	0.085 %	0.028 %	0.029 %	0.006 1 %	0.003 1 %	0.003 %	0.002 9 %	0.006 4 %	0.09 %
10 kHz	-	-	-	-	0.094 %	0.043 %	0.033 %	0.023 %	0.09 %
12.5 kHz	-	-	-	-	0.094 %	0.002 9 %	0.003 %	0.023 %	0.09%
48 kHz	-	-	-	-	0.094 %	0.003 3 %	0.003 4 %	0.023 %	0.09 %
96 kHz	-	-	-	-	0.094 %	0.004 5 %	0.004 2 %	0.023 %	0.09 %
100 kHz	-	-	-	-	0.094 %	0.043 %	0.03 %	0.02 %	0.004 9 %
1 MHz	-	-	-	-	0.096 %	0.003 9 %	0.004 2 %	0.03 %	0.005 %
2 MHz	-	-	-	-	0.094 %	0.04 %	0.03 %	-	-
3 MHz	-	-	-	-	0.1 %	0.05 %	0.03 %	-	-
4 MHz	-	-	-	-	0.1 %	0.05 %	0.04 %		
5 MHz	-	-	-	-	0.12 %	0.05 %	0.05 %	-	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	AC Resistance – Source								
Reference Standard, Method, and/or Equipment	Comparison to reference resistors								
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)									
Range	1 mΩ	10 mΩ	100 mΩ	1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
10 MHz	-	-	-	-	0.4 %	0.2 %	0.2 %	-	-
13 MHz	-	-	-	-	0.6 %	0.3 %	0.3 %	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Capacitance - Source							
Reference Standard, Method, and/or Equipment	Comparison to reference capacitors							
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)								
Range	1 pF	10 pF	100 pF	1000 pF	0.01 µF	0.1 µF	1 µF	10 µF
20 Hz	7.7 %	5.8 %	0.85 %	0.083 %	-	-	-	0.012 %
100 Hz	5.2 %	0.53 %	0.046 %	0.075 %	0.013 %	0.009 7 %	0.013 %	0.015 %
120 Hz	5.2 %	0.53 %	0.046 %	0.075 %	0.013 %	0.009 7 %	0.013 %	0.011 %
125 Hz	5.2 %	0.53 %	0.014 %	0.015 %	-	-	-	-
1 kHz	0.024 %	0.015 %	0.012 %	0.01 %	0.01 %	0.009 7 %	0.01 %	0.011 %
10 kHz	0.26 %	0.023 %	0.014 %	0.018 %	0.013 %	0.011 %	0.013 %	0.019 %
12.5 kHz	0.26 %	0.017 %	0.01 %	0.011 %	-	-	-	-
48 kHz	0.26 %	0.016 %	0.01 %	0.011 %	-	-	-	-
96 kHz	0.26 %	0.016 %	0.01 %	0.011 %	-	-	-	-
100 kHz	0.26 %	0.016 %	0.013 %	0.018 %	0.013 %	0.009 7 %	0.015 %	0.071 %
300 kHz	0.26 %	0.016 %	0.01 %	0.013 %	-	-	-	-
500 kHz	0.26 %	0.016 %	0.01 %	0.016 %	-	-	-	-
1 MHz	0.019 %	0.015 %	0.01 %	0.012 %	-	-	-	-
2 MHz	0.031 %	0.015 %	0.01 %	0.018 %	-	-	-	-
3 MHz	0.049 %	0.015 %	0.015 %	0.031 %	-	-	-	-
4 MHz	0.068 %	0.015 %	0.016 %	0.046 %	-	-	-	-
5 MHz	0.09 %	0.016 %	0.019 %	0.064 %	-	-	-	-
10 MHz	0.25 %	0.02 %	0.036 %	0.19 %	-	-	-	-
13 MHz	0.37 %	0.022 %	0.051 %	0.28 %	-	-	-	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Capacitance - Source and Measure							
Reference Standard, Method, and/or Equipment	Comparison to reference capacitances, capacitance bridge, LCR meter and a Keysight network analyzer							
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)								
Range	1 pF	10 pF	100 pF	1000 pF	0.01 µF	0.1 µF	1 µF	10 µF
120 Hz	-	-	-	-	0.004 %	0.004 %	0.005 %	0.005 %
1 kHz	0.004 4 %	0.003 9 %	0.003 8 %	0.004 1 %	0.004 %	0.004 %	0.004 %	0.005 %
10 kHz	-	-	-	-	0.004 %	0.004 %	0.004 %	0.016 %
100 kHz	-	-	-	-	0.004 %	0.004 %	0.004 %	0.07 %
1 MHz	0.009 %	0.003 9 %	0.004 %	0.006 4 %	-	-	-	-
2 MHz	0.023 %	0.004 %	0.004 8 %	0.015 %	-	-	-	-
3 MHz	0.041 %	0.004 3 %	0.006 6 %	0.028 %	-	-	-	-
4 MHz	0.063 %	0.004 7 %	0.009 1 %	0.044 %	-	-	-	-
5 MHz	0.088 %	0.005 4 %	0.013 %	0.062 %	-	-	-	-
10 MHz	0.25 %	0.012 %	0.033 %	0.19 %	-	-	-	-
13 MHz	0.37 %	0.016 %	0.049 %	0.28 %	-	-	-	-

Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Dissipation - Source							
Reference Standard, Method, and/or Equipment	Comparison to reference capacitors							
Expanded Uncertainty of Measurement (+/-)								
Range	1 pF	10 pF	100 pF	1 000 pF	0.01 µF	0.1 µF	1 µF	10 µF
20 Hz	-	-	0.003	0.000 31	-	-	-	0.000 073
100 Hz	0.025	0.003 9	0.000 43	0.000 46	0.000 062	-	-	0.000 078
120 Hz	0.025	0.003 9	0.000 43	0.000 46	0.000 02	0.000 03	0.000 04	0.0000 4
125 Hz	0.025	0.003 9	0.000 43	0.000077	-	-	-	-
1 kHz	0.000 02	0.000 02	0.000 02	0.000 02	0.000 02	0.000 02	0.000 02	0.000 03
10 kHz	0.002 4	0.000 24	0.000 086	0.000 065	0.000 02	0.000 02	0.000 03	0.000 28
12.5 kHz	0.002 4	0.000 061	0.000 061	0.000 065	-	-	-	-
48 kHz	0.002 4	0.000 061	0.000 061	0.000 065	-	-	-	-
96 kHz	0.002 4	0.000 061	0.000 061	0.000 065	-	-	-	-
100 kHz	0.002 4	0.000 061	0.000 061	0.000 065	0.000 02	0.000 03	0.000 04	0.000 7
300 kHz	0.002 4	0.000 061	0.000 061	0.000 065	-	-	-	-

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Electrical – DC/Low Frequency **Main Scope**

Parameter/Equipment	Dissipation - Source							
Reference Standard, Method, and/or Equipment	Comparison to reference capacitors							
Expanded Uncertainty of Measurement (+/-)								
Range	1 pF	10 pF	100 pF	1 000 pF	0.01 µF	0.1 µF	1 µF	10 µF
500 kHz	0.002 4	0.000 061	0.000 061	0.000 065	-	-	-	-
1 MHz	0.000 03	0.000 02	0.000 02	0.000 03	-	-	-	-
2 MHz	0.000 06	0.000 02	0.000 02	0.000 06	-	-	-	-
3 MHz	0.000 09	0.000 02	0.000 03	0.000 1	-	-	-	-
4 MHz	0.000 14	0.000 02	0.000 05	0.000 15	-	-	-	-
5 MHz	0.000 2	0.000 03	0.000 06	0.000 21	-	-	-	-
10 MHz	0.000 57	0.000 07	0.000 16	0.000 58	-	-	-	-
13 MHz	0.000 83	0.000 09	0.000 24	0.000 85	-	-	-	-

Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	**Range**	**Expanded Uncertainty of Measurement (+/-)**	**Reference Standard, Method, and/or Equipment**
Attenuation – Measure	Type-N, 3.5 mm, 2.4 mm (1 to 40) dB (0.3 to 500) MHz (0.5 to 2) GHz (2 to 18) GHz (18 to 40) GHz (40 to 50) GHz	 0.003 4 dB 0.004 7 dB ((0.011 % of reading * *f*) + 0.004 9) dB 0.008 9 dB 0.012 dB	Comparison to a Keysight network analyzer
Attenuation – Measure	Type-N: (50 to 80) dB 3.5 mm: 50, 60 dB 2.4 mm: 50 dB 300 kHz to 8 GHz (8 to 18) GHz (18 to 40) GHz (40 to 50) GHz	 0.025 dB 0.029 dB 0.034 dB 0.037 dB	Comparison to a Keysight network analyzer
Attenuation – Measure	Type-N: (70 to 100) dB 3.5 mm: 70 dB or 80 dB 300 kHz to 18 GHz (18 to 20) GHz (20 to 40) GHz (40 to 50) GHz	 0.048 dB 0.056 dB 0.059 dB 0.065 dB	Comparison to a Keysight network analyzer

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Measure	Type-N: 110, 120 dB 3.5 mm: 90 dB 2.4 mm: 65 or 90 dB 300 kHz to 18 GHz (18 to 20) GHz (20 to 40) GHz (40 to 50) GHz	 0.072 dB 0.08 dB 0.084 dB 0.094 dB	Comparison to a Keysight network analyzer
Attenuation – Measure	(1 to 12 dB) 20 Hz to 50 MHz 50 MHz to 1 GHz (1 to 2) GHz (2 to 4) GHz	 0.002 4 dB 0.004 8 dB 0.005 8 dB 0.007 5 dB	Comparison to ratio transformer
Impedance or VSWR [1]	1.0:1 to 2.0:1 DC	 0.000 32	Comparison to a Keysight 3458A multimeter
RF Power - Measure Calibration Factors [1]	(0.5 to 1.5) % DC	 0.002 8	Comparison to a Keysight 3458A multimeter

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Measure (Calibration Factors) [1]	(0.5 to 1.5) 9 kHz to 30 kHz 30 kHz to 50 MHz (50 to 100) MHz (0.1 to 6) GHz (6 to 7) GHz (7 to 8) GHz (8 to 18) GHz) (18 to 26) GHz (26 to 31) GHz (31 to 37) GHz (37 to 38) GHz (38 to 40) GHz (40 to 46) GHz (46 to 50) GHz (50 to 70) GHz (70 to 75) GHz (75 to 100) GHz (100 to 106) GHz (106 to 108) GHz (108 to 110) GHz (110 to 114) GHz (114 to 120) GHz	 0.003 1 0.002 9 0.002 1 0.002 9 0.003 1 0.003 2 0.003 8 0.008 1 0.008 6 0.008 4 0.009 3 0.008 3 0.014 0.013 0.02 0.041 0.044 0.043 0.045 0.051 0.054 0.057	Comparison to reference power sensor or Vector Network Analyzer
RF Power - Measure (Power Meter Reference)	1 mW, 50 MHz	0.22 % of reading	Comparison to a reference coaxial Thermistor Mount
RF Power - Measure (Relative)	Ref Power (-30 to 11) dBm 900 Hz to 9 kHz Test Port Power (-40 to -35) dB (-35 to -30) dB (-30 to -3) dB (-3 to 3) dB (3 to 10) dB (10 to 30) dB	 0.14 dB 0.051 dB 0.026 dB 0.006 1 dB 0.014 dB 0.023 dB	Comparison to power sensors

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Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Measure (Relative)	Ref Power (-30 to 11) dBm Test Port Power 9 kHz to 50 GHz (-130 to -110) dB (-110 to -100) dB (9 to 100) kHz 100 kHz to 3.6 GHz (3.6 to 30) GHz (30 to 50) GHz (-100 to -90) dB (-90 to -70) dB (-70 to -50) dB (-50 to -30) dB (-30 to -10) dB (-10 to -5) dB (-5 to 5) dB (5 to 10) dB (10 to 20) dB (20 to 30) dB (50 to 67) GHz (-130 to -120) dB (-120 to -80) dB (-80 to -70) dB (-70 to -60) dB (-60 to -50) dB (-50 to -40) dB (-40 to -35) dB (-35 to -30) dB (-30 to -3) dB (-3 to 3) dB (3 to 10) dB (10 to 30) dB (67 to 110) GHz (-40 to -35) dB (-35 to -30) dB (-30 to -3) dB (-3 to 3) dB (3 to 10) dB (10 to 30) dB	 0.17 dB 0.064 dB 0.05 dB 0.07 dB 0.074 dB 0.044 dB 0.034 dB 0.029 dB 0.018 dB 0.009 2 dB 0.006 5 dB 0.002 2 dB 0.006 5 dB 0.009 2 dB 0.026 dB 0.22 dB 0.17 dB 0.21 dB 0.050 dB 0.033 dB 0.025 dB 0.021 dB 0.019 dB 0.005 6 dB 0.002 2 dB 0.014 dB 0.023 dB 0.18 dB 0.063 dB 0.026 dB 0.006 1 dB 0.014 dB 0.023 dB	Comparison to power sensors

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Measure (Relative)	30.6 MHz, 49.6 MHz, 99.6 MHz Ref Power -35 dBm Test Port Power (-65 to -60) dBm (-60 to -50) dBm (-50 to -40) dBm (-40 to -20) dBm (-20 to -5) dBm Ref Power -55 dBm Test Port Power (-80 to -70) dBm (-70 to -50) dBm (-50 to -35) dBm (-35 to -25) dBm Ref Power -80 dBm Test Port Power (-75 to -65) dBm (-65 to -55) dBm	 0.013 dB 0.005 6 dB 0.002 8 dB 0.002 9 dB 0.003 3 dB 0.005 4 dB 0.003 4 dB 0.004 dB 0.004 4 dB 0.007 7 dB 0.009 4 dB	Comparison to a Keysight network analyzer, power sensor and signal source
RF Power – Measure (Relative)	1 MHz to 2 GHz Ref Power (-10 to -20) dBm Test Port Power -60 dBm (-60 to -50) dBm (-50 to -40) dBm (-40 to -30) dBm (-30 to -20) dBm (-20 to -10) dBm (-10 to -5) dBm (-5 to 5) dBm	 0.004 9 dB 0.001 5 dB 0.000 84 dB 0.000 76 dB 0.000 23 dB 0.000 097 dB 0.000 11 dB 0.000 32 dB	Comparison to a Keysight network analyzer, power sensor and signal source
RF Power – Measure (Relative)	1.195 GHz Ref Power (-10 to -22) dBm Test Port Power (-82 to -80) dBm (-80 to -73) dBm (-73 to -63) dBm (-63 to -43) dBm (-43 to -33) dBm (-33 to 0) dBm (0 to 10) dBm	 0.041 dB 0.027 dB 0.019 dB 0.011 dB 0.007 9 dB 0.003 7 dB 0.005 3 dB	Comparison to a Keysight network analyzer, power sensor and signal source

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure (Relative)	1.998 77 GHz Ref Power -20 dBm Test Port Power (-60 to -57) dBm (-57 to -52) dBm (-52 to -49) dBm (-49 to -47) dBm (-47 to -46) dBm (-46 to -44) dBm (-44 to -42) dBm (-42 to -41) dBm (-41 to -39) dBm (-39 to -37) dBm (-37 to -35) dBm (-35 to -33) dBm (-33 to -31) dBm (-31 to -29) dBm (-29 to -27) dBm (-27 to -26) dBm (-26 to -25) dBm (-25 to -23) dBm (-23 to -22) dBm (-22 to -19) dBm (-19 to -14) dBm (-14 to -9) dBm (-9 to -4) dBm (-4 to 1) dBm (1 to 5) dBm	 0.007 dB 0.006 7 dB 0.006 3 dB 0.006 dB 0.005 8 dB 0.005 4 dB 0.005 dB 0.004 8 dB 0.004 5 dB 0.004 1 dB 0.003 8 dB 0.003 5 dB 0.003 2 dB 0.003 dB 0.002 7 dB 0.002 5 dB 0.002 3 dB 0.001 9 dB 0.001 6 dB 0.001 dB 0.002 3 dB 0.003 3 dB 0.003 9 dB 0.004 7 dB 0.005 7 dB	Comparison to a Keysight network analyzer, power sensor and signal source

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensor – Linearity [1] (Relative Response)	50 MHz - 37 dBm (-36 to -30) dBm (-30 to -22) dBm (-22 to -15) dBm (-15 to -11) dBm (-11 to 0) dBm (0 to 9) dBm (9 to 13) dBm (13 to 18) dBm (18 to 21) dBm (21 to 26) dBm (26 to 30) dBm (60 to 90) GHz (-36 to -31) dBm (-30 to -21) dBm (-20 to -11) dBm (-10 to 7) dBm (8 to 20) dBm	 0.003 9 0.002 4 0.002 0.001 6 0.001 2 0.001 0.000 61 0.001 0.001 1 0.001 2 0.003 3 0.003 4 0.023 0.017 0.012 0.005 0.006	Relative comparison to a characterized Keysight network analyzer or a reference power sensor
Dynamic Range	(47 to 220) GHz (80 to 130) dB	 2.7 dB	Comparison to a Keysight network analyzer, millimeter wave test set
Amplitude Flatness - Measure	(0.1 to 8) V 10 kHz to 10 MHz (10 to 50) MHz 50 MHz (50 to 80) MHz (0.1 to 5.5) V (80 to 300) MHz (0.3 to 1.1) GHz (0.01 to 0.1) V (50 to 80) MHz (80 to 300) MHz (0.3 to 1.1) GHz	 0.025 dB 0.028 dB 0.018 dB 0.023 dB 0.023 dB 0.033 dB 0.027 dB 0.032 dB 0.034 dB	Comparison to a power sensor, AC measurement standard and a Keysight 3458A multimeter

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation Distortion - Measure	5 MHz to 2 GHz < 0.01 % distortion (0.01 to 0.016) % distortion (0.016 to 0.021) % distortion (0.021 to 0.026) % distortion (0.026 to 0.04) % distortion (0.04 to 0.1) % distortion (0.1 to 15) % distortion (100 to 800) kHz < 0.4 % distortion (0.4 to 0.5) % distortion (0.5 to 2) % distortion (2 to 15) % distortion 800 kHz to 26 GHz < 0.3 % distortion (0.3 to 1) % distortion (1 to 5) % distortion (5 to 15) % distortion (26 to 50) GHz (0.01 to 0.1) % distortion (0.1 to 0.3) % distortion (0.3 to 15) % distortion	0.000 6 % distortion 0.27 % of reading + 0.000 58 % distortion 0.38 % of reading + 0.000 56 % distortion 0.47 % of reading + 0.000 54 % distortion 0.55 % of reading + 0.000 52 % distortion 0.88 % of reading + 0.000 39 % distortion 1.1 % of reading + 0.000 1 % distortion 0.025 % distortion 0.24 % of reading + 0.024 % distortion 0.58 % of reading + 0.021 % distortion 1.1 % of reading + 0.006 6 % distortion 0.02 % distortion 0.32 % of reading + 0.019 % distortion 0.95 % of reading + 0.011 % distortion 1.1 % of reading + 0.004 4 % distortion 0.52 % of reading + 0.001 1 % distortion 1 % of reading + 0.000 63 % distortion 1.2 % of reading	Comparison to a Keysight signal analyzer

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Measure [3]	2 MHz to 3.6 GHz (0.2 to 100) (100 to 2 000) (3.6 to 8.4) GHz (0.2 to 100) (100 to 2 000) (8.4 to 17.1) GHz (0.2 to 100) (100 to 2 000) (17.1 to 34.5) GHz (0.2 to 100) (100 to 2 000) (34.5 to 50) GHz (0.2 to 100) (100 to 2 000)	 0.35 % of reading + 0.2 %*M* 0.8 % *M* 0.7 % of reading + 0.2 %*M* 2 % *M* 0.7 % of reading + 0.3 %*M* 2.5 % *M* 0.8 % of reading + 0.3 %*M* 3 % *M* 1.4 % of reading + 0.5 %*M* 4 % *M*	Comparison to a Keysight signal analyzer
Frequency Modulation Distortion - Measure	500 kHz to 50 GHz (0.01 to 15) %	2.3 % distortion	Comparison to a Keysight signal analyzer
Phase Modulation Distortion - Measure	500 kHz to 50 GHz (0.01 to 15) %	2.3 % distortion	Comparison to a Keysight signal analyzer
Phase Modulation – Measure	(0.2 to 1) rad 100 kHz to 3.6 GHz (3.6 to 17.1) GHz (17.1 to 34.5) GHz (34.5 to 50) GHz (1 to 10) rad 100 kHz to 3.6 GHz (3.6 to 17.1) GHz (17.1 to 34.5) GHz (34.5 to 50) GHz	 0.1 % of reading + 0.001 rad 0.1 % of reading + 0.002 rad 0.1 % of reading + 0.002 5 rad 0.1 % of reading + 0.004 9 rad 0.008 1 % + 0.002 rad 0.015 % of reading + 0.003 rad 0.02 % of reading + 0.003 5 rad 0.058 % of reading + 0.005 8 rad	Comparison to a Keysight signal analyzer
Phase Modulation Frequency Response - Measure	80 Hz to 100 kHz Deviation 4 rad 100 Hz to 100 kHz Deviation 1 rad	0.057 dB 0.14 dB	Comparison to a Keysight signal analyzer and a Keysight 3458A multimeter

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Modulation – Measure GSM EDGE	(0.46 to 2.7) GHz EDGE: residual EVM (0 to 1.5) % EVM GSM: residual phase (0 to 1)° GSM: peak phase (0 to 3)°	0.015 % EVM 0.01° 0.12°	Comparison to a Keysight signal analyzer
Digital Modulation – Measure CDMA2000 IS95 1xEV-DO	Residual EVM (0 to 2) % EVM (0.8 to 2.1) GHz	0.023 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure W-CDMA	Residual EVM (0 to 2) % EVM (0.8 to 2.2) GHz	0.025 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure BPSK	Residual EVM (0 to 2.5) % EVM ≤ 3 GHz (3 to 32) GHz (32 to 44) GHz	 0.02 % EVM 0.055 % EVM 0.07 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure QPSK	Residual EVM (0 to 2.5) % EVM ≤ 3 GHz (3 to 6) GHz (6 to 32) GHz (32 to 44) GHz	 0.02 % EVM 0.026 % EVM 0.05 % EVM 0.065 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure π/4 DQPSK	Residual EVM (0 to 2.5) % EVM ≤ 1 GHz (1 to 2) GHz (2 to 3) GHz (3 to 4) GHz (4 to 6) GHz	 0.025 % EVM 0.046 % EVM 0.059 % EVM 0.11 % EVM 0.059 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure 16, 64 and 256 QAM	Residual EVM (0 to 2.5) % EVM ≤ 3 GHz (3 to 6) GHz (6 to 32) GHz (32 to 44) GHz	 0.015 % EVM 0.017 % EVM 0.03 % EVM 0.045 % EVM	Comparison to a Keysight signal analyzer

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Modulation – Measure 2FSK (including DECT)	Shift Error or Deviation (0 to 4.0) % EVM ≤ 3 GHz (3 to 6) GHz (0 to 10) kHz DECT	 0.049 % EVM 0.048 % EVM 0.12 % of deviation	Comparison to a Keysight signal analyzer
Digital Modulation – Measure NADC	Residual EVM (0 to 2) % EVM (350 to 950) MHz	 0.042 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure PDC	Residual EVM (0 to 2) % EVM (350 to 1501) MHz	 0.055 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure PHS	Residual EVM (0 to 2) % EVM (0.35 to 2) GHz	 0.035 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure TETRA	Residual EVM (0 to 2) % EVM 350 MHz to 1 GHz	 0.044 % EVM	Comparison to a Keysight signal analyzer
CISPR Quasi-Peak Absolute Amplitude	Band A, B, C	0.28 dB	Comparison to pulse generator
CISPR Quasi-Peak Detector Variation	Band A, B, C, D	0.12 dB	Comparison to pulse generator
CISPR Response to Pulses Peak Detector	Band A, B Band C, D	0.33 dB 0.3 dB	Comparison to pulse generator
CISPR Response to Pulses RMS Average Detector	Band A Band B Band C, D	0.33 dB 0.35 dB 0.32 dB	Comparison to pulse generator
Distortion Measure	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	Comparison to an audio analyzer
Excess Noise Ratio - Source	(5 to 22) dB (0.01 to 8) GHz (8 to 18) GHz (18 to 28) GHz (28 to 40) GHz (40 to 50) GHz	 0.055 dB 0.035 dB 0.059 dB 0.078 dB 0.089 dB	Comparison to a noise source

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Excess Noise Ratio - Measure Cold Source Method	(5 to 22) dB (0.5 to 6) GHz (6 to 18) GHz (18 to 26.5) GHz (26.5 to 33) GHz (33 to 36) GHz (36 to 39) GHz (39 to 40) GHz (40 to 48) GHz (48 to 50) GHz (50 to 60) GHz (60 to 64) GHz (64 to 65) GHz (65 to 67) GHz	 0.1 dB 0.11 dB 0.13 dB 0.14 dB 0.15 dB 0.16 dB 0.17 dB 0.2 dB 0.21 dB 0.27 dB 0.29 dB 0.31 dB 0.29 dB	Comparison to a Keysight network analyzer, and a power Sensor
Noise Figure	50 MHz to 44 GHz 5 dB to 26 dB	 0.32 dB	Comparison to a power Sensor
Phase Noise – Measure	Carrier 50 kHz to 54 GHz Offset ≤ 10 Hz ≤ 1 MHz ≤ 100 MHz	 2 dB 1.8 dB 3.6 dB	Comparison to a phase noise measurement system
Phase Noise – Source	Carrier 1 GHz Offset 10 Hz, >-80 dBc/Hz 100 Hz, >-107 dBc/Hz 1 kHz, >-126 dBc/Hz 10 kHz, >-140 dBc/Hz 30 kHz, >-142 dBc/Hz 100 kHz, >-144 dBc/Hz 1 MHz, >-153 dBc/Hz 6 MHz, >-155 dBc/Hz (9.9, 10) MHz, >-155 dBc/Hz	 0.51 dB 0.51 dB 0.4 dB 0.37 dB 0.36 dB 0.53 dB 0.54 dB 0.54 dB 0.66 dB	Comparison to an ultra-low noise reference source
Phase Noise – Source	Carrier 70 MHz to 1 GHz Offset (0.1 to 1) kHz, >-105 dBc/Hz (1 to 10) kHz, >-120 dBc/Hz (10 to 100) kHz, >-130 dBc/Hz (0.1 to 1) MHz, >-130 dBc/Hz (1 to 10) MHz, > -145 dBc/Hz	 0.37 dB 0.37 dB 0.37 dB 0.4 dB 0.4 dB	Comparison to a low noise signal generator

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Noise Voltage - Measure	≤20 MHz or 1 GHz peak to peak (>0 to 2) mV 2 mV to 2 V 20 MHz rms (>0 to 0.5) mV (0.5 to 1) mV 1 mV to 1 V	 0.07 mV 1.9 % of reading 21 % of reading 6.6 % of reading 1.9 % of reading	Comparison to a differential amplifier and a voltmeter
Noise Current - Measure	20 MHz rms Up to 10 µA (10 to 100) µA (0.1 to 250) mA	 33 mA/A + 5.7 µA 0.11 A/A + 4.2 µA 0.15 A/A	Comparison to an oscilloscope and a current probe

Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Attenuation – Measure										
Reference Standard, Method, and/or Equipment	Comparison to a ratio transformer										
Expanded Uncertainty of Measurement (+/-)											
Ranges	10 dB	20 dB	30 dB	40 dB	50 dB	60 dB	70 dB	80 dB	90 dB	100 dB	110 dB
20 Hz to 50 MHz	0.002 5 dB	0.003 5 dB	0.004 4 dB	0.006 7 dB	0.008 5 dB	0.01 dB	0.014 dB	0.017 dB	0.02 dB	0.03 dB	0.037 dB
50 MHz to 1 GHz	0.005 2 dB	0.007 4	0.009 1 dB	0.014 dB	0.017 dB	0.02 dB	0.029 dB	0.036 dB	0.042 dB	0.06 dB	0.074 dB
(1 to 2) GHz	0.006 6 dB	0.01 dB	0.012 dB	0.019 dB	0.024 dB	0.028 dB	0.04 dB	0.049 dB	0.057 dB	0.081 dB	0.1 dB
(2 to 4) GHz	0.006 8 dB	0.011 dB	0.015 dB	0.025 dB	0.031 dB	0.037 dB	0.053 dB	0.066 dB	0.077 dB	0.11 dB	0.13 dB

Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Attenuation – Source									
Reference Standard, Method, and/or Equipment	Comparison to an attenuator									
Expanded Uncertainty of Measurement (+/-)										
Range	1 dB	2 dB	3 dB	4 dB	5 dB	6 dB	7 dB	8 dB	9 dB	10 dB	11 dB
20 Hz to 50 MHz	0.002 8 dB	0.002 8 dB	0.002 8 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB
50 MHz to 1 GHz	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 4 dB	0.005 4 dB
(1 to 2) GHz	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB

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Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Attenuation – Source										
Reference Standard, Method, and/or Equipment	Comparison to an attenuator										
Expanded Uncertainty of Measurement (+/-)											
Range	1 dB	2 dB	3 dB	4 dB	5 dB	6 dB	7 dB	8 dB	9 dB	10 dB	11 dB
(2 to 4) GHz	0.008 dB	0.008 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB
(4 to 10) GHz	0.013 dB	0.012 dB	0.015 dB	0.014 dB	0.017 dB	0.016 dB	0.015 dB	0.015 dB	0.021 dB	0.013 dB	0.015 dB
(10 to 12.4) GHz	0.021 dB	0.027 dB	0.032 dB	0.027 dB	0.022 dB	0.022 dB	0.019 dB	0.024 dB	0.025 dB	0.036 dB	0.036 dB
(12.4 to 18) GHz	0.034 dB	0.037 dB	0.035 dB	0.033 dB	0.040 dB	0.038 dB	0.035 dB	0.038 dB	0.045 dB	0.042 dB	0.036 dB

Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Attenuation – Source										
Reference Standard, Method, and/or Equipment	Comparison to an attenuator										
Expanded Uncertainty of Measurement (+/-)											
Range	10 dB	20 dB	30 dB	40 dB	50 dB	60 dB	70 dB	80 dB	90 dB	100 dB	110 dB
20 Hz to 50 MHz	0.003 9 dB	0.004 3 dB	0.007 5 dB	0.007 5 dB	0.009 6 dB	0.011 dB	0.016 dB	0.019 dB	0.022 dB	0.032 dB	0.039 dB
50 MHz to 1 GHz	0.005 1 dB	0.004 8 dB	0.005 7 dB	0.006 5 dB	0.019 dB	0.022 dB	0.032 dB	0.039 dB	0.045 dB	0.057 dB	0.074 dB
(1 to 2) GHz	0.006 dB	0.005 9 dB	0.006 dB	0.008 3 dB	0.025 dB	0.029 dB	0.042 dB	0.033 dB	0.058 dB	0.058 dB	0.082 dB
(2 to 4) GHz	0.007 5 dB	0.007 3 dB	0.008 2 dB	0.012 dB	0.034 dB	0.035 dB	0.057 dB	0.035 dB	0.06 dB	0.062 dB	0.086 dB
(4 to 10) GHz	0.01 dB	0.009 8 dB	0.01 dB	0.012 dB	0.038 dB	0.038 dB	0.065 dB	0.038 dB	0.065 dB	0.068 dB	0.093 dB
(10 to 12.4) GHz	0.01 dB	0.009 9 dB	0.01 dB	0.012 dB	0.038 dB	0.038 dB	0.065 dB	0.038 dB	0.065 dB	0.086 dB	0.12 dB
(12.4 to 18) GHz	0.01 dB	0.009 9 dB	0.01 dB	0.012 dB	0.038 dB	0.038 dB	0.065 dB	0.038 dB	0.065 dB	0.17 dB	0.18 dB

Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	RF Power - Measure											
Reference Standard, Method, and/or Equipment	Comparison to a power sensor and a signal analyzer											
Expanded Uncertainty of Measurement (+/-)												
Range	(-140 to -130) dBm	(-130 to -110) dBm	(-110 to -90) dBm	(-90 to -30) dBm	(-30 to -10) dBm	(-10 to -3) dBm	(-3 to +3) dBm	(3 to 14) dBm	(14 to 20) dBm	(20 to 25) dBm	(25 to 35) dBm	(35 to 44) dBm
(0.9 to 9) kHz	-	-	-	-	0.044 dB	0.044 dB	0.027 dB	0.032 dB	0.043 dB	-	-	-
(9 to 100) kHz	0.17 dB	0.17 dB	0.16 dB	0.16 dB	0.044 dB	0.044 dB	0.027 dB	0.032 dB	0.032 dB	0.034 dB	0.036 dB	-
(0.1 to 10) MHz	0.085 dB	0.071 dB	0.054 dB	0.045 dB	0.043 dB	0.042 dB	0.027 dB	0.032 dB	0.032 dB	0.034 dB	0.037 dB	-

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Electrical – RF/Microwave **Main Scope**

Parameter/ Equipment	RF Power - Measure											
Reference Standard, Method, and/or Equipment	Comparison to a power sensor and a signal analyzer											
Expanded Uncertainty of Measurement (+/-)												
Range	(-140 to -130) dBm	(-130 to -110) dBm	(-110 to -90) dBm	(-90 to -30) dBm	(-30 to -10) dBm	(-10 to -3) dBm	(-3 to +3) dBm	(3 to 14) dBm	(14 to 20) dBm	(20 to 25) dBm	(25 to 35) dBm	(35 to 44) dBm
50 MHz	0.079 dB	0.066 dB	0.048 dB	0.037 dB	0.034 dB	0.032 dB	0.02 dB	0.027 dB	0.023 dB	0.024 dB	0.029 dB	-
(10 to 100) MHz	0.081 dB	0.068 dB	0.05 dB	0.04 dB	0.038 dB	0.037 dB	0.027 dB	0.029 dB	0.032 dB	0.034 dB	0.036 dB	0.06 dB
(0.1 to 4) GHz	0.08 dB	0.067 dB	0.049 dB	0.039 dB	0.036 dB	0.035 dB	0.024 dB	0.027 dB	0.037 dB	0.038 dB	0.041 dB	0.057 dB
(4 to 8) GHz	0.081 dB	0.068 dB	0.05 dB	0.04 dB	0.038 dB	0.037 dB	0.027 dB	0.032 dB	0.039 dB	0.041 dB	0.043 dB	0.058 dB
(8 to 18) GHz	0.084 dB	0.071 dB	0.053 dB	0.043 dB	0.04 dB	0.039 dB	0.029 dB	0.035 dB	0.038 dB	0.04 dB	0.042 dB	0.06 dB
(18 to 24) GHz	0.091 dB	0.076 dB	0.069 dB	0.05 dB	0.048 dB	0.047 dB	0.031 dB	0.044 dB	0.053 dB	0.061 dB	0.063 dB	-
(24 to 40) GHz	0.12 dB	0.11 dB	0.1 dB	0.091 dB	0.069 dB	0.069 dB	0.059 dB	0.061 dB	0.068 dB	0.069 dB	0.076 dB	-
(40 to 50) GHz	0.13 dB	0.1 dB	0.098 dB	0.085 dB	0.083 dB	0.083 dB	0.079 dB	0.081 dB	0.086 dB	0.11 dB	0.11 dB	-
(50 to 60) GHz	0.17 dB	0.13 dB	0.12 dB	0.1 dB	0.099 dB	0.099 dB	0.093 dB	0.094 dB	0.099 dB	-	-	-
(60 to 67) GHz	0.52 dB	0.22 dB	0.22 dB	0.21 dB	0.099 dB	0.099 dB	0.093 dB	0.094 dB	0.099 dB	-	-	-
(67 to 80) GHz	-	-	-	-	0.26 dB	0.26 dB	0.26 dB	0.26 dB	0.26 dB	-	-	-
(80 to 90) GHz	-	-	-	-	0.32 dB	0.32 dB	0.32 dB	0.32 dB	0.32 dB	-	-	-
(90 to 100) GHz	-	-	-	-	0.3 dB	0.3 dB	0.3 dB	0.3 dB	0.3 dB	-	-	-
(100 to 110) GHz	-	-	-	-	0.29 dB	0.29 dB	0.29 dB	0.29 dB	0.29 dB	-	-	-

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Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Amplitude Modulation Depth - Measure		
Reference Standard, Method, and/or Equipment	Comparison to a signal analyzer (% indicates % depth where not specified)		
Frequency Range	**AM Depth**	**Modulation Rate**	**Expanded Uncertainty of Measurement (+/-)**
2 Hz to 50 GHz	(5 to 20) %	10 Hz to 100 kHz	0.11 % of reading + 0.008 3 %
	(20 to 40) %		0.022 % of reading + 0.026 %
	(40 to 50) %		0.002 7 % of reading + 0.034 %
	(50 to 60) %		-0.013 % of reading + 0.043 %
	(60 to 75) %		-0.041 % of reading + 0.06 %
	(75 to 90) %		-0.091 % of reading + 0.099 %
	(90 to 95) %		0.01 %
	(95 to 98) %		0.005 1 %
100 kHz to 13.6 GHz	(5 to 50) %	10 Hz to 25 kHz	0.1 % of reading
	(5 to 30) %	(25 to 50) kHz	0.16 % of reading
	(5 to 20) %	(50 to 100) kHz	0.22 % of reading
	(5 to 95) %	(100 to 250) kHz	0.32 % of reading
		(250 to 500) kHz	0.5 % of reading
		(0.5 to 1) MHz	0.71 % of reading
		1 MHz	1 % of reading
(13.5 to 17.1) GHz	(5 to 50) %	10 Hz to 10 kHz	0.1 % of reading
	(5 to 35) %	(10 to 25) kHz	0.14 % of reading
	(5 to 20) %	(25 to 50) kHz	0.22 % of reading
	(5 to 15) %	(50 to 100) kHz	0.32 % of reading
	(5 to 95) %	(100 to 250) kHz	0.45 % of reading
		(250 to 500) kHz	0.71 % of reading
		(0.5 to 1) MHz	1 % of reading
		1 MHz	1.4 % of reading
(17 to 34.5) GHz	(5 to 50) %	10 Hz to 5 kHz	0.1 % of reading
	(5 to 55) %	(5 to 10) kHz	0.095 % of reading
	(5 to 30) %	(10 to 25) kHz	0.15 % of reading
	(5 to 20) %	(25 to 50) kHz	0.25 % of reading
	(5 to 10) %	(50 to 100) kHz	0.36 % of reading
	(5 to 95) %	(100 to 250) kHz	0.52 % of reading
		(250 to 500) kHz	0.84 % of reading
		(0.5 to 1) MHz	1.2 % of reading
		1 MHz	1.7 % of reading
(34.4 to 50) GHz	(5 to 15) %	10 Hz to 5 kHz	0.25 % of reading
	(5 to 15) %	(5 to 10) kHz	0.31 % of reading
	(5 to 10) %	(10 to 25) kHz	0.37 % of reading
	(5 to 95) %	(100 to 250) kHz	1.5 % of reading
		(250 to 500) kHz	3.3 % of reading
		(0.5 to 1) MHz	6.3 % of reading
		1 MHz	12 % of reading

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Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Frequency Modulation Deviation – Measure			
Reference Standard, Method, and/or Equipment	Comparison to a signal analyzer			
Frequencies	**Deviation Range**	**Modulation Rate**	**Modulation index**	**Expanded Uncertainty of Measurement (+/-)**
100 kHz to 3.6 GHz	20 Hz to 2 MHz	10 Hz to 500 kHz	$\beta \geq 0.5$	0.2 % deviation
100 kHz to 3.6 GHz	10 Hz to 10 MHz	20 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % deviation
100 kHz to 3.6 GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2 % deviation
100 kHz to 3.6 GHz	10 Hz to 50 kHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % deviation
100 kHz to 3.6 GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % deviation
100 kHz to 3.6 GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % deviation
(3.5 to 8.4) GHz	20 Hz to 1 MHz	10 Hz to 500 kHz	$\beta \geq 0.5$	0.21 % deviation
(3.5 to 8.4) GHz	10 Hz to 5 MHz	20 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % deviation
(3.5 to 8.4) GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2.2 % deviation
(3.5 to 8.4) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % deviation
(3.5 to 8.4) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % deviation
(3.5 to 8.4) GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % deviation
(8.3 to 13.6) GHz	20 Hz to 2 MHz	10 Hz to 500 kHz	$\beta \geq 0.5$	0.21 % deviation
(8.3 to 13.6) GHz	10 Hz to 10 MHz	50 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % deviation
(8.3 to 13.6) GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2.2 % deviation
(8.3 to 13.6) GHz	10 Hz to 500 kHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % deviation
(8.3 to 13.6) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % deviation
(8.3 to 13.6) GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % deviation
(13.5 to 17.1) GHz	20 Hz to 1 MHz	10 Hz to 200 kHz	$\beta \geq 0.5$	0.21 % deviation
(13.5 to 17.1) GHz	10 Hz to 5 MHz	20 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % deviation
(13.5 to 17.1) GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2.2 % deviation
(13.5 to 17.1) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % deviation
(13.5 to 17.1) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % deviation
(13.5 to 17.1) GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % deviation
(17 to 26.5) GHz	50 Hz to 400 kHz	10 Hz to 50 kHz	$\beta \geq 0.8$	0.31 % deviation
(17 to 26.5) GHz	20 Hz to 5 MHz	10 Hz to 1 MHz	$\beta \geq 0.2$	0.9 % deviation
(17 to 26.5) GHz	20 Hz to 10 MHz	100 Hz to 1 MHz	$\beta \geq 0.08$	3.3 % deviation
(17 to 26.5) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.04$	6.3 % deviation
(17 to 26.5) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	12 % deviation
(17 to 26.5) GHz	10 Hz to 1 kHz	500 Hz to 100 kHz	$\beta \geq 0.01$	30 % deviation
(26.4 to 34.5) GHz	50 Hz to 400 kHz	10 Hz to 50 kHz	$\beta \geq 0.8$	0.31 % deviation

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Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Frequency Modulation Deviation – Measure			
Reference Standard, Method, and/or Equipment	Comparison to a signal analyzer			
Frequencies	**Deviation Range**	**Modulation Rate**	**Modulation index**	**Expanded Uncertainty of Measurement (+/-)**
(26.4 to 34.5) GHz	20 Hz to 5 MHz	10 Hz to MHz	$\beta \geq 0.2$	0.9 % deviation
(26.4 to 34.5) GHz	20 Hz to 10 MHz	100 Hz to 1 MHz	$\beta \geq 0.08$	3.3 % deviation
(26.4 to 34.5) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.04$	6.3 % deviation
(26.4 to 34.5) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.02$	12 % deviation
(26.4 to 34.5) GHz	10 Hz to 1 kHz	500 Hz to 100 kHz	$\beta \geq 0.01$	30 % deviation
(34.4 to 50) GHz	50 Hz to 100 kHz	10 Hz to 20 kHz	$\beta \geq 0.8$	0.32 % deviation
(34.4 to 50) GHz	20 Hz to 500 kHz	10 Hz to 200 kHz	$\beta \geq 0.2$	0.9 % deviation
(34.4 to 50) GHz	20 Hz to 2 MHz	20 Hz to 1 MHz	$\beta \geq 0.08$	3.3 % deviation
(34.4 to 50) GHz	10 Hz to 5 MHz	50 Hz to 1 MHz	$\beta \geq 0.04$	6.4 % deviation
(34.4 to 50) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.02$	12 % deviation
(34.4 to 50) GHz	10 Hz to 16 MHz	500 Hz to 200 kHz	$\beta \geq 0.01$	30 % deviation

Electrical - RF Microwave **Main Scope**

Parameter/Equipment	Voltage Reflection Coefficient S11/S22 - Magnitude (Linear)									
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer with Calibration Kits									
Expanded Uncertainty of Measurement (+/-)										
Range	0 to 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
DC to 10 MHz	0.000 17	0.000 23	0.000 3	0.000 37	0.000 41	0.000 45	0.000 48	0.000 51	0.000 53	0.000 22
10 MHz to 2 GHz	0.000 18	0.000 23	0.000 31	0.000 38	0.000 43	0.000 47	0.000 5	0.000 52	0.000 53	0.000 22
(2 to 8) GHz	0.000 56	0.000 61	0.000 71	0.000 76	0.000 75	0.000 72	0.000 66	0.000 59	0.000 55	0.000 23
(8.0 to 20) GHz	0.000 56	0.000 61	0.000 7	0.000 8	0.000 9	0.001	0.000 97	0.000 94	0.000 94	0.000 89
(20 to 26.5) GHz	0.000 89	0.000 96	0.001 1	0.001 2	0.001 4	0.001 6	0.001 5	0.001 4	0.001 4	0.001 4
(26.5 to 33) GHz	0.000 89	0.000 98	0.001 2	0.001 4	0.001 7	0.001 8	0.001 6	0.001 5	0.001 4	0.001 4
(33 to 40) GHz	0.000 9	0.000 99	0.001 2	0.001 5	0.001 7	0.002	0.001 8	0.001 6	0.001 5	0.001 5
(40 to 45) GHz	0.001 4	0.001 5	0.001 7	0.001 9	0.002 1	0.002 4	0.002 3	0.002 1	0.002 1	0.002 1
(45 to 50) GHz	0.001 4	0.001 5	0.001 7	0.001 8	0.002	0.002 2	0.002 4	0.002 3	0.002 1	0.002 1
(50 to 60) GHz	0.002 5	0.002 6	0.002 8	0.003 1	0.003 4	0.003 7	0.004	0.004 3	0.004 7	0.005 3
(60 to 67) GHz	0.002 5	0.002 7	0.002 9	0.003 2	0.003 7	0.004 2	0.004 7	0.005 1	0.005 7	0.006 4
(67 to 75) GHz	0.005 4	0.005 9	0.006 1	0.006 3	0.006 5	0.006 8	0.007 1	0.007 5	0.007 8	0.008 2

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Electrical - RF Microwave **Main Scope**

Parameter/Equipment	Voltage Reflection Coefficient S11/S22 - Magnitude (Linear)									
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer with Calibration Kits									
Expanded Uncertainty of Measurement (+/-)										
Range	0 to 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
(75 to 110) GHz	0.003 5	0.004	0.004 2	0.004 6	0.004 9	0.005 3	0.005 8	0.006 3	0.006 9	0.007 5
(110 to 120) GHz	0.03	0.033	0.036	0.039	0.04	0.047	0.052	0.057	0.063	0.07

Electrical - RF Microwave **Main Scope**

Parameter/Equipment	Voltage Reflection Coefficient S11/S22 – Phase									
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer with Calibration Kits									
Expanded Uncertainty of Measurement (+/-)										
Range	0 to 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
DC to 10 MHz	0.13°	0.086°	0.070°	0.059°	0.052°	0.046°	0.041°	0.038°	0.035°	0.013°
10 MHz to 2 GHz	0.13°	0.089°	0.073°	0.062°	0.054°	0.048°	0.043°	0.038°	0.035°	0.013°
(2.0 to 8.0) GHz	0.37°	0.22°	0.16°	0.12°	0.094°	0.076°	0.063°	0.05°	0.042°	0.026°
(8.0 to 20) GHz	0.39°	0.26°	0.21°	0.16°	0.13°	0.11°	0.092°	0.081°	0.071°	0.065°
(20 to 26.5) GHz	0.58°	0.4°	0.36°	0.29°	0.23°	0.2°	0.17°	0.16°	0.15°	0.15°
(26.5 to 33) GHz	0.57°	0.36°	0.31°	0.3°	0.29°	0.23°	0.19°	0.16°	0.14°	0.14°
(33 to 40) GHz	0.58°	0.39°	0.34°	0.32°	0.29°	0.24°	0.19°	0.16°	0.14°	0.13°
(40 to 45) GHz	0.86°	0.5°	0.39°	0.34°	0.32°	0.31°	0.31°	0.27°	0.26°	0.26°
(45 to 50) GHz	0.88°	0.55°	0.46°	0.43°	0.42°	0.36°	0.31°	0.28°	0.26°	0.26°
(50 to 60) GHz	1.5º	0.82°	0.63°	0.55°	0.52°	0.51°	0.52°	0.53°	0.5°	0.47°
(60 to 67) GHz	1.5º	0.84°	0.65°	0.58°	0.55°	0.54°	0.54°	0.53°	0.5°	0.47°
(67 to 75) GHz	3.2°	1.7°	1.2°	0.9°	0.75°	0.65°	0.58°	0.53°	0.5°	0.47°
(75 to 110) GHz	2.1°	1.1°	0.81°	0.65°	0.57°	0.51°	0.48°	0.45°	0.44°	0.43°
(110 to 120) GHz	18°	9.6°	6.9°	5.6°	4.9°	4.5°	4.3°	4.1°	4°	4°

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Electrical - RF Microwave **Main Scope**

Parameter/Equipment	Transmission S12/S21 – Magnitude								
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer with Calibration Kits								
Expanded Uncertainty of Measurement (+/-)									
Range	(0 to 3) dB	(3 to 6) dB	(6 to 10) dB	(10 to 20) dB	(20 to 30) dB	(30 to 40) dB	(40 to 50) dB	(50 to 60) dB	(60 to 70) dB
DC to 10 MHz	0.000 57 dB	0.005 8 dB	0.007 3 dB	0.009 3 dB	0.013 dB	0.017 dB	0.02 dB	0.026 dB	0.044 dB
10 MHz to 2 GHz	0.000 3 dB	0.005 3 dB	0.006 1 dB	0.007 2 dB	0.01 dB	0.014 dB	0.017 dB	0.021 dB	0.028 dB
(2.0 to 8.0) GHz	0.000 3 dB	0.005 3 dB	0.006 1 dB	0.007 2 dB	0.01 dB	0.014 dB	0.017 dB	0.021 dB	0.028 dB
(8.0 to 20) GHz	0.000 3 dB	0.005 3 dB	0.006 1 dB	0.007 2 dB	0.01 dB	0.015 dB	0.018 dB	0.021 dB	0.026 dB
(20 to 26.5) GHz	0.009 3 dB	0.01 dB	0.011 dB	0.012 dB	0.014 dB	0.016 dB	0.019 dB	0.022 dB	0.027 dB
(26.5 to 33) GHz	0.014 dB	0.015 dB	0.015 dB	0.016 dB	0.017 dB	0.019 dB	0.022 dB	0.028 dB	0.051 dB
(33 to 40) GHz	0.02 dB	0.021 dB	0.021 dB	0.021 dB	0.022 dB	0.026 dB	0.031 dB	0.036 dB	0.056 dB
(40 to 45) GHz	0.022 dB	0.022 dB	0.023 dB	0.023 dB	0.024 dB	0.028 dB	0.037 dB	0.044 dB	0.08 dB
(45 to 50) GHz	0.023 dB	0.024 dB	0.024 dB	0.024 dB	0.025 dB	0.029 dB	0.037 dB	0.045 dB	0.08 dB
(50 to 60) GHz	0.028 dB	0.028 dB	0.028 dB	0.029 dB	0.03 dB	0.031 dB	0.033 dB	0.042 dB	0.085 dB
(60 to 67) GHz	0.034 dB	0.034 dB	0.034 dB	0.035 dB	0.035 dB	0.037 dB	0.039 dB	0.048 dB	0.096 dB
(67 to 75) GHz	0.043 dB	0.046 dB	0.048 dB	0.051 dB	0.057 dB	0.064 dB	0.071 dB	0.078 dB	0.088 dB
(75 to 100) GHz	0.038 dB	0.041 dB	0.044 dB	0.046 dB	0.053 dB	0.06 dB	0.067 dB	0.074 dB	0.084 dB
(100 to 110) GHz	0.044 dB	0.048 dB	0.051 dB	0.054 dB	0.061 dB	0.068 dB	0.075 dB	0.082 dB	0.098 dB
(110 to 120) GHz	0.44 dB	0.44 dB	0.44 dB	0.44 dB	0.45 dB	0.45 dB	0.46 dB	0.47 dB	0.48 dB

Electrical - RF Microwave **Main Scope**

Parameter/Equipment	Transmission S12/S21 - Phase								
Reference Standard, Method, and/or Equipment	Comparison to Keysight network analyzer with Calibration Kits								
Expanded Uncertainty of Measurement (+/-)									
Range	(0 to 3) dB	(3 to 6) dB	(6 to 10) dB	(10 to 20) dB	(20 to 30) dB	(30 to 40) dB	(40 to 50) dB	(50 to 60) dB	(60 to 70) dB
DC to 10 MHz	0.004 3°	0.039°	0.048°	0.061°	0.084°	0.006 2°	0.007 9°	0.008 2°	0.008 5°
10 MHz to 2 GHz	0.002 9°	0.035°	0.04°	0.048°	0.067°	0.0062°	0.007 8°	0.007 9°	0.008 1°
(2 to 8) GHz	0.002 9°	0.035°	0.04°	0.048°	0.067°	0.006 8°	0.008 2°	0.008 4°	0.008 5°
(8 to 20) GHz	0.032°	0.035°	0.04°	0.048°	0.067°	0.00 91°	0.01°	0.01°	0.01°
(20 to 26.5) GHz	0.15°	0.15°	0.15°	0.15°	0.16°	0.011°	0.012°	0.012°	0.012°
(26.5 to 33) GHz	0.18°	0.18°	0.19°	0.19°	0.19°	0.015°	0.016°	0.016°	0.016°
(33 to 40) GHz	0.23°	0.24°	0.24°	0.24°	0.24°	0.25°	0.26°	0.28°	0.4°
(40 to 45) GHz	0.29°	0.29°	0.29°	0.29°	0.3°	0.31°	0.32°	0.35°	0.56°
(45 to 50) GHz	0.31°	0.31°	0.31°	0.31°	0.32°	0.32°	0.33°	0.37°	0.57°

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Electrical - RF Microwave **Main Scope**

Parameter/Equipment	Transmission S12/S21 - Phase								
Reference Standard, Method, and/or Equipment	Comparison to Keysight network analyzer with Calibration Kits								
Expanded Uncertainty of Measurement (+/-)									
Range	(0 to 3) dB	(3 to 6) dB	(6 to 10) dB	(10 to 20) dB	(20 to 30) dB	(30 to 40) dB	(40 to 50) dB	(50 to 60) dB	(60 to 70) dB
(50 to 60) GHz	0.28°	0.38°	0.38°	0.38°	0.38°	0.39°	0.4°	0.43°	0.65°
(60 to 67) GHz	0.28°	0.43°	0.43°	0.43°	0.44°	0.44°	0.45°	0.49°	0.73°
(50 to 75) GHz	0.28°	0.3°	0.32°	0.34°	0.38°	0.42°	0.47°	0.52°	0.58°
(75 to 100) GHz	0.25°	0.27°	0.29°	0.31°	0.35°	0.4°	0.44°	0.49°	0.56°
(100 to 110) GHz	0.29°	0.32°	0.34°	0.36	0.4°	0.45°	0.49°	0.55°	0.65°
(110 to 120) GHz	3°	3°	3°	3°	3°	3.1°	3.1°	3.2°	3.3°

Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Impedance – Source and Measure							
Reference Standard, Method, and/or Equipment	Comparison to a performance test kit							
Expanded Uncertainty of Measurement (+/-)								
Range	Admittance Open Magnitude 3 µS to 15 mS	Impedance Short Magnitude 0 Ω	Impedance Load Magnitude 50 Ω	Impedance Load Phase (-1 to 1)º	Impedance Airline Short Magnitude (0 to 25) Ω	Impedance Airline Short Phase (-100 to 100)º	Impedance Airline Open Magnitude 50 Ω to 25 kΩ	Impedance Airline Open Phase (-100 to 100)º
1 kHz	-	-	0.05 Ω	0.095 mrad	-	-	-	-
1 MHz	0.18 µS	2.5 mΩ	0.08 Ω	1.6 mrad	0.000 23 Ω	2.1 mrad	39 Ω	1.8 mrad
10 MHz	0.21 µS	3.5 mΩ	0.079 Ω	1.6 mrad	0.002 2 Ω	2.1 mrad	3.9 Ω	1.8 mrad
100 MHz	2.1 µS	14 mΩ	0.077 Ω	1.5 mrad	0.023 Ω	2.2 mrad	0.38 Ω	1.8 mrad
200 MHz	6.9 µS	25 mΩ	0.12 Ω	2.3 mrad	0.053 Ω	2.4 mrad	0.22 Ω	2.2 mrad
300 MHz	10 µS	30 mΩ	0.12 Ω	2.3 mrad	0.087 Ω	2.4 mrad	0.13 Ω	2.2 mrad
500 MHz	17 µS	40 mΩ	0.16 Ω	3.2 mrad	0.29 Ω	3.4 mrad	0.072 Ω	3.2 mrad
600 MHz	20 µS	40 mΩ	0.21 Ω	4.2 mrad	0.72 Ω	4.6 mrad	0.053 Ω	5.4 mrad
800 MHz	27 µS	50 mΩ	0.22 Ω	4.5 mrad	0.45 Ω	5.3 mrad	0.077 Ω	5.6 mrad
1 GHz	33 µS	50 mΩ	0.25 Ω	5 mrad	0.14 Ω	6.3 mrad	0.24 Ω	5.4 mrad
1 3 GHz	43 µS	100 mΩ	0.3 Ω	6 mrad	0.092 Ω	8.4 mrad	-	-
1.6 GHz	59 µS	100 mΩ	0.35 Ω	7 mrad	0.28 Ω	7.5 mrad	0.62 Ω	7.2 mrad
1.8 GHz	68 µS	100 mΩ	0.36 Ω	7.3 mrad	0.92 Ω	10 mrad	0.25 Ω	7.5 mrad
2 GHz	85 µS	200 mΩ	0.5 Ω	10 mrad	1.7 Ω	11 mrad	0.08 Ω	12 mrad
2.2 GHz	95 µS	200 mΩ	0.49 Ω	9.8 mrad	0.58 Ω	11 mrad	0.18 Ω	11 mrad

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Electrical – RF/Microwave **Main Scope**

Parameter/Equipment	Impedance – Source and Measure							
Reference Standard, Method, and/or Equipment	Comparison to a performance test kit							
Expanded Uncertainty of Measurement (+/-)								
Range	Admittance Open Magnitude 3 µS to 15 mS	Impedance Short Magnitude 0 Ω	Impedance Load Magnitude 50 Ω	Impedance Load Phase (-1 to 1)°	Impedance Airline Short Magnitude (0 to 25) Ω	Impedance Airline Short Phase (-100 to 100)°	Impedance Airline Open Magnitude 50 Ω to 25 kΩ	Impedance Airline Open Phase (-100 to 100)°
2.4 GHz	110 µS	200 mΩ	0.47 Ω	9.3 mrad	0.23 Ω	11 mrad	0.53 Ω	10 mrad
2.6 GHz	130 µS	200 mΩ	0.43 Ω	8.7 mrad	0.000 23 Ω	2.1 mrad	2.1 Ω	14 mrad
2.8 GHz	140 µS	200 mΩ	0.41 Ω	8.2 mrad	0.002 2 Ω	2.1 mrad	-	-
3 GHz	160 µS	200 mΩ	0.42 Ω	8.4 mrad	-	-	1.1 Ω	15 mrad

Length – Dimensional Metrology **Main Scope**

Parameter/Equipment	**Range**	**Expanded Uncertainty of Measurement (+/-)**	**Reference Standard, Method, and/or Equipment**
Dial and Digital Indicators [2]	Up to 100 mm	0.002 1 mm	Comparison to gage blocks
Feeler Gage [2]	(0.03 to 8.00) mm	0.001 1 mm	Comparison to a micrometer
Calipers [2]	Up to 300 mm	10 µm	Comparison to a caliper checker
Micrometers [2]	Up to 25 mm	1 µm	Comparison to gage blocks
Plain Plug Gages and Pin Gages, Diameter [2]	Up to 25 mm	0.59 µm	Comparison to a supermicrometer, laser interferometer, master cylinder gage
Thread Plug Gages Pitch Diameter [2]	Up to 25 mm	0.001 5 mm	Comparison to a supermicrometer, laser interferometer, master cylinder gage and thread wire

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Mass and Mass Related **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electric Torque Screwdriver [2]	(1 to 1.77) lbf·in (1.78 to 16) lbf·in (16 to 43.4) lbf·in	0.03 lbf·in 0.1 lbf·in (0.006 5τ + 0.009 1) lbf·in	Comparison to a torque analyzer
Torque – Measure	0.3 lbf·in to 1000 lbf·ft	0.7% of reading	Comparison to a torque analyzer
Pressure – Source and Measure	(-103.4 to 70) kPa (70 to 110) kPa (110 to 689.5) kPa (689.5 to 3447) kPa	0.069 kPa 0.01 % of reading 0.069 kPa 0.011 % of reading	Comparison to a pressure controller and monitor
Scales and Balances [4]	(5 to 500) mg (0.5 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 300) g (300 to 500) g (500 to 600) g 600 g to 1 kg (1 to 2) kg (2 to 5) kg (5 to 10) kg	0.015 mg 0.025 mg 0.039 mg 0.065 mg 0.13 mg 0.21 mg 0.39 mg 0.59 mg 1 mg 1.2 mg 6.6 mg 16 mg 35 mg 67 mg	Comparison to reference mass standards

Photometry and Radiometry **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Laser Optical Power – Measure	(80 to 1 000) µW (488 to 788) nm	0.046 µW/W + 0.09 µW	Comparison to photodiode power sensor
Laser Wavelength - Measure	633 nm	0.000 004 5 nm	Comparison to laser head

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Thermodynamic **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source	(-30 to 200) °C (200 to 420) °C (420 to 660) °C	0.074 °C 0.095 °C 0.113 °C	Comparison to a temperature well and a reference thermometer
Temperature – Measure [2]	(-197 to 0) °C (0 to 200) °C (200 to 420) °C (420 to 660) °C	0.01 °C 0.016 °C 0.026 °C 0.039 °C	Comparison to a Precision Reference Thermometer
Humidity – Source and Measure	(5 to 95) %RH	0.8 %RH	Comparison to humidity generator

Time and Frequency **Main Scope**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source	10 MHz	0.39 pHz/Hz	Comparison to Cesium frequency standard
Frequency – Source	10 MHz	1.2 pHz/Hz	Comparison to GPS frequency standard
Frequency – Source	10 MHz	510 pHz/Hz	Comparison to Rubidium frequency standard
Frequency – Source	(0.1 to 1) Hz 1 Hz to 250 kHz 250 kHz to 1 MHz 1 MHz to 12.4 GHz (12.4 to 46) GHz	2.0 µHz/Hz + 0.4 µHz 2.4 µHz/Hz 5.1 nHz/Hz + 0.13 mHz 5.2 nHz/Hz 5.2 nHz/Hz + 2 µHz	Comparison to Rubidium frequency standard and a function generator
Frequency – Measure	(0.1 to 1) Hz (1 to 10) Hz (10 to 100) Hz 100 Hz to 1 kHz (1 to 100) kHz 100 kHz to 10 MHz 10 MHz to 12.4 GHz (12.4 to 46) GHz	1.2 pHz/Hz + 63 pHz 0.61 pHz/Hz + 0.85 pHz 4.5 pHz/Hz + 4.1 nHz 23 pHz/Hz + 22 pHz 23 pHz/Hz + 0.13 nHz 23 pHz/Hz + 33 nHz 23 pHz/Hz + 32 nHz 24 pHz/Hz + 1.1 Hz	Comparison to frequency counter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Jitter - Source	(0.01 to 25) ps 2 GHz 2.5 GHz 2.75 GHz 3 GHz 3.2 GHz 5 GHz 8 GHz 10 GHz 12 GHz 13 GHz 14 GHz 15 GHz 28 GHz 32 GHz	 0.12 ps 44 fs 65 fs 0.13 ps 0.13 ps 0.1 ps 52 fs 31 fs 50 fs 50 fs 0.1 ps 50 fs 42 fs 37 fs	Comparison to a signal generator
Jitter - Measure	(0.1 to 130) ps 200 kHz to 15 GHz	 1.9 ps	Comparison to an Oscilloscope
Time Interval – Measure	10 ps to 430 ps 430 ps to 1 µs 1 µs to 50 ms 50 ms to 1 s 1 s to 10 s 10 s to 100 s	12 ms/s + 1.2 ps 6.7 ps 36 ns/s + 7.5 ps 1.9 ns 26 ps/s + 2.1 ns 33 ps/s + 2.7 ns	Comparison to a frequency counter and an oscilloscope
Transition - Measure	(8 to 30) ps (30 to 50) ps (50 to 200) ps (200 to 500) ps	1.2 ps 1.3 ps 10 fs/s + 0.9 ps 9.4 fs/s + 1 ps	Comparison to an oscilloscope

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Services performed at satellite laboratory

700 Lairport Street
El Segundo, CA 90245

Glenn Gaza 310-643-0438
glenn.gaza@keysight.com www.keysight.com

Acoustics and Vibration El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Source and Measure	Sinusoidal (2 to 4) Hz 5 Hz to 2 kHz (2 to 10) kHz	 2.5% of reading 1.5% of reading 2.5% of reading	Comparison to a reference accelerometer
	Shock (2 to 10) g	 2 % of reading	Comparison to a standard shock accelerometer

Electrical – DC/Low Frequency El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source	0 V 100 mV 1 V 10 V 100 V 1 000 V	54 nV 91 nV 0.32 µV 2.5 µV 38 µV 0.66 mV	Comparison to DC voltage standard characterized by a Keysight 3458A multimeter
DC Voltage – Source	(>0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 V to 1 100) V	7 µV/V + 0.39 µV 4.7 µV/V + 0.62 µV 3.1 µV/V + 2.3 µV 3.1 µV/V + 4.2 µV 4.7 µV/V + 39 µV 6.2 µV/V + 0.39 mV	Direct comparison to a DC voltage standard
DC Voltage – Source	(2 to 60) kV	40 µV/V	Comparison to a voltage divider
DC Voltage – Measure	(>0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	4.1 µV/V + 0.36 µV 3.7 µV/V + 0.35 µV 3.1 µV/V + 0.59 µV 5.3 µV/V + 36 µV 5.3 µV/V + 0.12 mV	Direct measurement with a Keysight 3458A multimeter

Electrical – DC/Low Frequency El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure (Differential)	(>0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	0.61 µV/V + 0.061 µV 0.37 µV/V + 0.12 µV 0.061 µV/V + 0.61 µV 0.61 µV/V + 0.012 mV 1.8 µV/V + 0.061 mV	Differential measurement with a Keysight 3458A multimeter
DC Current – Source	0 A 100 µA 1 mA 10 mA 100 mA 1 A	42 pA 0.15 nA 1.5 nA 17 nA 0.47 µA 9.6 µA	Comparison to a DC source characterized with a Keysight 3458A multimeter
DC Current – Source	(>0 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 200) mA (0.22 to 1) A (1 to 1.6) A (1.6 to 2.2) A (2.2 to 11) A (11 to 20.5) A	39 µA/A + 5.4 nA 31 µA/A + 6.3 nA 31 µA/A + 39 nA 39 µA/A + 0.62 µA 52 µA/A - 0.74 µA 70 µA/A + 12 µA 110 µA/A - 21 µA 150 µA/A - 92 µA 280 µA/A + 370 µA 0.82 mA/A + 0.89 µA	Comparison to a DC current source
DC Current – Source	(10 to 1 025) A	0.2 % of reading	Comparison to DC current source and a current coil
DC Current – Source and Measure	1 µA to 30 mA (30 to 100) mA (100 to 300) mA (300 to 400) mA (500 to 800) mA (800 to 900) mA 900 mA to 15 A (16 to 50) A (50 to 70) A (70 to 100) A (100 to 400) A	4 µA/A 5 µA/A 6 µA/A 13 µA/A 11 µA/A 9 µA/A 8 µA/A 13 µA/A 18 µA/A 24 µA/A 30 µA/A	Comparison to DC source, standard resistor and a voltmeter
DC Current – Measure	(0.10 to 1) A (1 to 100) A (100 to 500) A (500 to 1 000) A	73 µA/A + 1.3 µA 74 µA/A - 0.021 µA 58 µA/A + 180 µA 140 µA/A + 0.42 mA	Comparison to a DC current shunt and a Keysight 3458A multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure	(5 to 10) A (10 to 30) A (30 to 36) A (36 to 45) A (45 to 60) A (60 to 90) A (90 to 180) A (180 to 340) A (340 to 510) A (510 to 1 000) A (1 000 to 2 000) A	93 µA/A + 0.39 mA 140 µA/A 94 µA/A + 1.5 mA 92 µA/A + 1.9 mA 93 µA/A + 2.6 mA 91 µA/A + 4 mA 87 µA/A + 8.5 mA 200 µA/A 180 µA/A + 8.8 mA 180 µA/A + 18 mA 150 µA/A + 26 mA	Comparison to a DC current transducer and a Keysight 3458A multimeter
DC Current – Measure	0 pA (0.1 to 1.15) pA (1 to 115) pA (10 to 115) pA (0.1 to 1.15) nA (1 to 11.5) nA (10 to 115) nA (0.1 to 1.15) µA (1 to 11.5) µA	0.49 fA 0.83 mA/A + 0.59 fA 0.92 mA/A + 0.38 fA 0.24 mA/A + 1.4 fA 0.24 mA/A + 21 fA 26 µA/A + 0.25 pA 51 µA/A + 0.54 pA 20 µA/A + 1.7 pA 13 µA/A + 28 pA	Comparison to a Keysight 3458A multimeter and reference resistors
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 (1 to 3) 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 1.4 mA/A + 0.74 mA	Direct measurement with a Keysight multimeter
DC Current – Measure (Differential)	10 µA to 100 µA 100 µA to 1 mA	24 µA/A + 0.97 nA 24 µA/A + 6.1 nA	Direct measurement with a Keysight 3458A multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure (Differential)	1 mA to 10 mA 10 mA to 100 mA 100 mA to 1.0 A 1 A to 10 A 10 A to 30 A 30 A to 50 A 50 A to 100 A 100 A to 300 A 300 A to 500 A 500 A to 1 000 A	0.61 µA/A + 6.1 nA 0.061 µA/A + 6 nA 0.061 µA/A + 61 nA 0.061 µA/A + 1 µA 0.061 µA/A + 6.1 µA 0.061 µA/A + 12 µA 0.37 µA/A + 12 µA 0.37 µA/A + 0.12 mA 0.37 µA/A + 0.24 mA 0.61 µA/A + 0.61 mA	Comparison to a Keysight 3458A multimeter and a resistive shunt
AC Voltage – Measure	(1 to 80) kV 60 Hz	0.19 % of reading	Comparison to a voltage divider
AC Current – Source	1 kHz 10 µA 100 µA 1 mA 10 mA 100 mA 1 A	 3 nA 2.5 nA 32 nA 330 nA 3.3 µA 38 µA	Comparison to a multifunction calibrator and a Keysight 3458A multimeter
AC Current - Source	60 Hz 2.5A 5 A	 365 µA 669 µA	Comparison to an AC shunt and a Keysight 3458A multimeter
AC Current – Source (Relative) [1]	100 kHz to 100 MHz Ratio 0.7 to 1.1	 0.058	Comparison to an oscilloscope
AC Current - Measure	(45 to 100) Hz 2.5 A, 60 Hz 2.5 A, 500 Hz 5 A, 60 Hz 5 A, 500 Hz 10 A, (60, 500) Hz 20 A, (60, 500) Hz 40 A, (60, 500) Hz	 0.6 mA 1.2 mA 1.1 mA 2.4 mA 4.9 mA 9.5 mA 19 mA	Comparison to a resistive shunt and a Keysight 3458A multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source	(0.1 to 0.2) mΩ	7.2 μΩ/Ω	Comparison to Guildline 6675A Bridge, 6623 Extender, L&N Standard Resistors, ESIU SR 1010, SR 1050, Hart 7009 Oil Bath, MI 9300 Air Bath
	(0.2 to 0.3) mΩ	4.3 μΩ/Ω	
	(0.3 to 0.4) mΩ	3.3 μΩ/Ω	
	(0.4 to 1) mΩ	2.9 μΩ/Ω	
	(1 to 2) mΩ	1.4 μΩ/Ω	
	(3 to 5) mΩ	3.4 μΩ/Ω	
	(6 to 9) mΩ	2.4 μΩ/Ω	
	(10 to 20) mΩ	1.5 μΩ/Ω	
	(3 to 5) mΩ	3.4 μΩ/Ω	
	(6 to 9) mΩ	2.4 μΩ/Ω	
	(0.3 to 0.5) Ω	1.4 μΩ/Ω	
	(0.6 to 0.9) Ω	1 μΩ/Ω	
	(1 to 13) Ω	0.17 μΩ/Ω	
	14 Ω to 1 kΩ	0.38 μΩ/Ω	
	(1.1 to 9) kΩ	0.4 μΩ/Ω	
	(11 to 100) kΩ	0.45 μΩ/Ω	
	200 kΩ to 1 MΩ	0.84 μΩ/Ω	
	(2 to 10) MΩ	1.8 μΩ/Ω	
	(11 to 100) MΩ	4.1 μΩ/Ω	
	(200 to 900) MΩ	12 μΩ/Ω	
Resistance – Source	0.1 Ω	0.62 μΩ/Ω	Comparison to Guildline 6675Av Bridge, 6623 Extender, L&N Standard Resistors, ESIU SR 1010, SR 1050, Hart 7009 Oil Bath, MI 9300 Air Bath
	0.2 Ω	0.64 μΩ/Ω	
	1 Ω	0.17 μΩ/Ω	
	10 Ω	0.17 μΩ/Ω	
	100 Ω	0.38 μΩ/Ω	
	1 kΩ	0.38 μΩ/Ω	
	10 kΩ	0.25 μΩ/Ω	
	1 GΩ	12 μΩ/Ω	
Resistance – Source	1 Ω	86 μΩ/Ω	Comparison to a multifunction calibrator
	1.9 Ω	85 μΩ/Ω	
	(10, 19) Ω	21 μΩ/Ω	
	(100, 190) Ω	9.3 μΩ/Ω	
	(1, 1.9, 10, 19) kΩ	6.2 μΩ/Ω	
	100 kΩ	7.8 μΩ/Ω	
	190 kΩ	9.3 μΩ/Ω	
	1 MΩ	12 μΩ/Ω	
	1.9 MΩ	16 μΩ/Ω	
	10 MΩ	36 μΩ/Ω	
	19 MΩ	43 μΩ/Ω	
	100 MΩ	93 μΩ/Ω	

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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 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 110 μΩ/Ω + 0.2 kΩ 210 μΩ/Ω + 2 kΩ 410 μΩ/Ω + 2.8 kΩ 2.5 mΩ/Ω + 83 kΩ 12 mΩ/Ω + 0.4 MΩ	Comparison to a multiproduct calibrator
Resistance – Source and Measure	0 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ	7.6 μΩ 13 μΩ 76 μΩ 0.40 mΩ 4.5 mΩ 42 mΩ 0.88 Ω 22 Ω 1.3 kΩ	Comparison to multifunction calibrator and a Keysight 3458A multimeter
Resistance - Measure	(1 to 10) GΩ (10 to 100) GΩ 100 GΩ to 1 TΩ (1 to 10) TΩ (10 to 100) TΩ 100 TΩ to 1 PΩ (1 to 10) PΩ	0.8 mΩ/Ω 1.2 mΩ/Ω 2.3 mΩ/Ω 3.5 mΩ/Ω 5.8 mΩ/Ω 12 mΩ/Ω 0.12 Ω/Ω	Comparison to Guildline 6500A Terohmmeter
Resistance - Measure	(0 to 12) Ω (12 to 100) Ω (0.1 to 1.2) kΩ (1.2 to 12) kΩ (12 to 120) kΩ (0.12 to 1.2) MΩ (1.2 to 12) MΩ (12 to 120) MΩ (0.12 to 1.2) GΩ	20 μΩ/Ω + 79 μΩ 15 μΩ/Ω + 0.79 mΩ 13 μΩ/Ω + 0.79 mΩ 13 μΩ/Ω + 7.8 mΩ 13 μΩ/Ω + 78 mΩ 17 μΩ/Ω + 2.6 Ω 61 μΩ/Ω + 0.12 kΩ 0.58 mΩ/Ω + 3.6 kΩ 5.7 mΩ/Ω + 0.26 MΩ	Comparison to a Keysight 3458A multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure	50 Hz to 20 kHz (1 to 2) pF (2 to 4) pF (4 to 9) pF (10, 20, 30) pF (40 to 100) pF (300 to 400) pF (500 to 600) pF (700 to 800) pf 0.9 pF to 1 nF (1 to 4) nF (4 to 10) nF (10 to 40) nF (40 to 100) nF (100 to 400) nF (400 to 1200) nF	 4.1 µF/F 3.7 µF/F 3.6 µF/F 3.6 µF/F 3.5 µF/F 3.5 µF/F 3.6 µF/F 3.5 µF/F 3.6 µF/F 3.6 µF/F 3.7 µF/F 3.9 µF/F 4.7 µF/F 7.4 µF/F 15 µF/F	Comparison to a capacitance bridge
Capacitance – Measure	50 Hz to 20 kHz 1 pF 2 pF 0.2 nF	 4.1 µF/F 3.8 µF/F 3.6 µF/F	Comparison to Standard Capacitors
Capacitance – Source	(0.19 to 3.29) nF (3.3 to 10.99) nF (11 to 109.99) nF (110 to 329.99) nF (0.33 to 1.099) µF (1.1 to 3.299) µF (3.3 to 10.99) µF (11 to 32.99) µF (33 to 109.99) µF (110 to 329.99) µF (0.33 to 1.099) mF (1.1 to 3.299) mF (3.3 to 10.00) mF (11 to 32.99) mF (33 to 110) mF	3.1 mF/F + 7.7 pF 1.4 mF/F + 8.2 pF 1.4 mF/F + 80 pF 1.5 mF/F + 0.24 nF 1.4 mF/F + 0.82 nF 1.5 mF/F + 2.4 nF 1.4 mF/F + 8.1 nF 2.4 mF/F + 24 nF 2.6 mF/F + 83 nF 2.7 mF/F + 0.24 µF 2.6 mF/F + 0.82 µF 2.7 mF/F + 2.4 µF 3.3 mF/F + 5.2 µF 5.5 mF/F + 24 µF 7.9 mF/F + 79 µF	Comparison to a multiproduct calibrator

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Capacitance – Source	10 pF 50 Hz 0.1 kHz 0.4 kHz 0.8 kHz 1 kHz 2 kHz 6 kHz 8 kHz 10 kHz 16 kHz 20 kHz	 3.4 µF/F 1.6 µF/F 0.48 µF/F 0.35 µF/F 0.33 µF/F 0.32 µF/F 0.55 µF/F 0.75 µF/F 1.1 µF/F 2.3 µF/F 3.5 µF/F	Comparison to Standard Capacitors
Capacitance – Source	100 pF 50 Hz 0.1 kHz 0.4 kHz 0.8 kHz 1 kHz 2 kHz 6 kHz 8 kHz 10 kHz 16 kHz 20 kHz	 1.9 µF/F 1 µF/F 0.54 µF/F 0.46 µF/F 0.29 µF/F 0.28 µF/F 0.45 µF/F 0.81 µF/F 0.94 µF/F 2.1 µF/F 2.7 µF/F	Comparison to Standard Capacitors
Capacitance – Source	1 000 pF 0.1 kHz 0.4 kHz 1 kHz	 3.7 µF/F 2.7 µF/F 2.3 µF/F	Comparison to Standard Capacitors

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

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Source and Measure	100 µH 100 Hz 1 kHz 10 kHz 1 mH 100 Hz 1 kHz 10 kHz 10 mH 1 kHz 10 kHz 100 mH 100 Hz 1 kHz 10 Hz 1 H (100, 400) Hz 1 kHz 10 H (100, 400) Hz 1 kHz	 0.15 mH/H 80 µH/H 0.15 mH/H 0.1 mH/H 70 µH/H 0.15 mH/H 70 µH/H 0.13 mH/H 90 µH/H 70 µH/H 0.2 mH/H 80 µH/H 70 µH/H 90 µH/H 80 µH/H	Comparison to LCR Meter, Standard Inductors
Phase Angle – Source	(0 to 360)° @ 5 V Equal Input 1 Hz to 6.25 kHz (6.25 to 50) kHz (50 to 200) kHz @50 mV to 100 V 1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz @100V to 120 V 1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz	 0.005 8° 0.012° 0.047° 0.006° 0.012° 0.018° 0.047° 0.01 ° 0.02 ° 0.035° 0.093°	Comparison to Clark-Hess 5500-2 Phase Standard

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Angle – Measure	(0 to 360)° 10 mV to 350 V (5 to 10) Hz 10 Hz to 50 kHz (50 to 57) kHz (57 to 66) kHz (66 to 75) kHz (75 to 83) kHz (83 to 92) kHz (92 to 100) kHz 101 kHz 110 kHz 115 kHz 120 kHz 125 kHz 130 kHz 135 kHz 140 kHz 145 kHz 150 kHz 200 kHz 250 kHz 300 kHz 350 kHz 400 kHz 450 kHz 500 kHz	 0.23° 0.06° 0.12° 0.13° 0.14° 0.15° 0.16° 0.17° 0.57° 0.62° 0.64° 0.67° 0.69° 0.72° 0.74° 0.77° 0.79° 0.82° 1.1° 1.4° 1.6° 1.9° 2.1° 2.4° 2.6°	Comparison to Clark-Hess 6000A Phase Meter
Ratio Transformer	400 Hz, 1 kHz	0.000 051 % of Input	Comparison to Gertsch 1011 Ratio Standard

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Parameter/Equipment	AC Voltage - Source							
Reference Standard, Method, and/or Equipment	Comparison to a characterized AC voltage source							
Expanded Uncertainty of Measurement (+/-)								
Range	10 mV	100 mV	1 V	3 V	10 V	100 V	700 V	1000 V
10 Hz	0.69 µV	1.7 µV	-	-	76 µV	-	-	-

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Parameter/Equipment	AC Voltage - Source							
Reference Standard, Method, and/or Equipment	Comparison to a characterized AC voltage source							
Expanded Uncertainty of Measurement (+/-)								
Range	10 mV	100 mV	1 V	3 V	10 V	100 V	700 V	1000 V
20 Hz	0.51 µV	1.8 µV	-	-	45 µV	-	-	-
40 Hz	-	-	-	-	35 µV	-	-	-
200 Hz	-	-	-	-	24 µV	-	-	-
500 Hz	-	-	-	-	25 µV	-	-	-
1 kHz	70 nV	0.36 µV	2.6 µV	-	26 µV	0.42 mV	6.5 mV	16 mV
10 kHz	-	-	-	-	26 µV	-	7 mV	11 mV
20 kHz	76 nV	0.31 µV	2.8 µV	-	25 µV	0.35 mV		22 mV
50 kHz	-	-	3.7 µV	-	36 µV	0.67 mV		
100 kHz	62 nV	0.34 µV	4.6 µV	13 µV	44 µV	0.8 mV		
300 kHz	0.17 µV	0.7 µV	8 µV	-	73 µV	-	-	-
500 kHz	-	-	11 µV	-	0.11 mV	-	-	-
1 MHz	1.2 µV	2.7 µV	20 µV	-	0.19 mV	-	-	-
2 MHz	-	-	-	2.1 mV	-	-	-	-
4 MHz	10 µV	0.1 mV	1 mV	3.2 mV	-	-	-	-
8 MHz	-	0.16 mV	1.6 mV	4.8 mV	-	-	-	-
10 MHz	-	0.18 mV	1.8 mV	5.5 mV	-	-	-	-

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Parameter/Equipment	AC Voltage - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC voltage source								
Expanded Uncertainty of Measurement (+/-)									
Range	(>0 to 2.2) mV	(2.2 to 22) mV	(22 to 220) mV	(0.22 to 2.2) V	(2.2 to 22) V	(22 to 220) V	(220 to 250) V	(220 to 1 100) V	(220 to 750) V
(10 to 15) Hz	230 µV/V + 3.9 µV	230 µV/V + 3.9 µV	230 µV/V + 12 µV	230 µV/V + 39 µV	230 µV/V + 390 µV	230 µV/V + 3.9 mV	-	-	-
(15 to 20) Hz	230 µV/V + 3.9 µV	230 µV/V + 3.9 µV	230 µV/V + 12 µV	230 µV/V + 39 µV	230 µV/V + 390 µV	230 µV/V + 3.9 mV	280 µV/V + 16 mV	-	-
(20 to 40) Hz	89 µV/V + 3.9 µV	89 µV/V + 3.9 µV	89 µV/V + 6.2 µV	85 µV/V + 16 µV	85 µV/V + 160 µV	85 µV/V + 1.6 mV	280 µV/V + 16 mV	-	-
(40 to 50) Hz	77 µV/V + 3.9 µV	77 µV/V + 3.9 µV	54 µV/V + 6.2 µV	37 µV/V + 7.8 µV	37 µV/V + 54 µV	50 µV/V + 0.54 mV	-	70 µV/V + 3.1 mV	-
50 Hz to 1 kHz	77 µV/V + 3.9 µV	77 µV/V + 3.9 µV	54 µV/V + 6.2 µV	37 µV/V + 7.8 µV	37 µV/V + 54 µV	50 µV/V + 0.54 mV	-	66 µV/V + 3.1 mV	-
(1 to 20) kHz	77 µV/V + 3.9 µV	77 µV/V + 3.9 µV	54 µV/V + 6.2 µV	37 µV/V + 7.8 µV	37 µV/V + 54 µV	50 µV/V + 0.54 mV	-	130 µV/V + 4.7 mV	-

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Parameter/Equipment	AC Voltage - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC voltage source								
Expanded Uncertainty of Measurement (+/-)									
Range	(>0 to 2.2) mV	(2.2 to 22) mV	(22 to 220) mV	(0.22 to 2.2) V	(2.2 to 22) V	(22 to 220) V	(220 to 250) V	(220 to 1 100) V	(220 to 750) V
(20 to 30) kHz	190 µV/V + 3.9 µV	190 µV/V + 3.9 µV	120 µV/V + 6.2 µV	62 µV/V + 9.3 µV	62 µV/V + 93 µV	78 µV/V + 0.93 mV	-	470 µV/V + 8.5 mV	-
(30 to 50) kHz	190 µV/V + 3.9 µV	190 µV/V + 3.9 µV	120 µV/V + 6.2 µV	62 µV/V + 9.3 µV	62 µV/V + 93 µV	78 µV/V + 0.93 mV	-	-	470 µV/V + 8.5 mV
(50 to 100) kHz	460 µV/V + 4.7 µV	470 µV/V + 4.7 µV	310 µV/V + 16 µV	78 µV/V + 31 µV	78 µV/V + 190 µV	140 µV/V + 2.3 mV	-	-	1.8 mV/V + 35 mV
Range	(>0 to 2.2) mV	(2.2 to 22) mV	(22 to 220) mV	(0.22 to 2.2) V	(2.2 to 22) V	(22 to 2.2e7) V	(220 to 250) V	(220 to 1 100) V	(220 to 750) V
(100 to 300) kHz	1 mV/V + 9.3 µV	1 mV/V + 9.3 µV	620 µV/V + 19 µV	310 µV/V + 78 µV	230 µV/V + 620 µV	850 µV/V + 16 mV	-	-	-
(300 to 500) kHz	1.3 mV/V + 19 µV	1.3 mV/V + 19 µV	1.3 mV/V + 23 µV	930 µV/V + 190 µV	930 µV/V + 1.9 mV	4.2 mV/V + 39 mV	-	-	-
500 kHz to 1 MHz	2.6 mV/V + 19 µV	2.6 mV/V 19 µV	2.6 mV/V + 47 µV	1.6 mV/V + 310 µV	1.4 mV/V + 3.1 mV	7.8 mV/V + 78 mV	-	-	-

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Parameter/Equipment	AC Voltage - Measure								
Reference Standard, Method, and/or Equipment	Comparison to a Comparison to a Thermal Transfer Standard								
Expanded Uncertainty of Measurement (+/-)									
Range	1 V	2 V	6 V	10 V	20 V	60 V	200 V	600 V	1000 V
10 Hz	14 µV/V	13 µV/V	12 µV/V	16 µV/V	13 µV/V	14 µV/V	23 µV/V	21 µV/V	17 µV/V
20 Hz	9 µV/V	7 µV/V	7 µV/V	9 µV/V	8 µV/V	10 µV/V	13 µV/V	12 µV/V	12 µV/V
40 Hz	9 µV/V	7 µV/V	7 µV/V	8 µV/V	7 µV/V	9 µV/V	11 µV/V	12 µV/V	11 µV/V
100 Hz	7 µV/V	7 µV/V	7 µV/V	8 µV/V	7 µV/V	9 µV/V	10 µV/V	10 µV/V	11 µV/V
1 kHz	11 µV/V	7 µV/V	8 µV/V	9 µV/V	8 µV/V	9 µV/V	10 µV/V	10 µV/V	12 µV/V
10 kHz	12 µV/V	7 µV/V	8 µV/V	9 µV/V	8 µV/V	9 µV/V	11 µV/V	10 µV/V	12 µV/V
20 kHz	13 µV/V	7 µV/V	8 µV/V	10 µV/V	9 µV/V	10 µV/V	10 µV/V	10 µV/V	12 µV/V
50 kHz	9 µV/V	8 µV/V	8 µV/V	11 µV/V	10 µV/V	11 µV/V	13 µV/V	11 µV/V	13 µV/V
100 kHz	8 µV/V	8 µV/V	9 µV/V	11 µV/V	10 µV/V	14 µV/V	15 µV/V	15 µV/V	24 µV/V
300 kHz	12 µV/V	13 µV/V	11 µV/V	12 µV/V	11 µV/V	19 µV/V	-	-	-
500 kHz	15 µV/V	21 µV/V	16 µV/V	18 µV/V	15 µV/V	-	-	-	-
800 kHz	20 µV/V	27 µV/V	19 µV/V	20 µV/V	19 µV/V	-	-	-	-
1 MHz	27 µV/V	31 µV/V	25 µV/V	26 µV/V	25 µV/V	-	-	-	-

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Parameter/Equipment	AC Voltage - Measure					
Reference Standard, Method, and/or Equipment	Comparison to a Keysight 3458A multimeter					
Expanded Uncertainty of Measurement (+/-)						
Range	(>0 to 10 mV)	(10 to 120) mV	(0.12 to 1.2) V	(1.2 to 12) V	(12 to 120) V	(120 to 700) V
(1 to 40) Hz	0.35 mV/V + 3.4 µV	83 µV/V + 4.6 µV	83 µV/V + 46 µV	83 µV/V + 0.46 mV	0.23 mV/V + 4.6 mV	0.46 mV/V + 46 mV
40 Hz to 1 kHz	0.23 mV/V + 1.3 µV	83 µV/V + 2.3 µV	83 µV/V + 23 µV	83 µV/V + 0.23 mV	0.23 mV/V + 2.3 mV	0.46 mV/V + 23 mV
(1 to 20) kHz	0.34 mV/V + 1.3 µV	0.16 mV/V + 2.3 µV	0.16 mV/V + 23 µV	0.16 mV/V + 0.23 mV	0.23 mV/V + 2.3 mV	0.7 mV/V + 23 mV
(20 to 50) kHz	1.1 mV/V + 1.3 µ/V	0.34 mV/V + 2.3 µV	0.34 mV/V + 23 µV	0.34 mV/V + 0.23 mV	0.4 mV/V + 2.3 mV	1.4 mV/V + 23 mV
(50 to 100) kHz	5.7 mV/V + 1.2 µV	0.92 mV/V + 2.3 µV	0.92 mV/V + 23 µV	0.92 mV/V + 0.23 mV	1.4 mV/V + 2.3 mV	3.5 mV/V + 23 mV
(100 to 300) kHz	46 mV/V + 2.3 µV	3.4 mV/V + 12 µV	3.4 mV/V + 0.11 mV	3.4 mV/V + 1.2 mV	4.6 mV/V + 11 mV	-
300 kHz to 1 MHz	14 mV/V + 5.8 µV	11 mV/V + 12 µV	11 mV/V + 0.12 mV	11 mV/V + 1.2 mV	17 mV/V + 11 mV	-
(1 to 2) MHz	81 mV/V + 8.1 µV	17 mV/V + 12 µV	17 mV/V + 0.12 mV	17 mV/V + 1.2 mV	-	-
(2 to 4) MHz	82 mV/V + 8.1 µV	46 mV/V + 81 µV	46 mV/V + 0.81 mV	46 mV/V + 8.1 mV	-	-
(4 to 8) MHz	230 mV/V + 9.2 µV	46 mV/V + 92 µV	46 mV/V + 0.92 mV	46 mV/V + 9.2 mV	-	-
(8 to 10) MHz	-	170 mV/V + 120 µV	170 mV/V + 1.2 mV	170 mV/V + 12 mV	-	-

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Parameter/Equipment	AC Current - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC source								
Expanded Uncertainty of Measurement (+/-)									
Range	(10 to 20) Hz	(20 to 30) Hz	(30 to 40) Hz	(40 to 45) Hz	(45 to 100) Hz	(0.1 to 1) kHz	(1 to 5) kHz	(5 to 10) kHz	(10 to 30) kHz
(>0 to 220) µA	230 µA/A + 16 nA	160 µA/A + 9.3 nA	160 µA/A + 9.3 nA	93 µA/A + 7.8 nA	93 µA/A + 7.8 nA	93 µA/A + 7.8 nA	270 µA/A + 12 nA	1 mA/A + 62 nA	13 mA/A + 0.33 µA
(220 to 330) µA	230 µA/A + 39 nA	160 µA/A + 31 nA	160 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	190 µA/A + 100 nA	1 mA/A + 620 nA	13 mA/A + 0.33 µA
(0.33 to 2.2) mA	230 µA/A + 39 nA	160 µA/A + 31 nA	160 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	93 µA/A + 31 nA	190 µA/A + 100 nA	1 mA/A + 620 nA	8.2 mA/A + 0.49 µA
(2.2 to 3.3) mA	230 µA/A + 390 nA	160 µA/A + 310 nA	160 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	190 µA/A +540 nA	1 mA/A + 4.7 µA	8.2 mA/A + 0.49 µA

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Parameter/Equipment	AC Current - Source								
Reference Standard, Method, and/or Equipment	Comparison to an AC source								
Expanded Uncertainty of Measurement (+/-)									
Range	(10 to 20) Hz	(20 to 30) Hz	(30 to 40) Hz	(40 to 45) Hz	(45 to 100) Hz	(0.1 to 1) kHz	(1 to 5) kHz	(5 to 10) kHz	(10 to 30) kHz
(3.3 to 22) mA	230 µA/A + 390 nA	160 µA/A + 310 nA	160 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	93 µA/A + 310 nA	190 µA/A +540 nA	1 mA/A + 4.7 µA	3.3 mA/A + 3.3 µA
(22 to 33) mA	230 µA/A + 3.9 µA	160 µA/A + 3.1 µA	160 µA/A + 3.1 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	190 µA/A +3.1 µA	1 mA/A + 9.3 µA	3.3 mA/A + 3.3 µA
(33 to 220) mA	230 µA/A + 3.9 µA	160 µA/A + 3.1 µA	160 µA/A + 3.1 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	93 µA/A + 2.3 µA	190 µA/A +3.1 µA	1 mA/A + 9.3 µA	3.3 mA/A + 0.16 mA
(220 to 330) mA	1.5 mA/A + 16 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	390 µA/A +78 µA	6.2 mA/A + 160 µA	3.3 mA/A + 0.16 mA
(0.33 to 2.2) A	1.5 mA/A + 82 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	230 µA/A + 31 µA	390 µA/A +78 µA	6.2 mA/A + 160 µA	-
(2.2 to 3) A	1.5 mA/A + 82 µA	1.5 mA/A + 82 µA	1.5 mA/A + 82 µA	360 µA/A + 130 µA	360 µA/A + 130 µA	360 µA/A + 130 µA	740 µA/A +290 µA	2.8 mA/A + 580 µA	-
(3 to 11) A	-	-	-	360 µA/A + 130 µA	360 µA/A + 130 µA	360 µA/A + 130 µA	740 µA/A +290 µA	2.8 mA/A + 580 µA	-
(11 to 20.5) A	-	-	-	-	0.98 mA/A + 4.1 mA	1.2 mA/A + 4.1 mA	25 mA/A + 4.1 mA	-	-

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Parameter/Equipment	AC Current - Source and Measure					
Reference Standard, Method, and/or Equipment	Comparison to AC shunts and a Thermal Transfer Standard					
Expanded Uncertainty of Measurement (+/-)						
Range	20 Hz	400 Hz	1 kHz	5 kHz	20 kHz	50 kHz
10 mA	31 µA/A	18 µA/A	18 µA/A	18 µA/A	18 µA/A	29 µA/A
20 mA	31 µA/A	18 µA/A	18 µA/A	18 µA/A	-	-
50 mA	31 µA/A	18 µA/A	18 µA/A	18 µA/A	-	-
100 mA	32 µA/A	21 µA/A	21 µA/A	21 µA/A	21 µA/A	41 µA/A
200 mA	34 µA/A	22 µA/A	22 µA/A	22 µA/A	-	-
500 mA	36 µA/A	23 µA/A	23 µA/A	23 µA/A	-	-
1 A	38 µA/A	25 µA/A	25 µA/A	25 µA/A	-	-
2 A	25 µA/A	55 µA/A	42 µA/A	27 µA/A	27 µA/A	27 µA/A

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Parameter/Equipment	AC Current - Measure			
Reference Standard, Method, and/or Equipment	Comparison to a Keysight 3458A multimeter			
Expanded Uncertainty of Measurement (+/-)				
Range	(10 to 20) Hz	(20 to 45) Hz	(45 to 100) Hz	(0.1 to 5) kHz
(>0 to 120) µA	4.6 mA/A + 34 nA	1.7 mA/A + 34 nA	0.69 mA/A + 34 nA	0.69 mA/A + 34 nA
(0.1 to 1.2) mA	4.6 mA/A + 0.23 µA	1.7 mA/A + 0.23 µA	0.69 mA/A + 0.23 µA	0.35 mA/A + 0.23 µA
(1 to 12) mA	4.6 mA/A + 2.3 µA	1.7 mA/A + 2.3 µA	0.69 mA/A + 2.3 µA	0.35 mA/A + 2.3 µA
(10 to 120) mA	4.6 mA/A + 23 µA	1.7 mA/A + 23 µA	0.69 mA/A + 23 µA	0.35 mA/A + 23 µA
(0.12 to 1.05) A	4.6 mA/A + 0.23 mA	1.8 mA/A + 0.23 mA	0.93 mA/A + 0.23 mA	1.1 mA/A + 0.23 mA

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Parameter/Equipment	AC Current - Measure							
Reference Standard, Method, and/or Equipment	Comparison to an AC source and a current coil							
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)								
Range	(10 to 20) Hz	(20 to 45) Hz	(45 to 65) Hz	(45 to 100) Hz	45 Hz to 1 kHz	(65 to 400) Hz	(0.1 to 1) kHz	(1 to 5) kHz
(0.1 to 1) mA	0.13% + 0.43 µA	0.078% + 0.47 µA	-	-	0.058% + 0.5 µA	-	-	0.13% + 0.53 µA
(1 to 3) mA	0.15% + 0.25 µA	0.095% + 0.35 µA	-	-	0.075% + 0.35 µA	-	-	0.15% + 0.35 µA
(3 to 10) mA	0.11% + 5 µA	0.063% + 4.4 µA	-	-	0.02% + 5.3 µA	-	-	0.050% + 5 µA
(10 to 30) mA	0.14% + 3 µA	0.063% + 4.4 µA	-	-	0.02% + 5.3 µA	-	-	0.050% + 5 µA
(30 to 300) mA	0.12% + 48 µA	0.063% + 44 µA	-	-	0.02% + 54 µA	-	-	0.077% + 58 µA
(0.3 to 1) A	0.15% + 86 µA	0.12% + 0.4 mA	-	-	0.02% + 0.52 mA	-	-	0.46% + 1 mA
(1 to 2.5) A	0.67% - 0.5 mA	0.46% - 0.5 mA	-	0.1%	-	-	0.14%	0.56% + 0.75 mA
(2.5 to 3) A	-	-	-	0.1%	-	-	0.14%	2.3% + 5 mA
(3 to 10) A	-	-	-	0.034% + 5.1 mA	-	-	0.058% + 5.2 mA	2.3% + 5 mA
(10 to 20) A	-	-	-	0.15% - 6.8 mA	-	-	0.18% - 7 mA	2.3% + 5 mA
(20 to 30)A	-	-	0.24% + 23 mA	-	-	0.58% + 34 mA	-	-
(30 to 150) A	-	-	0.21% + 44 mA	-	-	0.63% + 25 mA	-	-

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Parameter/Equipment	AC Current - Measure							
Reference Standard, Method, and/or Equipment	Comparison to an AC source and a current coil							
Expanded Uncertainty of Measurement (+/-) (% indicates % of reading where not specified)								
Range	(10 to 20) Hz	(20 to 45) Hz	(45 to 65) Hz	(45 to 100) Hz	45 Hz to 1 kHz	(65 to 400) Hz	(0.1 to 1) kHz	(1 to 5) kHz
(150 to 300) A	-	-	0.23% + 94 mA	-	-	0.64% + 71 mA	-	-
(300 to 1 020) A	-	-	0.25% + 0.19 A	-	-	0.64% + 60 mA	-	-

Electrical – RF/Microwave El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Measure Number of attenuation segments 1 or any configuration of multiple segments with attenuation totaling from 1 dB up to and including 40 dB	Type-N, 3.5 mm, 2.4 mm (1 to 40) dB (0.3 to 500) MHz (0.5 to 2) GHz (2 to 18) GHz (18 to 40) GHz (40 to 50) GHz	 0.003 4 dB 0.004 7 dB ((0.011 % of reading * *f*) + 0.004 9) dB 0.008 9 dB 0.012 dB	Comparison to a Keysight network analyzer
Attenuation – Measure Number of attenuation segments 2	Type-N: (50 to 80) dB 3.5 mm: 50, 60 dB 2.4 mm: 50 dB 300 kHz to 8 GHz (8 to 18) GHz (8 to 40) GHz (40 to 50) GHz	 0.025 dB 0.029 dB 0.034 dB 0.037 dB	Comparison to a Keysight network analyzer
Attenuation – Measure Number of attenuation segments 3	Type-N: (70 to 100) dB 3.5 mm: 70 dB or 80 dB 300 kHz to 18 GHz (18 to 20) GHz (20 to 40) GHz (40 to 50) GHz	 0.048 dB 0.056 dB 0.059 dB 0.065 dB	Comparison to a Keysight network analyzer

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Measure Number of attenuation segments 4	Type-N: 110, 120 dB 3.5 mm: 90 dB 2.4 mm: 65 or 90 dB 300 kHz to 18 GHz (18 to 20) GHz (20 to 40) GHz (40 to 50) GHz	 0.072 dB 0.08 dB 0.084 dB 0.094 dB	Comparison to a Keysight network analyzer
RF Power - Measure Power Meter Reference	1 mW, 50 MHz	0.23 % of reading	Comparison to a power meter
RF Power - Measure DC VSWR [1]	1:1 to 2:1	0.000 32	Comparison to a Keysight 3458A multimeter
RF Power - Measure Calibration Factors [1]	(0 to 105) % DC to 9 kHz	 0.003 9	Comparison to a Keysight 3458A multimeter
RF Power - Measure Calibration Factors [1]	(0.5 to 1.5) 9 kHz to 30 kHz 30 kHz to 50 MHz (50 to 100) MHz (0.1 to 6) GHz (6 to 7) GHz (7 to 8) GHz (8 to 18 GHz) (18 to 26) GHz (26 to 31) GHz (31 to 37 GHz (37 to 38) GHz (38 to 40) GHz (40 to 46) GHz (46 to 50) GHz (50 to 70) GHz (70 to 75) GHz (75 to 100) GHz (100 to 106) GHz (106 to 108) GHz (108 to 110) GHz (110 to 114) GHz (114 to 120) GHz	 0.003 1 0.002 9 0.002 1 0.002 9 0.003 1 0.003 2 0.003 8 0.008 1 0.008 6 0.008 4 0.009 3 0.008 3 0.014 0.013 0.02 0.041 0.044 0.043 0.045 0.051 0.054 0.057	Comparison to a power sensor

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Measure (Relative)	(Ref -30 to 11 dBm)		Comparison to power sensors
	900 Hz to 9 kHz		
	(-40 to -35) dB	0.14 dB	
	(-35 to -30) dB	0.051 dB	
	(-30 to -3) dB	0.026 dB	
	(-3 to 3) dB	0.006 1 dB	
	(3 to 10) dB	0.014 dB	
	(10 to 30) dB	0.023 dB	
	9 kHz to 50 GHz		
	(-130 to -110) dB	0.17 dB	
	(-110 to -100) dB		
	(9 to 100) kHz	0.064 dB	
	100 kHz to 3.6 GHz	0.05 dB	
	(3.6 to 30) GHz	0.07 dB	
	(30 to 50) GHz	0.074 dB	
	(-100 to -90) dB	0.044 dB	
	(-90 to -70) dB	0.034 dB	
	(-70 to -50) dB	0.029 dB	
	(-50 to -30) dB	0.018 dB	
	(-30 to -10) dB	0.009 2 dB	
	(-10 to -5) dB	0.006 5 dB	
	(-5 to 5) dB	0.002 2 dB	
	(5 to 10) dB	0.006 5 dB	
	(10 to 20) dB	0.092 dB	
	(20 to 30) dB	0.026 dB	
	(50 to 67) GHz		
	(-130 to -120) dB	0.22 dB	
	(-120 to -80) dB	0.17 dB	
	(-80 to -70) dB	0.21 dB	
	(-70 to -60) dB	0.05 dB	
	(-60 to -50) dB	0.033 dB	
	(-50 to -40) dB	0.025 dB	
	(-40 to -35) dB	0.021 dB	
	(-35 to -30) dB	0.019 dB	
	(-30 to -3) dB	0.005 6 dB	
	(-3 to 3) dB	0.002 2 dB	
	(3 to 10) dB	0.014 dB	
	(10 to 30) dB	0.023 dB	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Measure (Relative)	(Ref -30 to 11 dBm) (67 to 110) GHz (-40 to -35) dB (-35 to -30) dB (-30 to -3) dB (-3 to 3) dB (3 to 10) dB (10 to 30) dB	 0.18 0.063 0.026 0.0061 0.014 0.023	Comparison to power sensors
RF Power – Measure (Relative)	1 MHz to 2 GHz (Ref -10 to -20 dBm) -60 dBm (-60 to -50) dBm (-50 to -40) dBm (-40 to -30) dBm (-30 to -20) dBm (-20 to -10) dBm (-10 to -5) dBm (-5 to 5) dBm 1.195 GHz (Ref -10 to -22 dBm) (-82 to -80) dBm (-80 to -73) dBm (-73 to -63) dBm (-63 to -43) dBm (-43 to -33) dBm (-33 to 0) dBm (0 to 10) dBm	 0.004 9 dB 0.001 5 dB 0.000 84 dB 0.000 76 dB 0.000 23 dB 0.000 097 dB 0.000 11 dB 0.000 32 dB 0.041 dB 0.027 dB 0.019 dB 0.011 dB 0.007 9 dB 0.003 7 dB 0.005 3 dB	Comparison to a Keysight network analyzer, power sensor and signal source

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure (Relative)	1.998 77 GHz (Ref -20 dBm) (-60 to -57) dBm (-57 to -52) dBm (-52 to -49) dBm (-49 to -47) dBm (-47 to -46) dBm (-46 to -44) dBm (-44 to -42) dBm (-42 to -41) dBm (-41 to -39) dBm (-39 to -37) dBm (-37 to -35) dBm (-35 to -33) dBm (-33 to -31) dBm (-31 to -29) dBm (-29 to -27) dBm (-27 to -26) dBm (-26 to -25) dBm (-25 to -23) dBm (-23 to -22) dBm (-22 to -19) dBm (-19 to -14) dBm (-14 to -9) dBm	 0.007 dB 0.006 7 dB 0.006 3 dB 0.006 dB 0.005 8 dB 0.005 4 dB 0.005 dB 0.004 8 dB 0.004 5 dB 0.004 1 dB 0.003 8 dB 0.003 5 dB 0.003 2 dB 0.003 dB 0.002 7 dB 0.002 5 dB 0.002 3 dB 0.001 9 dB 0.001 6 dB 0.001 dB 0.002 3 dB 0.003 3 dB	Comparison to a Keysight network analyzer, power sensor and signal source
RF Power – Measure (Relative)	1.998 77 GHz (Ref -20 dBm) (-9 to -4) dBm (-4 to 1) dBm (1 to 5) dBm	 0.003 9 dB 0.004 7 dB 0.005 7 dB	Comparison to a Keysight network analyzer, power sensor and signal source

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensor - Linearity	50 MHz - 37 dBm (-36 to -30) dBm (-30 to -22) dBm (-22 to -15) dBm (-15 to -11) dBm (-11 to 0) dBm (0 to 9) dBm (9 to 13) dBm (13 to 18) dBm (18 to 21) dBm (21 to 26) dBm (26 to 30) dBm	0.39 % of reading 0.24 % of reading 0.2 % of reading 0.16 % of reading 0.12 % of reading 0.1 % of reading 0.061 % of reading 0.1 % of reading 0.11 % of reading 0.12 % of reading 0.33 % of reading 0.34 % of reading	Comparison to a Keysight network analyzer
Dynamic Range	(47 to 220 GHz) (80 to 130) dB	2.7 dB	Comparison to a Keysight network analyzer, millimeter wave test set
Amplitude Flatness - Measure	0.1 V to 8 V 10 kHz to 10 MHz (10 to 50) MHz 50 MHz (50 to 80) MHz 0.1 V to 5.5 V (80 to 300) MHz (0.3 to 1.1) GHz 0.01 V to 0.1 V (50 to 80) MHz (80 to 300) MHz (0.3 to 1.1) GHz	 0.025 dB 0.028 dB 0.018 dB 0.023 dB 0.023 dB 0.033 dB 0.027 dB 0.032 dB 0.034 dB	Comparison to a power sensor AC measurement standard and a Keysight 3458A multimeter
Amplitude Modulation Distortion - Measure	500 kHz to 50 GHz (0.01 to 0.1) % Distortion (0.1 to 0.3) % Distortion (0.3 to 15) % Distortion	0.52% of reading + 0.001 1 % Distortion 1 % of reading + 0.000 63 % Distortion 1.2 % distortion	Comparison to a Keysight signal analyzer

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Measure	2 MHz to 3.6 GHz (0.2 to 100) (100 to 2 000) (3.6 to 8.4) GHz (0.2 to 100) (100 to 2 000) (8.4 to 17.1) GHz (0.2 to 100) (100 to 2 000) (17.1 to 34.5) GHz (0.2 to 100) (100 to 2 000) (34.5 to 50) GHz (0.2 to 100) (100 to 2 000)	0.35 % of reading + 0.2 %*M* 0.8 %M 0.7 % of reading + 0.2 %*M* 2 %M 0.7 % of reading + 0.3 %*M* 2.5 %M 0.8 % of reading + 0.3 %*M* 3 %M 1.4 % of reading + 0.5 %*M* 4 %M	Comparison to a Keysight signal analyzer
Frequency Modulation Distortion - Measure	500 kHz to 50 GHz (0.01 to 15) % Distortion	2.3 % Distortion	Comparison to a Keysight signal analyzer
Phase Modulation Distortion - Measure	500 kHz to 50 GHz (0.01 to 15) % Distortion	2.3 % Distortion	Comparison to a Keysight signal analyzer
Phase Modulation – Measure	(0.2 to 1) rad 100 kHz to 3.6 GHz (3.6 to 17.1) GHz (17.1 to 34.5) GHz (34.5 to 50) GHz (1 to 10) rad 100 kHz to 3.6 GHz (3.6 to 17.1) GHz (17.1 to 34.5) GHz (34.5 to 50) GHz	0.1% of reading + 0.001 rad 0.1% of reading + 0.002 rad 0.1% of reading + 0.002 5 rad 0.1% of reading + 0.004 9 rad 0.008 1 % of reading + 0.002 rad 0.015 % of reading + 0.003 rad 0.02 % of reading + 0.003 5 rad 0.058 % of reading + 0.005 8 rad	Comparison to a Keysight signal analyzer
Phase Modulation Frequency Response - Measure	80 Hz to 100 kHz Deviation 4 rad 100 Hz to 100 kHz Deviation 1 rad	0.057 dB 0.14 dB	Comparison to a Keysight signal analyzer and a Keysight 3458A multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Modulation – Measure GSM EDGE	(0.46 to 2.7) GHz EDGE: residual EVM (0 to 1.5) % GSM: residual phase (0 to 1)° GSM: peak phase (0 to 3)°	0.015 %EVM 0.01° 0.12°	Comparison to a Keysight signal analyzer
Digital Modulation – Measure CDMA2000 IS95 1xEV-DO	Residual EVM (0 to 2) % EVM (0.8 to 2.1) GHz	0.023 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure W-CDMA	Residual EVM (0 to 2) % EVM (0.8 to 2.2) GHz	0.025 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure BPSK	Residual EVM (0 to 2.5) % EVM ≤ 3 GHz (3 to 32) GHz (32 to 44) GHz	 0.02 % EVM 0.055 % EVM 0.07 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure QPSK	Residual EVM (0 to 2.5) % EVM ≤ 3 GHz (3 to 6) GHz (6 to 32) GHz (32 to 44) GHz	 0.02 % EVM 0.026 % EVM 0.05 % EVM 0.065 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure π/4 DQPSK	Residual EVM (0 to 2.5) % EVM ≤ 1 GHz (1 to 2) GHz (2 to 3) GHz (3 to 4) GHz (4 to 6) GHz	 0.025 % EVM 0.046 % EVM 0.059 % EVM 0.11 % EVM 0.059 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure 16, 64 and 256 QAM	Residual EVM (0 to 2.5) % EVM ≤ 3 GHz (3 to 6) GHz (6 to 32) GHz (32 to 44) GHz	 0.015 % EVM 0.017 % EVM 0.03 % EVM 0.045 % EVM	Comparison to a Keysight signal analyzer

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Modulation – Measure 2FSK (including DECT)	Shift Error or Deviation (0 to 4) % EVM ≤ 3 GHz (3 to 6) GHz (0 to 10) kHz DECT - kHz	 0.049 % 0.048 % 0.12 % of deviation	Comparison to a Keysight signal analyzer
Digital Modulation – Measure NADC	Residual EVM (0 to 2) % EVM (350 to 950) MHz	 0.042 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure PDC	Residual EVM (0 to 2) % EVM (350 to 1501) MHz	 0.055 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure PHS	Residual EVM (0 to 2) % EVM (0.35 to 2) GHz	 0.035 % EVM	Comparison to a Keysight signal analyzer
Digital Modulation – Measure TETRA	Residual EVM (0 to 2) % EVM 350 MHz to 1 GHz	 0.044 % EVM	Comparison to a Keysight signal analyzer
CISPR Quasi-Peak Absolute Amplitude	Band A, B, C	0.28 dB	Comparison to pulse generator
CISPR Quasi-Peak Detector Variation	Band A, B, C, D	0.12 dB	Comparison to pulse generator
CISPR Response to Pulses Peak Detector	Band A, B Band C, D	0.33 dB 0.3 dB	Comparison to pulse generator
CISPR Response to Pulses Average Detector	Band A Band B Band C, D	0.33 dB 0.35 dB 0.32 dB	Comparison to pulse generator
Distortion Measure	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	Comparison to an audio analyzer
Excess Noise Ratio - Measure	(5 to 22) dB (0.01 to 8) GHz (8 to 18) GHz (18 to 28) GHz (28 to 40) GHz (40 to 50) GHz	 0.055 dB 0.035 dB 0.059 dB 0.078 dB 0.089 dB	Comparison to a noise source

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Excess Noise Ratio - Measure Cold Source Method	(5 to 22) dB (0.5 to 6) GHz (6 to 18) GHz (18 to 26.5) GHz (26.5 to 33) GHz (33 to 36) GHz (36 to 39) GHz (39 to 40) GHz (40 to 48) GHz (48 to 50) GHz (50 to 60) GHz (60 to 64) GHz (64 to 65) GHz (65 to 67) GHz	 0.1 dB 0.11 dB 0.13 dB 0.14 dB 0.15 dB 0.16 dB 0.17 dB 0.2 dB 0.21 dB 0.27 dB 0.29 dB 0.31 dB 0.29 dB	Comparison to a Keysight network analyzer, and a power Sensor
Phase Noise – Measure	50 kHz to 54 GHz ≥ -187 dBc/Hz ≤ 10 Hz ≤ 1 MHz ≤ 100 MHz	 2 dB 1.8 dB 3.6 dB	Comparison to a phase noise measurement system
Phase Noise – Source	1 GHz ≥ -167 dBc/Hz (10 to 100) Hz (0.1 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	 0.5 dB 0.36 dB 0.48 dB 0.53 dB	Comparison to an ultra-low noise reference source
Phase Noise – Source	70 MHz to 1 GHz >-105 dBc/Hz >-120 dBc/Hz >-130 dBc/Hz >-130 dBc/Hz > -145 dBc/Hz	 0.37 dB 0.37 dB 0.37 dB 0.4 dB 0.40 dB	Comparison to a low noise signal generator
Noise Voltage - Measure	20 MHz or 1 GHz peak to peak (>0 to 2) mV 2 mV to 2 V 20 MHz rms (>0 to 0.5) mV (0.5 to 1) mV 1 mV to 1 V	 0.07 mV 1.9 % of reading 21 % of reading 6.6 % of reading 1.9 % of reading	Comparison to a differential amplifier and a voltmeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Noise Current - Measure	20 MHz rms Up to 10 µA (10 to 100) µA (0.1 to 250) mA	 33 mA/A + 5.7 µA 0.11 A/A + 4.2 µA 0.15 A/A	Comparison to an oscilloscope and a current probe
Antenna Gain On Axis Gain, Antenna factor Dish Antenna	 (5 to 25) dB (0.2 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz (140 to 220) GHz (5 to 45) dB (12.4 to 110) GHz	 0.15 dB 0.2 dB 0.2 dB 0.25 dB 0.3 dB 0.5 dB 0.31 dB	Comparison to Keysight network analyzer, 8530A Receiver, 8517B S-Parameter Test Set, V85104A, W85104A Modules, Scientific Atlanta 12-2.9, 12-5.8, 12-8.2, 12-12, 12-18, 12-26, 12-33 Narda 642, 643, 645 TRG 861B/383, Ab90 FXR M638A Hughes 45826H-1020 TRG/Custom Microwave Wr-5 Gain Horns, X, Ku, K, Ka, Q, V, W Probes Leica LT300 Laser Tracker
Directional/ SWR Bridge Reflections/ Directivity Insertion Loss/Linearity	(0 to 60) dB 5 Hz to 110 GHz (0 to 60) dB 5 Hz to 67 GHz (67 to 110) GHz	0.03 Γ 1 dB 0.1 dB 0.1 dB	Comparison to Agilent/HP 8757D Network Analyzer, 355C/D Step Attenuators, 85054B Calibration Kit, 8481D opt H70, 8487A, VA8486A, W8486 Power Sensors, E8361C Network Analyzer, V85104A, W85104A Modules

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Directional Coupler Main Line Loss Coupling Loss Reflection Directivity	 5 Hz to 67 GHz (67 to 110) GHz 5 Hz to 67 GHz (67 to 110) GHz 5 Hz to 110 GHz 5 Hz to 110 GHz	 0.1 dB 0.2 dB 0.1 dB 0.2 dB 0.03 Γ 1 dB	Comparison to Agilent/HP E8361A Network Analyzer, 8510C Network Analyzer, 8517B S-Parameter Test Set V85104A, W85104A Modules, E8361C Network Analyzer, 85054B Calibration Kit, TRL Calibration Kit
Gaussian Noise Noise Output Power Signal Path Response	(-100 to +20) dBm 100 kHz to 18 GHz (18 to 40) GHz (-60 to +20) dB 9 kHz to 3 GHz (3 to 22) GHz (22 to 50) GHz	 0.05 dB 0.11 dB 1 dB 2.6 dB 3.5 dB	Comparison to Agilent/HP 8482A/D, 8481A/D, 8485A/D, 8487 A/D Power Sensors, Agilent/HP 8565E Spectrum Analyzer
Gaussian Noise Attenuation	(0 to 10) dB (10 to 30) dB (40 to 50) dB	0.1 dB 0.2 dB 0.3 dB	Comparison to Agilent E4448A Spectrum Analyzer
Harmonic Mixer Conversion Loss	(0 to 50) dB (18 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	 1.8 dB 1.8 dB 1.8 dB 1.8 dB 1.8 dB	Comparison to Agilent/HP 8563E Spectrum Analyzer, 8485A, 8487A, V8486A, W8486A Power Sensors Hughes/HP/Millitech Thermistor mounts
RF Power – Absolute WR-42 WR-28 WR-22 WR-15 WR-10	(-30 to +20) dBm (18 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz (50 to 75) GHz (75 to 110) GHz	 1.1 % of reading 1.1 % of reading 1.5 % of reading 2 % of reading 2.5 % of reading	Comparison to Hughes/Millitech/ Agilent/HP Thermistor Mounts, V8486A, W8486A, E4419B

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Sensor Characterization Waveguide			Comparison to Waveguide Thermistor/ Thermocouple or Diode Power Sensors
S Band	(2.6 to 3.95) GHz	0.9 dB	
G Band	(3.95 to 5.85) GHz	0.9 dB	
H Band	(7.05 to 10) GHz	0.9 dB	
X Band	(8.2 to 12.4) GHz	1.1 dB	
Ku band	(12.4 to 18) GHz	1.1 dB	
K Band	(18 to 26.5) GHz	1.2 dB	
Ka Band	(26.5 to 40) GHz	1.1 % of reading	
Q Band	(33 to 50) GHz	1.8 % of reading	
Power Sensor Characterization V Band	(50 to 52) GHz	2.5 % of reading	Comparison to Waveguide Thermistor/ Thermocouple or Diode Power Sensors
	(52 to 56) GHz	2.4 % of reading	
	(56 to 64) GHz	2.7 % of reading	
	(65 to 75) GHz	2.4 % of reading	
Power Sensor Characterization W Band	(75 to 76) GHz	3.2 % of reading	Comparison to Waveguide Thermistor/ Thermocouple or Diode Power Sensors
	(76 to 77) GHz	3 % of reading	
	(77 to 80) GHz	2.9 % of reading	
	(80 to 81) GHz	4.6 % of reading	
	(81 to 110) GHz	3.1 % of reading	
Power Sensor Characterization (75 Ω)	100 kHz to 2 GHz	1.3 % of reading	Comparison to Tegam F1119, Tegam 1804 Power Standards, NIST CN Mount, Agilent 11852B
	(2 to 4.2) GHz	1.5 % of reading	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameters Waveguide Reflection: S11 and S22 Reflection Coefficient	(2.6 to 12.4) GHz (0 to 1) lin (-180 to 180)° (12.4 to 26.5) GHz (0 to 1) lin (-180 to 180)° (26.5 to 50) GHz (0 to 1) lin (-180 to 180)° (50 to 75) GHz (0 to 1) lin (-180 to 180)° (75 to 110) GHz (0 to 1) lin (-180 to 180)° (140 to 220) GHz (0 to 1) lin (-180 to 180)°	 0.009 0.5° 0.01 0.5° 0.006 0.3° 0.018 1.1° 0.024 1.4° 0.048 10°	Comparison to Agilent/HP 8510C Network Analyzer, 8517B S-Parameter Test Set, E8361A Network Analyzer, V85104A, W85104A Modules. PSNA TRL Calibration Kit, Oleson V05 VNA1-T/R WR28 S-Parameter Ref Standards WR22 S-Parameter Ref Standards WR15 S-Parameter Ref Standards WR10 S-Parameter Ref Standards

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scattering Parameters Waveguide	(2.6 to 12.4) GHz (0 to 30) dB (-180 to 180)° (30 to 50) dB (-180 to 180) ° (0 to 30) dB (-180 to 180)° (12.4 to 18) GHz (30 to 50) dB (-180 to 180)° (0 to 30) dB (-180 to 180)° (18 to 26.5) GHz (30 to 50) dB (-180 to 180)° (0 to 30) dB (-180 to 180)° (26.5 to 40) GHz (30 to 50) dB (-180 to 180)° (0 to 30) dB (-180 to 180)°	 0.02 dB 0.6° 0.08 dB 0.7° 0.02 dB 0.7° 0.09 dB 0.7° 0.05 dB 1.8° 0.08 dB 1.8° 0.03 dB 1.2° 0.09 dB 1.4° 0.03 dB 1.8°	Comparison to Agilent/HP 8510C Network Analyzer, 8517B S-Parameter Test Set, E8361A Network Analyzer, V85104A, W85104A Modules, PSNA TRL Calibration Kit, Oleson V05 VNA1-T/R WR28 S-Parameter Ref Standards WR22 S-Parameter Ref Standards WR15 S-Parameter Ref Standards WR10 S-Parameter Ref Standards
Scattering Parameters Waveguide	(40.0 to 50.0) GHz (30 to 50) dB (-180 to 180)° (0 to 30) dB (-180 to 180)° (50 to 75.0) GHz (30 to 50) dB (-180 to 180)° (0 to 30) dB (-180 to 180)° (75 to 110) GHz (30 to 50) dB (-180 to 180)° (0 to 30) dB (-180 to 180)° (140 to 220) GHz (30 to 40) dB (-180 to 180)°	 0.09 dB 2.1° 0.05 dB 3.3° 0.1 dB 3.4° 0.06 dB 4.6° 0.11 dB 5.4° 0.07 dB 9.3° 1 dB 14°	Comparison to Agilent/HP 8510C Network Analyzer, 8517B S-Parameter Test Set, E8361A Network Analyzer, V85104A, W85104A Modules, PSNA TRL Calibration Kit, Oleson V05 VNA1-T/R WR28 S-Parameter Ref Standards WR22 S-Parameter Ref Standards WR15 S-Parameter Ref Standards WR10 S-Parameter Ref Standards

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

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Parameter/Equipment	Attenuation – Source										
Reference Standard, Method, and/or Equipment	Comparison to an attenuator										
Expanded Uncertainty of Measurement (+/-)											
Range	1 dB	2 dB	3 dB	4 dB	5 dB	6 dB	7 dB	8 dB	9 dB	10 dB	11 dB
20 Hz to 50 MHz	0.002 8 dB	0.002 8 dB	0.002 8 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB	0.002 9 dB
50 MHz to 1 GHz	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 3 dB	0.005 4 dB	0.005 4 dB
(1 to 2) GHz	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB	0.006 3 dB
(2 to 4) GHz	0.008 dB	0.008 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB	0.008 1 dB
(4 to 10) GHz	0.013 dB	0.012 dB	0.015 dB	0.014 dB	0.017 dB	0.016 dB	0.015 dB	0.015 dB	0.021 dB	0.013 dB	0.015 dB
(10 to 12.4) GHz	0.021 dB	0.027 dB	0.032 dB	0.027 dB	0.022 dB	0.022 dB	0.019 dB	0.024 dB	0.025 dB	0.036 dB	0.036 dB
(12.4 to 18) GHz	0.034 dB	0.037 dB	0.035 dB	0.033 dB	0.040 dB	0.038 dB	0.035 dB	0.038 dB	0.045 dB	0.042 dB	0.036 dB

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Parameter/Equipment	Attenuation – Source										
Reference Standard, Method, and/or Equipment	Comparison to an attenuator										
Expanded Uncertainty of Measurement (+/-)											
Range	10 dB	20 dB	30 dB	40 dB	50 dB	60 dB	70 dB	80 dB	90 dB	100 dB	110 dB
20 Hz to 50 MHz	0.003 9 dB	0.004 3 dB	0.007 5 dB	0.007 5 dB	0.009 6 dB	0.011 dB	0.016 dB	0.019 dB	0.022 dB	0.032 dB	0.039 dB
50 MHz to 1 GHz	0.005 1 dB	0.004 8 dB	0.005 7 dB	0.006 5 dB	0.019 dB	0.022 dB	0.032 dB	0.039 dB	0.045 dB	0.057 dB	0.074 dB
(1 to 2) GHz	0.006 dB	0.005 9 dB	0.006 dB	0.008 3 dB	0.025 dB	0.029 dB	0.042 dB	0.033 dB	0.058 dB	0.058 dB	0.082 dB
(2 to 4) GHz	0.007 5 dB	0.007 3 dB	0.008 2 dB	0.012 dB	0.034 dB	0.035 dB	0.057 dB	0.035 dB	0.06 dB	0.062 dB	0.086 dB
(4 to 10) GHz	0.01 dB	0.009 8 dB	0.01 dB	0.012 dB	0.038 dB	0.038 dB	0.065 dB	0.038 dB	0.065 dB	0.068 dB	0.093 dB
(10 to 12.4) GHz	0.01 dB	0.009 9 dB	0.01 dB	0.012 dB	0.038 dB	0.038 dB	0.065 dB	0.038 dB	0.065 dB	0.086 dB	0.12 dB
(12.4 to 18) GHz	0.01 dB	0.009 9 dB	0.01 dB	0.012 dB	0.038 dB	0.038 dB	0.065 dB	0.038 dB	0.065 dB	0.17 dB	0.18 dB

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Parameter/ Equipment	RF Power - Measure											
Reference Standard, Method, and/or Equipment	Comparison to a power sensor and a Keysight signal analyzer											
Expanded Uncertainty of Measurement (+/-)												
Range	(-140 to -130) dBm	(-130 to -110) dBm	(-110 to -90) dBm	(-90 to -30) dBm	(-30 to -10) dBm	(-10 to -3) dBm	(-3 to +3) dBm	(3 to 14) dBm	(14 to 20) dBm	(20 to 25) dBm	(25 to 35) dBm	(35 to 44) dBm
(0.9 to 9) kHz	-	-	-	-	0.044 dB	0.044 dB	0.027 dB	0.032 dB	0.043 dB	-	-	-
(9 to 100) kHz	0.17 dB	0.17 dB	0.16 dB	0.16 dB	0.044 dB	0.044 dB	0.027 dB	0.032 dB	0.032 dB	0.034 dB	0.036 dB	-
(0.1 to 10) MHz	0.085 dB	0.071 dB	0.054 dB	0.045 dB	0.043 dB	0.042 dB	0.027 dB	0.032 dB	0.032 dB	0.034 dB	0.037 dB	-
50 MHz	0.079 dB	0.066 dB	0.048 dB	0.037 dB	0.034 dB	0.032 dB	0.02 dB	0.027 dB	0.023 dB	0.024 dB	0.029 dB	-
(10 to 100) MHz	0.081 dB	0.068 dB	0.05 dB	0.04 dB	0.038 dB	0.037 dB	0.027 dB	0.029 dB	0.032 dB	0.034 dB	0.036 dB	0.06 dB
(0.1 to 4) GHz	0.080 dB	0.067 dB	0.049 dB	0.039 dB	0.036 dB	0.035 dB	0.024 dB	0.027 dB	0.037 dB	0.038 dB	0.041 dB	0.057 dB
(4 to 8) GHz	0.081 dB	0.068 dB	0.05 dB	0.04 dB	0.038 dB	0.037 dB	0.027 dB	0.032 dB	0.039 dB	0.041 dB	0.043 dB	0.058 dB
(8 to 18) GHz	0.084 dB	0.071 dB	0.053 dB	0.043 dB	0.040 dB	0.039 dB	0.029 dB	0.035 dB	0.038 dB	0.040 dB	0.042 dB	0.06 dB
(18 to 24) GHz	0.091 dB	0.076 dB	0.069 dB	0.050 dB	0.048 dB	0.047 dB	0.031 dB	0.044 dB	0.053 dB	0.061 dB	0.063 dB	-
(24 to 40) GHz	0.12 dB	0.11 dB	0.1 dB	0.091 dB	0.069 dB	0.069 dB	0.059 dB	0.061 dB	0.068 dB	0.069 dB	0.076 dB	-
(40 to 50) GHz	0.13 dB	0.10 dB	0.098 dB	0.085 dB	0.083 dB	0.083 dB	0.079 dB	0.081 dB	0.086 dB	0.11 dB	0.11 dB	-
(50 to 60) GHz	0.17 dB	0.13 dB	0.12 dB	0.10 dB	0.099 dB	0.099 dB	0.093 dB	0.094 dB	0.099 dB	-	-	-
(60 to 67) GHz	0.52 dB	0.22 dB	0.22 dB	0.21 dB	0.099 dB	0.099 dB	0.093 dB	0.094 dB	0.099 dB	-	-	-
(67 to 80) GHz	-	-	-	-	0.26 dB	0.26 dB	0.26 dB	0.26 dB	0.26 dB	-	-	-
(80 to 90) GHz	-	-	-	-	0.32 dB	0.32 dB	0.32 dB	0.32 dB	0.32 dB	-	-	-
(90 to 100) GHz	-	-	-	-	0.3 dB	0.3 dB	0.3 dB	0.3 dB	0.3 dB	-	-	-
(100 to 110) GHz	-	-	-	-	0.29 dB	0.29 dB	0.29 dB	0.29 dB	0.29 dB	-	-	-

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Parameter/Equipment	Amplitude Modulation Depth - Measure		
Reference Standard, Method, and/or Equipment	Comparison to a Keysight signal analyzer (% indicates % Depth where not specified)		
Frequency Range	**AM Depth**	**Modulation Rate**	**Expanded Uncertainty of Measurement (+/-)**
2 Hz to 50 GHz	(5 to 20) %	10 Hz to 100 kHz	0.11% of reading + 0.0083 %
	(20 to 40) %		0.022% of reading + 0.026 %
	(40 to 50) %		0.0027% of reading + 0.034 %
	(50 to 60) %		-0.013% of reading + 0.043 %
	(60 to 75) %		-0.041% of reading + 0.06 %
	(75 to 90) %		-0.091% of reading + 0.099 %
	(90 to 95) %		0.01 %
	(95 to 98) %		0.0051 %
100 kHz to 13.6 GHz	(5 to 50) %	10 Hz to 25 kHz	0.1% of reading
	(5 to 30) %	(25 to 50) kHz	0.16% of reading
	(5 to 20) %	(50 to 100) kHz	0.22% of reading
	(5 to 95) %	(100 to 250) kHz	0.32% of reading
		(250 to 500) kHz	0.5% of reading
		(0.5 to 1) MHz	0.71% of reading
		1 MHz	1% of reading
(13.5 to 17.1) GHz	(5 to 50) %	10 Hz to 10 kHz	0.1% of reading
	(5 to 35) %	(10 to 25) kHz	0.14% of reading
	(5 to 20) %	(25 to 50) kHz	0.22% of reading
	(5 to 15) %	(50 to 100) kHz	0.32% of reading
	(5 to 95) %	(100 to 250) kHz	0.45% of reading
		(250 to 500) kHz	0.71% of reading
		(0.5 to 1) MHz	1% of reading
		1 MHz	1.4% of reading
(17 to 34.5) GHz	(5 to 50) %	10 Hz to 5 kHz	0.1% of reading
	(5 to 55) %	(5 to 10) kHz	0.095% of reading
	(5 to 30) %	(10 to 25) kHz	0.15% of reading
	(5 to 20) %	(25 to 50) kHz	0.25% of reading
	(5 to 10) %	(50 to 100) kHz	0.36% of reading
	(5 to 95) %	(100 to 250) kHz	0.52% of reading
		(250 to 500) kHz	0.84% of reading
		(0.5 to 1) MHz	1.2% of reading
		1 MHz	1.7% of reading
(34.4 to 50) GHz	(5 to 15) %	10 Hz to 5 kHz	0.25% of reading
	(5 to 15) %	(5 to 10) kHz	0.31% of reading
	(5 to 10) %	(10 to 25) kHz	0.37% of reading
	(5 to 95) %	(100 to 250) kHz	1.5% of reading
		(250 to 500) kHz	3.3% of reading
		(0.5 to 1) MHz	6.3% of reading
		1 MHz	12% of reading

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Parameter/Equipment	Frequency Modulation Deviation - Measure			
Reference Standard, Method, and/or Equipment	Comparison to a Keysight signal analyzer			
Frequencies	**Deviation Range**	**Modulation Rate**	**Modulation index**	**Expanded Uncertainty of Measurement (+/-)**
100 kHz to 3.6 GHz	20 Hz to 2 MHz	10 Hz to 500 kHz	$\beta \geq 0.5$	0.2 % of reading
100 kHz to 3.6 GHz	10 Hz to 10 MHz	20 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % of reading
100 kHz to 3.6 GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2 % of reading
100 kHz to 3.6 GHz	10 Hz to 50 kHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % of reading
100 kHz to 3.6 GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % of reading
100 kHz to 3.6 GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % of reading
(3.5 to 8.4) GHz	20 Hz to 1 MHz	10 Hz to 500 kHz	$\beta \geq 0.5$	0.21 % of reading
(3.5 to 8.4) GHz	10 Hz to 5 MHz	20 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % of reading
(3.5 to 8.4) GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2.2 % of reading
(3.5 to 8.4) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % of reading
(3.5 to 8.4) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % of reading
(3.5 to 8.4) GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % of reading
(8.3 to 13.6) GHz	20 Hz to 2 MHz	10 Hz to 500 kHz	$\beta \geq 0.5$	0.21 % of reading
(8.3 to 13.6) GHz	10 Hz to 10 MHz	50 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % of reading
(8.3 to 13.6) GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2.2 % of reading
(8.3 to 13.6) GHz	10 Hz to 500 kHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % of reading
(8.3 to 13.6) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % of reading
(8.3 to 13.6) GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % of reading
(13.5 to 17.1) GHz	20 Hz to 1 MHz	10 Hz to 200 kHz	$\beta \geq 0.5$	0.21 % of reading
(13.5 to 17.1) GHz	10 Hz to 5 MHz	20 Hz to 1 MHz	$\beta \geq 0.2$	0.7 % of reading
(13.5 to 17.1) GHz	10 Hz to 16 MHz	50 Hz to 1 MHz	$\beta \geq 0.05$	2.2 % of reading
(13.5 to 17.1) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.025$	5.2 % of reading
(13.5 to 17.1) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	10 % of reading
(13.5 to 17.1) GHz	10 Hz to 20 kHz	500 Hz to 1 MHz	$\beta \geq 0.01$	20 % of reading
(17 to 26.5) GHz	50 Hz to 400 kHz	10 Hz to 50 kHz	$\beta \geq 0.8$	0.31 % of reading
(17 to 26.5) GHz	20 Hz to 5 MHz	10 Hz to 1 MHz	$\beta \geq 0.2$	0.9 % of reading
(17 to 26.5) GHz	20 Hz to 10 MHz	100 Hz to 1 MHz	$\beta \geq 0.08$	3.3 % of reading
(17 to 26.5) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.04$	6.3 % of reading
(17 to 26.5) GHz	10 Hz to 40 kHz	100 Hz to 1 MHz	$\beta \geq 0.02$	12 % of reading
(17 to 26.5) GHz	10 Hz to 1 kHz	500 Hz to 100 kHz	$\beta \geq 0.01$	30 % of reading
(26.4 to 34.5) GHz	50 Hz to 400 kHz	10 Hz to 50 kHz	$\beta \geq 0.8$	0.31 % of reading

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Parameter/Equipment	Frequency Modulation Deviation - Measure			
Reference Standard, Method, and/or Equipment	Comparison to a Keysight signal analyzer			
Frequencies	**Deviation Range**	**Modulation Rate**	**Modulation index**	**Expanded Uncertainty of Measurement (+/-)**
(26.4 to 34.5) GHz	20 Hz to 5 MHz	10 Hz to MHz	$\beta \geq 0.2$	0.9 % of reading
(26.4 to 34.5) GHz	20 Hz to 10 MHz	100 Hz to 1 MHz	$\beta \geq 0.08$	3.3 % of reading
(26.4 to 34.5) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.04$	6.3 % of reading
(26.4 to 34.5) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.02$	12 % of reading
(26.4 to 34.5) GHz	10 Hz to 1 kHz	500 Hz to 100 kHz	$\beta \geq 0.01$	30 % of reading
(34.4 to 50) GHz	50 Hz to 100 kHz	10 Hz to 20 kHz	$\beta \geq 0.8$	0.32 % of reading
(34.4 to 50) GHz	20 Hz to 500 kHz	10 Hz to 200 kHz	$\beta \geq 0.2$	0.9 % of reading
(34.4 to 50) GHz	20 Hz to 2 MHz	20 Hz to 1 MHz	$\beta \geq 0.08$	3.3 % of reading
(34.4 to 50) GHz	10 Hz to 5 MHz	50 Hz to 1 MHz	$\beta \geq 0.04$	6.4 % of reading
(34.4 to 50) GHz	10 Hz to 16 MHz	100 Hz to 1 MHz	$\beta \geq 0.02$	12 % of reading
(34.4 to 50) GHz	10 Hz to 16 MHz	500 Hz to 200 kHz	$\beta \geq 0.01$	30 % of reading

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Parameter/Equipment	Voltage Reflection Coefficient S11/S22 - Magnitude [3]									
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer									
Expanded Uncertainty of Measurement (+/-)										
Range	0 to 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
DC to 10 MHz	0.000 17	0.000 23	0.000 3	0.000 37	0.000 41	0.000 45	0.000 48	0.000 51	0.000 53	0.000 22
10 MHz to 2 GHz	0.000 18	0.000 23	0.000 31	0.000 38	0.000 43	0.000 47	0.000 5	0.000 52	0.000 53	0.000 22
(2 to 8) GHz	0.000 56	0.000 61	0.000 71	0.000 76	0.000 75	0.000 72	0.000 66	0.000 59	0.000 55	0.000 23
(8.0 to 20) GHz	0.000 56	0.000 61	0.000 7	0.000 8	0.000 9	0.001	0.000 97	0.000 94	0.000 94	0.000 89
(20 to 26.5) GHz	0.000 89	0.000 96	0.001 1	0.001 2	0.001 4	0.001 6	0.001 5	0.001 4	0.001 4	0.001 4
(26.5 to 33) GHz	0.000 89	0.000 98	0.001 2	0.001 4	0.001 7	0.001 8	0.001 6	0.001 5	0.001 4	0.001 4
(33 to 40) GHz	0.000 9	0.000 99	0.001 2	0.001 5	0.001 7	0.002	0.001 8	0.001 6	0.001 5	0.001 5
(40 to 45) GHz	0.001 4	0.001 5	0.001 7	0.001 9	0.002 1	0.002 4	0.002 3	0.002 1	0.002 1	0.002 1
(45 to 50) GHz	0.001 4	0.001 5	0.001 7	0.001 8	0.002	0.002 2	0.002 4	0.002 3	0.002 1	0.002 1
(50 to 60) GHz	0.002 5	0.002 6	0.002 8	0.003 1	0.003 4	0.003 7	0.004	0.004 3	0.004 7	0.005 3
(60 to 67) GHz	0.002 5	0.002 7	0.002 9	0.003 2	0.003 7	0.004 2	0.004 7	0.005 1	0.005 7	0.006 4
(67 to 75) GHz	0.005 4	0.005 9	0.006 1	0.006 3	0.006 5	0.006 8	0.007 1	0.007 5	0.007 8	0.008 2

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Parameter/Equipment	Voltage Reflection Coefficient S11/S22 - Magnitude [3]									
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer									
Expanded Uncertainty of Measurement (+/-)										
(75 to 110) GHz	0.003 5	0.004	0.004 2	0.004 6	0.004 9	0.005 3	0.005 8	0.006 3	0.006 9	0.007 5
(110 to 120) GHz	0.03	0.033	0.036	0.039	0.04	0.047	0.052	0.057	0.063	0.07

Electrical - RF Microwave

Parameter/Equipment	Voltage Reflection Coefficient S11/S22 – Phase									
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer									
Expanded Uncertainty of Measurement (+/-)										
Range	0 to 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
DC to 10 MHz	0.13°	0.086°	0.070°	0.059°	0.052°	0.046°	0.041°	0.038°	0.035°	0.013°
10 MHz to 2 GHz	0.13°	0.089°	0.073°	0.062°	0.054°	0.048°	0.043°	0.038°	0.035°	0.013°
(2.0 to 8.0) GHz	0.37°	0.22°	0.16°	0.12°	0.094°	0.076°	0.063°	0.05°	0.042°	0.026°
(8.0 to 20) GHz	0.39°	0.26°	0.21°	0.16°	0.13°	0.11°	0.092°	0.081°	0.071°	0.065°
(20 to 26.5) GHz	0.58°	0.40°	0.36°	0.29°	0.23°	0.2°	0.17°	0.16°	0.15°	0.15°
(26.5 to 33) GHz	0.57°	0.36°	0.31°	0.0°	0.29°	0.23°	0.19°	0.16°	0.14°	0.14°
(33 to 40) GHz	0.58°	0.39°	0.34°	0.32°	0.29°	0.24°	0.19°	0.16°	0.14°	0.13°
(40 to 45) GHz	0.86°	0.50°	0.39°	0.34°	0.32°	0.31°	0.31°	0.27°	0.26°	0.26°
(45 to 50) GHz	0.88°	0.55°	0.46°	0.43°	0.42°	0.36°	0.31°	0.28°	0.26°	0.26°
(50 to 60) GHz	1.5º	0.82°	0.63°	0.55°	0.52°	0.51°	0.52°	0.53°	0.5°	0.47°
(60 to 67) GHz	1.5º	0.84°	0.65°	0.58°	0.55°	0.54°	0.54°	0.53°	0.5°	0.47°
(67 to 75) GHz	3.2°	1.7°	1.2°	0.90°	0.75°	0.65°	0.58°	0.53°	0.5°	0.47°
(75 to 110) GHz	2.1°	1.1°	0.81°	0.65°	0.57°	0.51°	0.48°	0.45°	0.44°	0.43°
(110 to 120) GHz	18°	9.6°	6.9°	5.6°	4.9°	4.5°	4.3°	4.1°	4.0°	4.0°

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Parameter/Equipment	Transmission S12/S21 – Magnitude								
Reference Standard, Method, and/or Equipment	Comparison to a Keysight network analyzer								
Expanded Uncertainty of Measurement (+/-)									
Range	(0 to 3) dB	(3 to 6) dB	(6 to 10) dB	(10 to 20) dB	(20 to 30) dB	(30 to 40) dB	(40 to 50) dB	(50 to 60) dB	(60 to 70) dB
DC to 10 MHz	0.000 57 dB	0.005 8 dB	0.007 3 dB	0.009 3 dB	0.013 dB	0.017 dB	0.02 dB	0.026 dB	0.044 dB
10 MHz to 2 GHz	0.000 3 dB	0.005 3 dB	0.006 1 dB	0.007 2 dB	0.01 dB	0.014 dB	0.017 dB	0.021 dB	0.028 dB
(2.0 to 8.0) GHz	0.000 3 dB	0.005 3 dB	0.006 1 dB	0.007 2 dB	0.01 dB	0.014 dB	0.017 dB	0.021 dB	0.028 dB
(8.0 to 20) GHz	0.000 3 dB	0.005 3 dB	0.006 1 dB	0.007 2 dB	0.01 dB	0.015 dB	0.018 dB	0.021 dB	0.026 dB
(20 to 26.5) GHz	0.009 3 dB	0.01 dB	0.011 dB	0.012 dB	0.014 dB	0.016 dB	0.019 dB	0.022 dB	0.027 dB
(26.5 to 33) GHz	0.014 3 dB	0.015 dB	0.015 dB	0.016 dB	0.017 dB	0.019 dB	0.022 dB	0.028 dB	0.051 dB
(33 to 40) GHz	0.020 1 dB	0.021 dB	0.021 dB	0.021 dB	0.022 dB	0.026 dB	0.031 dB	0.036 dB	0.056 dB
(40 to 45) GHz	0.022 dB	0.022 dB	0.023 dB	0.023 dB	0.024 dB	0.028 dB	0.037 dB	0.044 dB	0.08 dB
(45 to 50) GHz	0.023 1 dB	0.024 dB	0.024 dB	0.024 dB	0.025 dB	0.029 dB	0.037 dB	0.045 dB	0.08 dB
(50 to 60) GHz	0.027 9 dB	0.028 dB	0.028 dB	0.029 dB	0.03 dB	0.031 dB	0.033 dB	0.042 dB	0.085 dB
(60 to 67) GHz	0.034 dB	0.034 dB	0.034 dB	0.035 dB	0.035 dB	0.037 dB	0.039 dB	0.048 dB	0.096 dB
(67 to 75) GHz	0.043 dB	0.046 dB	0.048 dB	0.051 dB	0.057 dB	0.064 dB	0.071 dB	0.078 dB	0.088 dB
(75 to 100) GHz	0.038 dB	0.041 dB	0.044 dB	0.046 dB	0.053 dB	0.06 dB	0.067 dB	0.074 dB	0.084 dB
(100 to 110) GHz	0.044 dB	0.048 dB	0.051 dB	0.054 dB	0.061 dB	0.068 dB	0.075 dB	0.082 dB	0.098 dB
(110 to 120) GHz	0.44 dB	0.44 dB	0.44 dB	0.44 dB	0.45 dB	0.45 dB	0.46 dB	0.47 dB	0.48 dB

Electrical - RF Microwave El Segundo, CA

Parameter/Equipment	Transmission S12/S21 - Phase								
Reference Standard, Method, and/or Equipment	Comparison to Keysight network analyzer								
Expanded Uncertainty of Measurement (+/-)									
Range	(0 to 3) dB	(3 to 6) dB	(6 to 10) dB	(10 to 20) dB	(20 to 30) dB	(30 to 40) dB	(40 to 50) dB	(50 to 60) dB	(60 to 70) dB
DC to 10 MHz	0.004 3°	0.039°	0.048°	0.061°	0.084°	0.006 2°	0.007 9°	0.008 2°	0.008 5°
10 MHz to 2 GHz	0.002 9°	0.035°	0.04°	0.048°	0.067°	0.0062°	0.007 8°	0.007 9°	0.008 1°
(2 to 8) GHz	0.002 9°	0.035°	0.04°	0.048°	0.067°	0.006 8°	0.008 2°	0.008 4°	0.008 5°
(8 to 20) GHz	0.032°	0.035°	0.04°	0.048°	0.067°	0.00 91°	0.01°	0.01°	0.01°
(20 to 26.5) GHz	0.15°	0.15°	0.15°	0.15°	0.16°	0.011°	0.012°	0.012°	0.012°
(26.5 to 33) GHz	0.18°	0.18°	0.19°	0.19°	0.19°	0.015°	0.016°	0.016°	0.016°

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Parameter/Equipment	Transmission S12/S21 - Phase								
Reference Standard, Method, and/or Equipment	Comparison to Keysight network analyzer								
Expanded Uncertainty of Measurement (+/-)									
Range	(0 to 3) dB	(3 to 6) dB	(6 to 10) dB	(10 to 20) dB	(20 to 30) dB	(30 to 40) dB	(40 to 50) dB	(50 to 60) dB	(60 to 70) dB
(33 to 40) GHz	0.23°	0.24°	0.24°	0.24°	0.24°	0.25°	0.26°	0.28°	0.4°
(40 to 45) GHz	0.29°	0.29°	0.29°	0.29°	0.3°	0.31°	0.32°	0.35°	0.56°
(45 to 50) GHz	0.31°	0.31°	0.31°	0.31°	0.32°	0.32°	0.33°	0.37°	0.57°
(50 to 60) GHz	0.28°	0.38°	0.38°	0.38°	0.38°	0.39°	0.4°	0.43°	0.65°
(60 to 67) GHz	0.28°	0.43°	0.43°	0.43°	0.44°	0.44°	0.45°	0.49°	0.73°
(50 to 75) GHz	0.28°	0.3°	0.32°	0.34°	0.38°	0.42°	0.47°	0.52°	0.58°
(75 to 100) GHz	0.25°	0.27°	0.29°	0.31°	0.35°	0.4°	0.44°	0.49°	0.56°
(100 to 110) GHz	0.29°	0.32°	0.34°	0.36	0.4°	0.45°	0.49°	0.55°	0.65°
(110 to 120) GHz	3°	3°	3°	3°	3°	3.1°	3.1°	3.2°	3.3°

Length – Dimensional Metrology El Segundo, CA

Parameter/Equipment	**Range**	**Expanded Uncertainty of Measurement (+/-)**	**Reference Standard, Method, and/or Equipment**
Calipers [3]	(0 to 12) in (>12 to 60) in	(310 + 2*L*) µin (310 + 4*L*) µin	Comparison to gage blocks
Connector Gage Masters Flatness Step	 to 0.001 in 0 to 0.35 in	 25 µin 150 µin	Comparison to an optical flat electronic indicator
Cylindrical Plug Gages [3]	to 4 in	(20 + 10*D*) µin	Comparison to gage blocks
Cylindrical Ring Gages [3]	to 6 in	(6 + 12*L*) µin	Comparison to gage blocks
Dial and Digital Indicators Digital Indicators Dial Indicators	 (0 to 1) in (1 to 2) in (2 to 6) in (0 to 1) in (1 to 6) in	 35 µin 38 µin 80 µin 64 µin 621 µin	Comparison to gage blocks
Electronic Gage Amplifiers	(>0 to 0.1) in	10 µin	Comparison to gage blocks

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Length – Dimensional Metrology El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [3]	(0.01 to 4) in Length Parallelism/VIL	(2 + 1*L*) µin 1.2 µin	Electromechanical comparison
Height Gages [3]	(>0 to 48) in	(310 + 4*L*) µin	Comparison to gage blocks
Length – Non-Contact Measurement [3]	(>0 to 12) in (12 to 60) in	(10 + 10*L*) µin (100 + 5*L*) µin	Comparison to laser interferometer
Outside Micrometer Length [3]	(0 to 12) in (>12 to 48) in	(30 + 6*L*) µin (30 + 7*L*) µin	Comparison to gage blocks
Outside Micrometer Anvil Flatness	(>0 to 48) µin	6 µin	Comparison to optical flats
Inside Micrometer Length [3]	(>0 to 12) in	(30 + 6*L*) µin	Comparison to gage blocks
Depth Micrometer Length [3]	(>0 to 12) in	(30 + 6*L*) µin	Comparison to gage blocks
Thread Measuring Wires	(4 to 80) TPI	17 µin	Mechanical comparison
Torque Moment Arms and Wheels [3]	Up to 48 in	(150 + 50*L*) µin	Comparison to gage blocks, electronic amplifier
Alignment Collimator	(-30 to 30) arc s 2 ft to Infinity Focus	1 arc s	Comparison to optical wedge
Autocollimators	(>0 to 1 800) arc s	0.15 % of reading + 0.3 arc s	Comparison to laser interferometer
Angle Generator	(0.05 to 100) arc s (100 to 180) arc s (180 to 1 000) arc s	0.4 arc s 0.6 arc s 0.33% of reading	Comparison to laser interferometer
Angle Gage Blocks	1 arcsec to 45 °	1.1 arc s	Comparison to angle blocks; autocollimator
Electronic Levels	(>0 to 200) arc s (200 to 1 000) arc s	0.8 arc s 2.9 arc s	Comparison to laser interferometer
Bubble Levels [3]	(>0 to 15) in	0.65*R* µin	Comparison to gage blocks
Sine Bars & Plates Angle Parallelism	(>0 to 45) ° 0.10 in	2.4 arc s 33 µin	Comparison to angle gage blocks, gaging amplifier

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Length – Dimensional Metrology El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Squares and Angle Plates	90 °	6.5 arc s	Comparison to cylindrical square
Protractor	(>0 to 90) °	53 arc s	Comparison to sine bar, gage blocks, precision level
Optical Flat Flatness Parallelism	Up to 4 in	 4 µin 1.2 µin	Comparison to optical flats, gage block comparator
Optical Wedge	Up to 30 arc s	0.3 arc s	Comparison to laser interferometer
Theodolite/Transmit/ Alignment Telescope Collimation Line of Sight Trunnion Axis	 Infinity focus 2 ft to infinity focus (60 to 135) °	 1.1 arc s 1.6 arc s 1.2 arc s	Comparison to alignment collimator
V-Blocks Parallelism Perpendicularity	To 6 in Up to 1 000 µin Up to 1 800 arc s	 37 µin 6.5 arc s	Comparison to Gaging amplifier Cylindrical square
Surface Plate [3] Overall Flatness Local Area Flatness	(60 x 96) in Up to 2 400 µin Up to 240 µin	 12 $\sqrt{D}$ µin 30 µin	Comparison to electronic level repeat reading gage
Thread Plug Gages Pitch Diameter Major Diameter	to 1 in	 60 µin 50 µin	Comparison to 3 wire method Gage blocks
Thread Ring Gages Pitch Diameter	to 1 in	160 µin	Comparison to thread setting plug

Mass and Mass Related El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gas Flow	10 sccm to 30 slpm (30 to 100) slpm	0.5 % of reading 0.75 % of reading	Comparison to mass flow standards
Helium Leak Rate	(10^{-09} to 10^{-03}) sccs	11 % of reading	Comparison to standard leak
Force	(>0 to 50 000) lbf (50 000 to 100 000) lbf	0.05 % of reading 0.22 % of reading	Comparison to deadweight, load cell

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Mass and Mass Related El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass Standards	(1 to 500) mg 500 mg to 2 g (2 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g 500 g to 1 kg (1 to 2) kg (2 to 5) kg 10 kg 1 lb 2 lb 5 lb 10 lb 20 lb 25 lb 50 lb	0.012 mg 0.043 mg 0.046 mg 0.075 mg 0.12 mg 0.23 mg 0.46 mg 0.91 mg 2.3 mg 5.2 mg 26 mg 33 mg 0.25 g 7.3 E-6 lb 1.5 E-5 lb 5.7 E-5 lb 8.5 E-5 lb 5.6E-4 lb 5.7 E-4 lb 6.6 E-4 lb	Comparison to reference weights, electronic balances
Pressure	(0.2 to 100) psia (100 to 1 000) psia (1 000 to 15 000) psig (15 000 to 20 000) psig	0.003 6% of reading 0.004% of reading 0.004 4% of reading 0.006 2% of reading	Comparison to deadweight tester
Scales and Balances [4]	(5 to 500) mg (0.5 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g (500 to 1000) g (1 to 2) kg (2 to 5) kg (5 to 20) kg (20 to 32) kg	0.012 mg 0.044 mg 0.064 mg 0.093 mg 0.14 mg 0.3 mg 0.6 mg 1.5 mg 3 mg 6.6 mg 16 mg 0.1 g 0.13 g	Comparison to reference weights
Scales and Balances [4]	(50 to 2 000) lb (2 000 to 5 000) lb	0.025 % of reading 0.06 % of reading	Comparison to reference weights

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Mass and Mass Related El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Vacuum Ionization Gages, Inverted Magnetron Gages, Cold Cathode Gages, Residual Drag Gages	2.0×10^{-7} torr 5.0×10^{-7} torr 9.0×10^{-7} torr	24 % of reading 21 % of reading 11 % of reading	Comparison to ionization gage
Vacuum Ionization Gages, Inverted Magnetron Gages, Cold Cathode Gages, Residual Drag Gages	2.0×10^{-6} torr 5.0×10^{-6} torr 9.0×10^{-6} torr 2.0×10^{-5} torr 5.0×10^{-5} torr 9.0×10^{-5} torr 2.0×10^{-4} torr 5.0×10^{-4} torr 9.0×10^{-4} torr	6.7 % of reading 12 % of reading 4.7 % of reading 6.7 % of reading 4.9 % of reading 4 % of reading 6.4 % of reading 4.4 % of reading 3.2 % of reading	Comparison to spinning rotor gage
Thermocouple Vacuum Gage/Capacitance Manometer	(0.01 to 0.1) torr (0.1 to 10) torr (10 to 1 000) torr	0.6 % of reading + 0.2 mtorr 0.6 % of reading + 1 mtorr 0.006 6 % of reading	Capacitance diaphragm comparison to deadweight tester
Torque Transducers	10 ozf·in to 2 000 lbf·ft	0.03% of reading	Comparison to standard weights, torque moment Arms
Torque Wrench and Torque Screwdriver	5 ozf·in to 2 000 lbf·ft	0.7% of reading	Comparison to torque testers

Photometry and Radiometry El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Fiber Optic Attenuation Single Mode Multi-Mode	(1 310, 1 550) nm (0 to 60) dB (850, 1 300) nm (0 to 60) dB	0.021 dB 0.021 dB	Comparison to optical power meter
Fiber Optic Power Single Mode Multi-Mode	(1 310, 1 550) nm (-60 to 5) dBm (850, 1 300) nm (-60 to 5) dBm	0.047 dB 0.047 dB	Comparison to optical power meter

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Photometry and Radiometry El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Fiber Optic Wavelength Wavelength Meter	(1 528 to 1 563) nm	0.001 4 nm	Comparison to NIST SRM 2519
Fiber Optic Wavelength Measure (Single Mode)	(700 to 1 700) nm	2 pm	Comparison to wavelength meter
Fiber Optic Wavelength Measure (Multi Mode)	(550 to 2 000) nm	2.9 nm	Comparison of a monochromator
Luminous Intensity	(20 to 500) fc	0.8% of reading	Comparison to NIST luminous intensity lamp

Thermodynamic El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dewpoint / Frostpoint Indicators	(-80 to 10) °C	0.35 °C	Comparison to a humidity generator
Relative Humidity	(10 to 90) %RH	0.8 %RH	Comparison to a humidity generator
Infrared Thermometers	(-15 to 0) °C (0 to 100) °C (100 to 200) °C (200 to 350) °C (350 to 500) °C	1.3 °C 1.2 °C 1.4 °C 1.9 °C 2.4 °C	Comparison to infrared calibrator $\varepsilon = 0.95$, $\lambda = (8 \text{ to } 14)$ µm
Resistance Thermometry Fixed Point	-195.5 °C	0.002 3 ºC	Comparison to DCC Resistance Bridge, NIST SPRT comparator
Resistance Thermometry Fixed Point	-38.8344 °C	0.001 4 ºC	Comparison to DCC Resistance Bridge, NIST SPRT, TP Mercury cell
Resistance Thermometry Fixed Point	0.01 °C	0.000 4 °C	Comparison to DCC Resistance Bridge, NIST SPRT, TP Water cell
Resistance Thermometry Fixed Point	231.9280 °C	0.002 5 ºC	Comparison to DCC Resistance Bridge, NIST SPRT, FP Tin cell
Resistance Thermometry Fixed Point	419.527 °C	0.002 8 ºC	Comparison to DCC Resistance Bridge, NIST SPRT, FP Zinc cell

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Thermodynamic El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature	(-80 to 0) °C (1 to 125) °C (126 to 300) °C (301 to 1 000) °C	0.005 °C 0.003 °C 0.005 °C 0.3 °C	Comparison to super thermometer, SPRT, TPW cell, thermocouple
Optical Pyrometer	(800 to 849) °C (850 to 949) °C (950 to 1 049) °C (1 050 to 1 149) °C (1 150 to 1 249) °C (1 250 to 1 349) °C (1 350 to 1 549) °C (1 550 to 1 649) °C (1 650 to 1 749) °C (1 750 to 1 849) °C (1 850 to 1 949) °C (1 950 to 2 049) °C (2 050 to 2 149) °C (2 150 to 2 249) °C (2 250 to 2 300) °C	3.3 °C 3 °C 2.6 °C 3.1 °C 2.4 °C 2.5 °C 2.8 °C 3.1 °C 2.9 °C 3.1 °C 3.2 °C 4.1 °C 5 °C 4.5 °C 3.8 °C	Comparison to NIST Tungsten strip lamp
Temperature – Source (stimulation)	(-210 to -200) °C (-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 760) °C (760 to 800) °C (800 to 1 200) °C (1 200 to 1 372) °C	0.22 °C 0.039 °C 0.055 °C 0.070 °C 0.078 °C 0.093 °C 0.14 °C 0.18 °C 0.19 °C 0.32 °C	Comparison to a resistance, voltage generator

Time and Frequency El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Allan Variance	(1, 5, 10) MHz	7.8×10^{-14} Hz	Comparison to phase noise test set
Frequency - Measure	(1, 5, 10) MHz	5.8 parts in 10^{14} Hz	Comparison to NIST TMAS System

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Time and Frequency El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source	10 MHz	510 pHz/Hz	Comparison to Rubidium frequency standard
Frequency – Source	(0.1 to 1) Hz 1 Hz to 250 kHz 250 kHz to 1 MHz 1 MHz to 12.4 GHz (12.4 to 46) GHz	2.0 µHz/Hz + 0.4 µHz 2.4 µHz/Hz 5.1 nHz/Hz + 0.13 mHz 5.2 nHz/Hz 5.2 nHz/Hz + 2 µHz	Comparison to Rubidium frequency standard and a function generator
Frequency – Measure	(0.1 to 1) Hz (1 to 10) Hz (10 to 100) Hz 100 Hz to 1 kHz (1 to 100) kHz 100 kHz to 10 MHz 10 MHz to 12.4 GHz (12.4 to 46) GHz	1.2 pHz/Hz + 63 pHz 0.61 pHz/Hz + 0.85 pHz 4.5 pHz/Hz + 4.1 nHz 23 pHz/Hz + 22 pHz 23 pHz/Hz + 0.13 nHz 23 pHz/Hz + 33 nHz 23 pHz/Hz + 32 nHz 24 pHz/Hz + 1.1 Hz	Comparison to frequency counter
Stop Watches, Timers	24 hr	0.23 s/24 hr	Comparison to NIST TMAS System
Time Interval – Measure	(10 to 430) ps 430 ps to 1 µs 1 µs to 50 ms 50 ms to 1 s (1 to 10) s (10 to 100) s	12 ms/s + 1.2 ps 6.7 ps 36 ns/s + 7.5 ps 1.9 ns 26 ps/s + 2.1 ns 33 ps/s + 2.7 ns	Comparison to a frequency counter and an oscilloscope
Transition - Measure	(8 to 30) ps (30 to 50) ps (50 to 200) ps (200 to 500) ps	1.2 ps 1.3 ps 10 fs/s + 0.9 ps 9.4 fs/s + 1 ps	Comparison to an oscilloscope

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Time and Frequency El Segundo, CA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Jitter - Source	(0.01 to 25) ps 2 GHz 2.5 GHz 2.75 GHz 3 GHz 3.2 GHz 5 GHz 8 GHz 10 GHz 12 GHz 13 GHz 14 GHz 15 GHz 28 GHz 32 GHz	 0.12 ps 44 fs 65 fs 0.13 ps 0.13 ps 0.1 ps 52 fs 31 fs 50 fs 50 fs 0.1 ps 50 fs 42 fs 37 fs	Comparison to a signal generator
Jitter - Measure	(0.1 to 130) ps 200 kHz to 15 GHz	 1.9 ps	Comparison to an oscilloscope

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Services performed at satellite laboratory

1346 Yellowwood Road
Kimballton, IA 51543

Nate Potts 712-248-6069
nate.potts@keysight.com www.keysight.com

Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
ISN –			CISPR 22, CISPR 32, CISPR 16-1-2 E5061B, E5071C Network Analyzers
Phase	(0 to 360)°		
	150 kHz to 80 MHz	3°	
Insertion Loss	(0 to 110) dB		
	150 kHz to 80 MHz	0.36 dB	
Impedance	(0 to 5000) Ω		
	150 kHz to 80 MHz	2.4 Ω	
Longitudinal Conversion Loss	(0 to 110) dB		
	150 kHz to 80 MHz	0.88 dB	
Decoupling Attenuation	(0 to 110) dB		
	150 kHz to 80 MHz	0.36 dB	
LISN			ANSI C63.4, CISPR 25 & CISPR 16-1-2, ISO 7637-2, MIL-STD-461, RTCA DO-160
Insertion Loss	(0 to 110) dB		
	9 kHz to 108 MHz	0.66 dB	
	(108 to 400) MHz	0.86 dB	
	(0 to 110) dB		
	150 kHz to 100 MHz	0.38 dB	
	(100 to 200) MHz	0.61 dB	
	(200 to 400) MHz	1.4 dB	
	(400 to 600) MHz	1.3 dB	
	(600 to 800) MHz	1.4 dB	
	800 MHz to 1 GHz	2.3 dB	
Impedance – Magnitude	(0 to 5 000) Ω		
	9 kHz to 100 MHz	0.2 Ω	
	(100 to 200) MHz	0.7 Ω	
	(200 to 400) MHz	1.2 Ω	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
LISN			ANSI C63.4, CISPR 25 & CISPR 16-1-2, ISO 7637-2, MIL-STD-461, RTCA DO-160
Impedance – Magnitude	(0 to 5 000) Ω		
	150 kHz to 100 MHz	0.35 Ω	
	(100 to 200) MHz	1.3 Ω	
	(200 to 400) MHz	2.3 Ω	
	(400 to 600) MHz	2.2 Ω	
	(600 to 800) MHz	1.9 Ω	
	800 MHz to 1 GHz	2.2 Ω	
Impedance – Phase	(0 to 360) °		
	9 kHz to 100 MHz	3.6 °	
	(100 to 200) MHz	3.4°	
	(200 to 400) MHz	3.2 °	
Isolation	(0 to 110) dB		
	9 kHz to 100 MHz	0.36 dB	
	(100 to 200) MHz	1.1 dB	
	(200 to 400) MHz	1.6 dB	
	400 MHz to 1.0 GHz	1.6 dB	
Current Probes & Bulk Current Injection Probes			CISPR 16-1-2, IEC/EN 61000-4-6 E5061B, E5071C Network Analyzers, BNC & Type "N" calibration standards
Insertion Loss	(0 to 110) dB		
	5 Hz to 500 MHz	0.77 dB	
	500 MHz to 2.4 GHz	1.1 dB	
Transfer Impedance	(0 to 110) dB		
	5 Hz to 500 MHz	0.77 dB	
	500 MHz to 2.4 GHz	1.1 dB	
CDN's & Adapters (50 to 150) Ω			IEC/EN 61000-4-6 CISPR 16-1-2 E5061B, E5071C Network Analyzers, BNC and Type "N" calibration standards
Adapter Insertion Loss	(0 to 110) dB		
	10 kHz to 230 MHz	1.2 dB	
Coupling Factor	(0 to 110) dB		
	10 kHz to 230 MHz	1.1 dB	
Impedance	(0 to 5000) Ω		
	10 kHz to 230 MHz	3.5 Ω	
CDN's & Adapters – (50 to 150) Ω Voltage Division Factor	(0 to 110) dB		IEC/EN 61000-4-6 CISPR 16-1-2 Agilent E5061B ENA Network Analyzer
	10 kHz to 230 MHz	0.25 dB	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Absorbing Clamps	(0 to 110) dB 30 MHz to 1 GHz 30 MHz to 1 GHz	 0.32 dB 2.4 dB	CISPR 16-1-3 Annex B, Agilent E5061B Network Analyzer, original calibration method, OATS/CALTS CISPR 16-1-3 Annex C, Agilent E5061B
Injection Clamps	(0 to 110) dB (0.01 to 1) MHz (1 to 1 000) MHz	 0.3 dB 0.35 dB	IEC/EN 61000-4-6 E5061B
NSA/CALTS Measurements	(0 to 110) dB (30 to 1 000) MHz	 0.1 dB	ANSI C63.5, ANSI C63.4, EN 50147-2 (1997) CISPR 16-1-4, CISPR 16-1-5 Agilent E5061B & E5071C HP 8753D, Agilent E8364C, Keysight N5225A Network Analyzers
Site VSWR Measurements	(0 to 110) dB (1 to 3) GHz (3 to 18) GHz	 0.66 dB 0.84 dB	CISPR 16-1-4, CISPR 16-1-5 Agilent E8364C, Keysight N5225A Network Analyzers
Field Uniformity	(0 to 110) dB 26 MHz to 18 GHz	 1.2 dB	IEC/EN 61000-4-3
ESD Targets Frequency Response Low Frequency Transfer Function Insertion Loss	 (0 to 110) dB DC to 4 GHz (0 to 30) A (0 to 110) dB Up to 300 kHz (0.30 to 10) MHz (0.010 to 3.0) GHz (3.0 to 4.0) GHz	 0.26 dB 0.32 % of reading 0.072 dB 0.076 dB 0.08 dB 0.092 dB	IEC 61000-4-2, ISO 10605 Agilent ENA E5071C Network Analyzer, Fluke 123 Scopemeter, HP 3478A Multimeter, Solar 7144-1.0 Decade Resistor

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
ESD Simulators –			
Contact Voltage (Positive & Negative)	(0 to 2) kV (2 to 8) kV (8 to 15) kV (15 to 30) kV (30 to 40) kV	2.6 % of reading 0.7 % of reading 0.6 % of reading 0.54 % of reading 0.72 % of reading	
Rise Time	(0 to 2) ns	61 ps	IEC/EN 61000-4-2; ISO 10605; SAE J1113-13, GR1089 TEK TDS 7404 Oscilloscope IEC ESD target applied kilovolt 149-3 High Voltage Meter
Peak Current 30 ns Current 60 ns Current	(0 to 40) A (0 to 40) A (0 to 40) A	5 % of reading 5.6 % of reading 6.1 % of reading	
Air Discharge Voltage (Positive & Negative)	(0 to 2) kV (2 to 20) kV (20 to 40) kV	0.15 % of reading 0.61 % of reading 1.2 % of reading	
Rise Time – RC Time Constant	(0 to 2) ns	61 ps	
(at ± 15 kV) 330 pF probe 150 pF probe	 600 ns ± 130 ns 300 ns ± 60 ns	 7.2 ns 6 ns	
Magnetic Field Strength Meters – DC AC	 (50 to 2 000) G 0.20 mG to 20 G	 2 % of reading 0.33 % +1.2 mG	Comparison to Reference Magnets, Standard Field using Helmholtz coil
RF Pre-Amplifiers, Amplifiers – Gain	(0 to 110) dB 5 Hz to 18 GHz (18 to 50) GHz	 0.97 dB 1 dB	IEEE 291 Agilent E5061B, E5071C Agilent E8364C, Keysight N5225A Network Analyzer
RF Isotropic E-Field Probe Field Strengths up to 1200 V/m	(0 to 15) dB 5 kHz to 800 MHz Frequency Response Linearity Isotropic Response	 0.73 dB 0.91 dB 0.92 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution, Calculated using TEM Cell

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Isotropic E-Field Probe Field Strengths up to 1200 V/m	(0 to 15) dB 10 kHz to 1 000 MHz Frequency Response Linearity Isotropic Response	 0.86 dB 1.1 dB 1.2 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution, Calculated Tri-plate
RF Isotropic E-Field Probe Field Strengths up to 1200 V/m	(0 to 15) dB 10 kHz to 1 000 MHz Frequency Response Linearity Isotropic Response	 0.79 dB 0.94 dB 0.97 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution using GTEM Cell
RF Isotropic E-Field Probe Field Strengths up to 1200 V/m	(0 to 15) dB 450 MHz to 18 GHz Frequency Response Linearity Isotropic Response 18 to 40 GHz Frequency Response Linearity Isotropic Response	 0.91 dB 1.1 dB 1.1 dB 1.1 dB 1.7 dB 1.7 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution, Calculated using Anechoic chamber
RF Isotropic E-Field Probe Field Strengths up to 1200 V/m	(0 to 15) dB 40 to 60 GHz Frequency Response Linearity Isotropic Response	 1.7 dB 0.54 dB 0.47 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution using Anechoic chamber
Electronic E-Field Probes	(0 to 15) dB 10 kHz to 5 GHz Frequency Response Linearity Channel Match Factor	 1.3 dB 0.83 dB 1 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution using FP 5000 type probe
Electronic E-Field Probes	(0 to 15) dB 10 kHz to 5 GHz Isotropic Response	 0.83 dB	IEEE 1309, IEC/EN 61000-4-3 FP 5000 type probe
Electronic E-Field Probes	(0 to 15) dB 80 MHz to 18 GHz Frequency Response Linearity	 1.9 dB 0.84 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution, Calculated using FP 2080 type probe
Electronic E-Field Probes	(0 to 15) dB (18 to 40) GHz Frequency Response Linearity	 2.3 dB 1.3 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution using FP 2080 type probe

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electronic E-Field Probes	(0 to 5) dB 80 MHz to 40 GHz Isotropic Response	1.2 dB	IEEE 1309, IEC/EN 61000-4-3 FP 2080 type probe
Electronic E-Field Probes	(0 to 5) dB 80 MHz to 18 GHz Channel Match Factor	1 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution, Calculated using FP 2080 type probe
Electronic E-Field Probes	(0 to 5) dB (18 to 40) GHz Channel Match Factor	1.3 dB	IEEE 1309, IEC/EN 61000-4-3 Substitution using FP 2080 type probe
Dipole Antennae 3 meter distance	(0 to 110) dB (30 to 60) MHz (50 to 150) MHz (140 to 400) MHz (400 to 1 000) MHz	0.5 dB 0.48 dB 0.55 dB 0.6 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/ Vertical Polarization
Dipole Antennae 3 meter distance	(0 to 110) dB (30 to 60) MHz (50 to 150) MHz (140 to 400) MHz (400 to 1 000) MHz	0.52 dB 0.55 dB 0.60 dB 0.62 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Reference Antenna Method, Horizontal/ Vertical Polarization
Dipole Antennae 3 meter distance	(0 to 110) dB (30 to 60) MHz (50 to 150) MHz (140 to 400) MHz (400 to 1 000) MHz	0.45 dB 0.52 dB 0.45 dB 0.58 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6, SAE ARP: Identical Antenna Method, Horizontal/Vertical Polarization

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dipole Antennae 3 meter distance	(0 to 110) dB (30 to 1 000) MHz	0.59 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Standard Antenna Method, Horizontal/Vertical Polarization
Dipole Antennae 3 meter distance	(0 to 110) dB (30 to 1 000) MHz	0.4 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Three Antenna Method, Horizontal/Vertical Polarization
Dipole Antennae 10 meter distance	(0 to 110) dB (30 to 60) MHz (50 to 150) MHz (140 to 400) MHz (400 to 1 000) MHz	 0.41 dB 0.45 dB 0.51 dB 0.55 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/ Vertical Polarization
Dipole Antennae 10 meter distance	(0 to 110) dB (30 to 60) MHz (50 to 150) MHz (140 to 400) MHz (400 to 1 000) MHz	 0.35 dB 0.4 dB 0.45 dB 0.51 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Reference Antenna Method, Horizontal/Vertical Polarization

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dipole Antennae 10 meter distance	(0 to 110) dB (30 to 60) MHz (50 to 150) MHz (140 to 400) MHz (400 to 1 000) MHz	 0.41 dB 0.38 dB 0.45 dB 0.5 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Identical Antenna Method, Horizontal/Vertical Polarization
Dipole Antennae 10 meter distance	(0 to 110) dB (30 to 1 000) MHz	 0.63 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Standard Antenna Method, Horizontal/ Vertical Polarization
Dipole Antennae 10 meter distance	(0 to 110) dB (30 to 1 000) MHz	 0.41 dB	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6, SAE ARP 958: Three Antenna Method, Horizontal/ Vertical Polarization
Horn Antennae Log Periodic Antennas Dipole Antennas 1 meter distance	(0 to 110) dB 700 MHz to 50 GHz	 0.45 dB	Fully Anechoic Room (FAR), Keysight N5225A, E8364B Network Analyzers SAE ARP 958: Identical
Horn Antennae Log Periodic Antennas Dipole Antennas 3 meter distance	(0 to 110) dB 700 MHz to 50 GHz	 0.45 dB	Fully Anechoic Room (FAR), Keysight N5225A, E8364B Network Analyzers SAE ARP: Appendix C

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Horn Antennae Log Periodic Antennas Dipole Antennas 1 and 3 meter distance Far Field	(0 to 110) dB 700 MHz to 18 GHz (18 to 26.5) GHz (26.5 to 50) GHz	 0.37 dB 0.42 dB 0.47 dB	Fully Anechoic Room (FAR), Keysight N5225A, E8364B Network Analyzers SAE ARP 958: Combo of Identical and Appendix C, Horizontal/Vertical Polarization
Horn Antennae Log Periodic Antennas Dipole Antennas 1 and 3 meter distance Far Field	(0 to 110) dB 700 MHz to 18 GHz (18 to 26.5) GHz (26.5 to 50) GHz (50 to 67) GHz	 0.37 dB 0.42 dB 0.47 dB 0.21 dB	Fully Anechoic Room (FAR), Keysight N5225A, N5291A, E8364B Network Analyzers CISPR 16-1-6: Three Antenna Method, Horizontal/Vertical Polarization
Horn Antennae Log Periodic Antennas Dipole Antennas 1 and 3 meter distance Far Field	(0 to 110) dB 700 MHz to 18 GHz (18 to 26.5) GHz (26.5 to 50) GHz	 0.37 dB 0.42 dB 0.47 dB	Fully Anechoic Room (FAR), Keysight N5225A, E8364B Network Analyzers ANSI C63.5: Standard Site Method, Horizontal/Vertical Polarization
Horn Antennae Log Periodic Antennas Dipole Antennas	(0 to 110) dB 700 MHz to 50 GHz Far Field Near Field	 0.44 dB 0.5 dB	Fully Anechoic Room (FAR), Keysight N5225A, E8364B Network Analyzers ANSI C63.5: Identical Antenna Method, Three Antenna Method, Horizontal/Vertical Polarization

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Horn Antennae Log Periodic Antennas Dipole Antennas	(0 to 110) dB 700 MHz to 50 GHz Time Domain	0.46 dB	Fully Anechoic Room (FAR), Keysight N5225A, E8364B Network Analyzers ANSI C63.5, CISPR 16-1-6: Identical Antenna Method, Three Antenna Method Horizontal/Vertical Polarization
Lens Antennas 1 and 3 meter distance Far Field	(1 to 110) dB (20 to 46) GHz	0.24 dB	Fully Anechoic Room (FAR), Keysight N5225A Network Analyzer CISPR 16-1-6: Three Antenna Method

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Parameter/ Equipment	Attenuation – Measure [1]											
Reference Standard, Method, and/or Equipment	Comparison to N5225A/C Network Analyzer and Calibration Kit											
Range	Expanded Uncertainty of Measurement (+/-)											
Frequency Ranges	Step Attenuation Level in dB											
	0	1	2	3	4	5	6	7	8	9	10	11
10 MHz ≤ f < 300 MHz	0.028	0.03	0.031	0.03	0.032	0.033	0.032	0.034	0.035	0.035	0.035	0.037
300 MHz ≤ f < 2 GHz	0.028	0.03	0.032	0.032	0.033	0.034	0.034	0.036	0.037	0.037	0.037	0.039
2 GHz ≤ f < 8 GHz	0.047	0.048	0.049	0.049	0.051	0.052	0.052	0.054	0.055	0.055	0.054	0.057
8 GHz ≤ f < 12 GHz	0.052	0.053	0.055	0.054	0.056	0.057	0.056	0.059	0.06	0.06	0.059	0.062
12 GHz ≤ f < 18 GHz	0.059	0.061	0.062	0.061	0.064	0.065	0.064	0.067	0.067	0.068	0.067	0.07
18 GHz ≤ f < 20 GHz	-	-	-	0.061	-	-	0.064	-	-	-	0.067	-
20 GHz ≤ f < 30 GHz	-	-	-	0.11	-	-	0.11	-	-	-	0.12	-
30 GHz ≤ f < 40 GHz	-	-	-	0.12	-	-	0.13	-	-	-	0.13	-
40 GHz ≤ f < 50 GHz	-	-	-	0.18	-	-	0.19	-	-	-	0.2	-

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Parameter/ Equipment	Attenuation – Measure									
Reference Standard, Method, and/or Equipment	Comparison to N5225A/C Network Analyzer and Calibration Kit									
Range	**Expanded Uncertainty of Measurement (+/-)**									
Frequency Ranges	Step Attenuation Level in dB									
	20	30	40	50	60	70	80	90	100	110
10 MHz ≤ f < 50 MHz	0.042	0.053	0.089	0.17	0.12	0.14	0.17	0.18	0.18	0.19
50 MHz ≤ f < 500 MHz	0.042	0.053	0.063	0.095	0.097	0.11	0.12	0.14	0.14	0.16
500 MHz ≤ f < 2 GHz	0.044	0.051	0.06	0.085	0.1	0.11	0.1	0.11	0.12	0.14
2 GHz ≤ f < 8 GHz	0.061	0.051	0.078	0.11	0.14	0.19	0.15	0.2	0.2	0.25
8 GHz ≤ f < 12 GHz	0.066	0.068	0.089	0.15	0.19	0.25	0.21	0.26	0.29	0.33
12 GHz ≤ f < 18 GHz	0.074	0.074	0.096	0.16	0.34	0.39	0.35	0.4	0.41	0.47
18 GHz ≤ f < 20 GHz	0.074	0.082	0.096	-	-	-	-	-	-	-
20 GHz ≤ f < 26.5 GHz	0.12	0.12	0.12	-	-	-	-	-	-	-
26.5 GHz ≤ f < 30 GHz	0.13	0.13	0.15	-	-	-	-	-	-	-
30 GHz ≤ f < 40 GHz	0.14	0.15	0.17	-	-	-	-	-	-	-
40 GHz ≤ f < 50 GHz	0.2	0.21	0.24	-	-	-	-	-	-	-

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Parameter/ Equipment	S11 - Reflection Magnitude									
Reference Standard, Method, and/or Equipment	Comparison to 85054B, 85031B, ET33700, 85056A, 85058B Calibration Kits									
Range	**Expanded Uncertainty of Measurement (+/-)**									
Frequency	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
5 Hz to 9 kHz	0.003 1	0.003 3	0.003 6	0.004 1	0.004 5	0.005 1	0.005 6	0.006 2	0.006 8	0.007 4
(9 to 100) kHz	0.003 1	0.003 3	0.003 6	0.004 1	0.004 5	0.005 1	0.005 6	0.006 2	0.006 8	0.007 4
(0.1 to 20 MHz	0.003 1	0.003 3	0.003 6	0.004 1	0.004 7	0.005 4	0.006 2	0.007 2	0.008	0.009 5
(0.02 to 2) GHz	0.000 54	0.000 62	0.000 7	0.000 81	0.000 93	0.001 1	0.001 2	0.001 4	0.001 6	0.001 7
(2 to 8) GHz	0.000 78	0.00 082	0.000 89	0.000 98	0.001 1	0.001 2	0.001 4	0.001 5	0.001 7	0.001 9
(8 to 20) GHz	0.001 4	0.001 4	0.001 5	0.001 5	0.001 6	0.001 7	0.001 8	0.002	0.002 3	0.002 6
(20 to 26.5) GHz	0.001 9	0.001 9	0.001 9	0.002	0.002	0.002 1	0.002 3	0.002 5	0.002 7	0.003 1
(26.5 to 40) GHz	0.003 9	0.004 1	0.004 4	0.004 9	0.005 6	0.006 6	0.007 7	0.009 1	0.011	0.012

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Parameter/ Equipment	S11 - Reflection Magnitude									
Reference Standard, Method, and/or Equipment	Comparison to 85054B, 85031B, ET33700, 85056A, 85058B Calibration Kits									
Range	**Expanded Uncertainty of Measurement (+/-)**									
Frequency	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
(40 to 50) GHz	0.005 2	0.005 4	0.005 8	0.006 3	0.007	0.008 1	0.009 5	0.011	0.013	0.015
(50 to 67) GHz	0.014	0.014	0.014	0.014	0.014	0.014	0.015	0.015	0.015	0.016

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Parameter/ Equipment	S11 - Reflection Phase									
Reference Standard, Method, and/or Equipment	Comparison to 85054B, 85031B, ET33700, 85056A, 85058B Calibration Kits									
Range	**Expanded Uncertainty of Measurement (+/-)**									
Frequency	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
5 Hz to 9 kHz	1.9	1	0.77	0.65	0.58	0.53	0.50	0.48	0.47	0.47
(9 to 100) kHz	1.9	1	0.77	0.65	0.58	0.53	0.50	0.48	0.47	0.47
(0.1 to 20 MHz	1.9	1	0.78	0.67	0.61	0.59	0.58	0.58	0.6	0.6
(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)	8.1	4.1	2.7	2.0	1.6	1.4	1.2	1.1	1	0.95

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Electrical – RF/Microwave Kimballton, IA

Parameter/ Equipment	S21 - Transmission Magnitude								
Reference Standard, Method, and/or Equipment	Comparison to 85054B, 85031B, ET33700, 85056A, 85058B, 85059B Calibration Kits								
Range	**Expanded Uncertainty of Measurement (+/-)**								
Frequency	Measured Magnitude (dB)								
	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
5 Hz to 9 kHz	0.058	0.058	0.063	0.067	0.074	0.088	0.104	0.126	0.175
(9 to 100) kHz	0.028	0.029	0.031	0.034	0.038	0.049	0.082	0.123	0.159
(0.1 to 130) MHz	0.028	0.029	0.031	0.034	0.038	0.047	0.069	0.09	0.128
(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	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13

Electrical – RF/Microwave Kimballton, IA

Parameter/ Equipment	S21 - Transmission Phase								
Reference Standard, Method, and/or Equipment	Comparison to 85054B, 85031B, ET33700, 85056A, 85058B Calibration Kits								
Range	**Expanded Uncertainty of Measurement (+/-)**								
Frequency	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
5 Hz to 9 kHz	0.38	0.38	0.42	0.45	0.49	0.58	0.69	0.83	1.2
(9 to 100) kHz	0.19	0.19	0.21	0.22	0.25	0.32	0.54	0.82	1.1
(0.1 to 130) MHz	0.19	0.19	0.2	0.22	0.25	0.31	0.46	0.61	0.85
(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

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Electrical – RF/Microwave Kimballton, IA

Parameter/ Equipment	S21 - Transmission Phase								
Reference Standard, Method, and/or Equipment	Comparison to 85054B, 85031B, ET33700, 85056A, 85058B Calibration Kits								
Range	**Expanded Uncertainty of Measurement (+/-)**								
Frequency	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
(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	0.79	0.79	0.79	0.79	0.8	0.81	0.83	0.86	0.89

Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Biconical Antennas		
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers		
Method	**Distance/ Domain**	**Frequency Range**	**Expanded Uncertainty of Measurement (+/-)**
SAE ARP 958	1 Meter	(0 to 110) dB (20 to 70) MHz (70 to 200) MHz (200 to 300) MHz	 0.33 dB 0.34 dB 0.37 dB
SAE ARP 958: Appendix C	3 Meter	(0 to 110) dB (20 to 70) MHz (70 to 200) MHz (200 to 300) MHz	 0.37 dB 0.48 dB 0.37 dB
ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (20 to 70) MHz (70 to 200) MHz (200 to 300) MHz	 0.93 dB 0.54 dB 0.25 dB
ANSI C63.5, CISPR 16-1-6: Reference Antenna Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	 0.95 dB 0.55 dB 0.41 dB 0.5 dB 0.6 dB

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Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Biconical Antennas
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Keysight E5071C, N5225A, E8364B Network Analyzers

Method	**Distance/ Domain**	**Frequency Range**	**Expanded Uncertainty of Measurement (+/-)**
ANSI C63.5, CISPR 16-1-6: Identical Antenna Method, horizontal/vertical	3 Meter	(0 to 110) dB (20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	 0.96 dB 0.6 dB 0.39 dB 0.47 dB 0.52 dB
ANSI C63.5, CISPR 16-1-6: Standard Antenna Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (20 to 300) MHz	 0.5 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (20 to 300) MHz	 0.4 dB
ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	 0.93 dB 0.52 dB 0.24 dB 0.2 dB 0.25 dB
ANSI C63.5, CISPR 16-1-6 Reference Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	 0.97 dB 0.62 dB 0.41 dB 0.3 dB 0.31 dB
ANSI C63.5, CISPR 16-1-6: Identical Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 72.5) MHz (72.5 to 115) MHz (115 to 157.5) MHz (157.5 to 200) MHz (200 to 300) MHz	 0.96 dB 0.6 dB 0.38 dB 0.46 dB 0.52 dB
ANSI C63.5, CISPR 16-1-6: Standard Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 300) MHz	 0.52 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 300) MHz	 0.43 dB

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Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Log-Periodic Antennas - Horns		
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Fully Anechoic Room (FAR), Keysight E5071C, N5225A, E8364B Network Analyzers		
Method	**Distance/ Domain**	**Range**	**Expanded Uncertainty of Measurement (+/-)**
SAE ARP 958	1 Meter	(0 to 110) dB (140 to 400) MHz (400 to 1 000) MHz (1 000 to 5 000) MHz	 0.32 dB 0.38 dB 0.52 dB
SAE ARP 958: Appendix C	3 Meter	(0 to 110) dB (140 to 400) MHz (400 to 1 000) MHz (1 000 to 5 000) MHz	 0.38 dB 0.45 dB 0.58 dB
ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (140 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1 000) MHz (1 000 to 5 000) MHz	 0.3 dB 0.3 dB 0.4 dB 0.4 dB 0.4 dB 0.5 dB 0.5 dB 0.6 dB 0.7 dB
ANSI C63.5, CISPR 16-1-6: Identical Antenna Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (140 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1 000) MHz (1 000 to 5 000) MHz	 0.2 dB 0.2 dB 0.2 dB 0.25 dB 0.35 dB 0.45 dB 0.45 dB 0.5 dB 0.6 dB
ANSI C63.5, CISPR 16-1-6: Standard Antenna Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (140 to 5 000) MHz	 0.65 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method, Horizontal/Vertical Polarization	3 Meter	(0 to 110) dB (140 to 5 000) MHz	 0.46 dB

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Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Log-Periodic Antennas - Horns		
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Fully Anechoic Room (FAR), Keysight E5071C, N5225A, E8364B Network Analyzers		
Method	**Distance/ Domain**	**Range**	**Expanded Uncertainty of Measurement (+/-)**
ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (140 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1 000) MHz (1 000 to 5 000) MHz	 0.3 dB 0.3 dB 0.4 dB 0.4 dB 0.4 dB 0.5 dB 0.5 dB 0.6 dB 0.7 dB
ANSI C63.5, CISPR 16-1-6: Identical Antenna Method	10 Meter	(0 to 110) dB (140 to 300) MHz (300 to 400) MHz (400 to 500) MHz (500 to 600) MHz (600 to 700) MHz (700 to 800) MHz (800 to 900) MHz (900 to 1 000) MHz (1 000 to 5 000) MHz	 0.3 dB 0.3 dB 0.3 dB 0.3 dB 0.45 dB 0.45 dB 0.55 dB 0.6 dB 0.7 dB
ANSI C63.5, CISPR 16-1-6: Standard Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (140 to 5 000) MHz	 0.69 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (140 to 5 000) MHz	 0.5 dB

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Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Hybrid Antennas		
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Fully Anechoic Room (FAR), Keysight E5071C, N5225A, E8364B Network Analyzers		
Method	**Distance/ Domain**	**Range**	**Expanded Uncertainty of Measurement (+/-)**
SAE ARP 958	1 Meter	(0 to 110) dB (20 to 70) MHz (70 to 200) MHz (200 to 400) MHz (400 to 1 000) MHz (1 000 to 6 000) MHz	 0.5 dB 0.76 dB 0.91 dB 0.74 dB 0.75 dB
SAE ARP958: Appendix C	3 Meter	(0 to 110) dB (20 to 70) MHz (70 to 200) MHz (200 to 400) MHz (400 to 1 000) MHz (1 000 to 6 000) MHz	 0.11 dB 0.11 dB 0.19 dB 0.26 dB 0.41 dB
ANSI C63.5, CISPR 16-1-6: Standard Site Method	3 Meter	(0 to 110) dB (20 to 1000) MHz (1 000 to 6 000) MHz	 0.58 dB 0.75 dB
ANSI C63.5, CISPR 16-1-6: Standard Antenna Method	3 Meter	(0 to 110) dB (20 to 6 000) MHz	 0.74 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method	3 Meter	(0 to 110) dB (20 to 6 000) MHz	 0.46 dB
ANSI C63.5, CISPR 16-1-6: Standard Site Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 1 000) MHz (1 000 to 6 000) MHz	 0.58 dB 0.75 dB
ANSI C63.5, CISPR 16-1-6: Identical Antenna Method, Horizontal/Vertical Polarization	10 Meter	(0 to 110) dB (20 to 1 000) MHz (1 000 to 6 000) MHz	 0.68 dB 0.89 dB
ANSI C63.5, CISPR 16-1-6: Standard Antenna Method	10 Meter	(0 to 110) dB (20 to 6 000) MHz	 0.77 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method	10 Meter	(0 to 110) dB (20 to 6 000) MHz	 0.5 dB

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Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Conical Log Spiral Antennas		
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Fully Anechoic Room (FAR), Keysight E5071C, N5225A, E8364B Network Analyzers		
Method	**Distance/Domain**	**Frequency Range**	**Expanded Uncertainty of Measurement (+/-)**
SAE ARP 958	1 Meter	(0 to 110) dB (200 to 400) MHz (400 to 1 000) MHz (1 000 to 10 000) MHz	2.2 dB 0.88 dB 1.7 dB

Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Loop Antennas	
Reference Standard	Electromagnetic Shielded Enclosure, Keysight E4445A Spectrum Analyzer	
Method	**Range**	**Expanded Uncertainty of Measurement (+/-)**
Standard field using Vacuo junction	(0 to 110) dB 5 Hz to 30 MHz	0.32 dB
ANSI C63.5, CISPR 16-1-6: Three Antenna Method	(0 to 110) dB 5 Hz to 30 MHz	0.5 dB
Standard field using loop current measurement	(0 to 110) dB 5 Hz to 30 MHz	0.34 dB
Substitution method using reference antenna	(0 to 110) dB 5 Hz to 30 MHz	0.44 dB

Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Rod Antennas	
Reference Standard	Keysight E5061B, E5071C Network Analyzers	
Method	**Range**	**Expanded Uncertainty of Measurement (+/-)**
CISPR 25, ANSI C63.5, SAE ARP 958, CISPR 16-1-4, CISPR 16-1-6: Equivalent Capacitance Substitution Method (ECSM)	(0 to 110) dB 10 Hz to 60 MHz	0.23 dB

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Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Additional Antenna Parameters	
Reference Standard	Calibration Test Site (CALTS) / Open Area Test Site (OATS), Fully Anechoic Room (FAR), Open Ended Anechoic Room, Keysight E5071C, N5225A, E8364B Network Analyzers	
Method	**Range**	**Expanded Uncertainty of Measurement (+/-)**
ANSI C63.5 4.4, CISPR 16-1-6: Symmetry	(0 to 110) dB 300 kHz to 1 GHz 10 MHz to 18 GHz (18 to 40) GHz	 0.07 dB 0.05 dB 0.084 dB
CISPR 16-1-4, CISPR 16-1-6: Balance	(0 to 110) dB 20 MHz to 40 GHz	 0.09 dB
CISPR 16-1-4, CISPR 16-1-6: Electric Field Discrimination	(0 to 110) dB 5 Hz to 30 MHz	 0.13 dB
CISPR 16-1-4, CISPR 16-1-6: Cross-Polar Response	(0 to 110) dB 20 MHz to 40 GHz	 0.5 dB
ANSI C63.4, CISPR 16-1-4, CISPR 16-1-6, IEEE 149-1979: VSWR	(0 to 110) dB (20 to 2000) MHz (1 to 40) GHz	 0.6 dB 0.9 dB
CISPR 16-1-6: Pattern Measurements	(0 to 110) dB 1 MHz to 40 GHz	 0.25 dB

Electrical – RF/Microwave Kimballton, IA

Parameter/Equipment	Antenna Site Parameters [1]	
Reference Standard	Keysight E5071C, N5225A, E8364B Network Analyzers	
Method	**Range**	**Expanded Uncertainty of Measurement (+/-)**
ANSI C63.4, CISPR 16-1-4, CISPR 16-1-5, EN 50147-2: Normalized Site Attenuation (NSA)	(0 to 110) dB (30 to 1000) MHz	 0.1 dB
ANSI C63.4, CISPR 16-1-4, CISPR 16-1-5: Site VSWR	(0 to 110) dB (1 to 6) GHz (6 to 18) GHz	 0.66 dB 0.84 dB

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Length – Dimensional Metrology Kimballton, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pin Depth	(0.18 to 0.23) in	34 µin	Comparison to Maury Microwave A020D

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Elk Horn, IA 51531

Nate Potts 712-248-6069
nate.potts@keysight.com www.keysight.com

Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source	Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V 220 V to 1.1 kV	7 µV/V + 0.54 µV 5 µV/V + 0.8 µV 3.5 µV/V + 0.4 µV 3.6 µV/V + 4.5 µV 5.3 µV/V + 23 µV 7.1 µV/V + 0.3 mV	Comparison to Fluke 5720A or 5730A Multiproduct Calibrator with Fluke 5725A Amplifier
DC Voltage – Source Fixed Values	1 mV 10 mV	15 µV 110 nV	Comparison to Fluke 57x0A Calibrator Fluke 742A Resistors
DC Voltage – Source Fixed Values	100 mV 1 V 10 V 100 V 1 000 V	270 nV 1.5 µV 11 µV 150 µV 5.3 mV	Comparison to Fluke 57x0A Multiproduct Calibrator disciplined with HP Keysight 3458A multimeter/100 NPLC Option 002 Multimeter
DC Voltage – Measure	(0 to 0.1) V (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	4.1 µV/V + 0.36 µV 3.7 µV/V + 0.35 µV 3.1 µV/V + 0.59 µV 5.3 µV + 36 µV 5.3 µV/V + 0.12 mV	Comparison to Keysight 3458A multimeter/100 NPLC Option 002 Multimeter
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	Comparison to Keysight 3458A multimeter
DC Current – Source	(>0 to 220) µA 220 µA to 22 mA (22 to 100) mA (100 to 220) mA 220 mA to 1 A (1 to 2.2) A	35 µA/A 29 µA/A 37 µA/A 50 µA/A - 1.2 µA 59 µA/A + 12 µA 120 µA/A - 42 µA	Comparison to Fluke 5720A or 5730A Multiproduct Calibrator

Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source	(2.2 to 11) A	0.28 mA/A + 41 µA	Comparison to Fluke 5720A or 5730A Multiproduct Calibrator with Fluke 5725A Amplifier
DC Current – Source	100 µA 1 mA 10 mA 100 mA 1 A	1.3 nA 9.5 nA 93 nA 2.2 µA 36 µA	Comparison to Fluke 57x0A Multiproduct Calibrator disciplined with HP Keysight 3458A multimeter/100 NPLC Option 002 Multimeter
DC Current – Source	(10 to 20) A (20 to 200) A (200 to 1 000) A	0.57 % of reading + 21 mA 0.57 % of reading + 145 mA 0.57 % of reading + 510 mA	Comparison to Fluke 5520A Multiproduct Calibrator, Fluke Current Coil
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	Comparison to Keysight 3458A multimeter
DC Current – Measure	(0.10 to 1.0) A (1.0 to 3.0) A (3.0 to 10) A	22 µA/A + 61 µA 38 µA/A + 0.8 mA 0.02 % of reading + 1.9 mA	Comparison to Keysight 34470A Multimeter
DC Current – Measure	(1.0 to 2.0) A (2.0 to 10) A (10 to 20) A (20 to 50) A	0.016 % of reading - 0.032 mA 90 µA/A + 1 mA 0.047 % of reading - 2.7 mA 0.048 % of reading - 2.7 mA	Comparison to PA2201A
DC Current – Measure	(20 to 500) A	0.09 % of reading	Comparison to 500 A shunts

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Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source Fixed Points	0 W 1 W 1.9 W 10 W 19 W 100 W 190 W 1 kW 1.9 k W 10 kW 19 kW 100 kW 190 kW 1 MW 1.9 MW	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	Comparison to Fluke 5730A Multiproduct Calibrator
Resistance – Source Fixed Points	10 MΩ 19 MΩ 100 MΩ	0.4 kΩ 1.5 kΩ 12 kΩ	Comparison to Fluke 5730A Multiproduct Calibrator
Resistance - Source Fixed Points	0 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ	21 µΩ 49 µΩ 420 µΩ 1.8 mΩ 17 mΩ 190 mΩ 4.6 Ω 140 Ω 18 kΩ	Comparison to Fluke 57x0A Multiproduct Calibrator disciplined with Keysight 3458A multimeter
Resistance – Source	(0 to 11) Ω (11 to 110) Ω 110 Ω to 1.1 kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 110) kΩ 110 kΩ to 1.1 MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (330 to 1 100) MΩ	33 µΩ/Ω + 8.3 mΩ 25 µΩ/Ω + 12.5 mΩ 23 µΩ/Ω + 17 mΩ 23 µΩ/Ω + 170 mΩ 23 µΩ/Ω + 84 mΩ 23 µΩ/Ω + 0.84 Ω 27 µΩ/Ω + 8 Ω 50 µΩ/Ω + 125 Ω 0.11 mΩ/Ω + 0.2 kΩ 0.21 mΩ/Ω + 2 kΩ 0.41 mΩ/Ω + 2.8 kΩ 2.5 mΩ/Ω + 83 kΩ 13 mΩ/Ω + 0.4 MΩ	Comparison to Fluke 5520A Multiproduct Calibrator

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Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source	(1 to 10) GΩ (10 to 100) GΩ	1.2 % of reading + 56 kΩ 1.2 % of reading + 0.56 MΩ	Comparison to IET HRRS-F-6, 2177 Decade Resistor
Resistance – Measure	(0 to 12) Ω (10 to 120) Ω 100 Ω to 1.2 kΩ (1 to 12) kΩ (10 to 120) kΩ 100 kΩ to 1.2 MΩ (1 to 12) MΩ (10 to 120) MΩ 100 Ω to 1.2 GΩ	18 µΩ/ Ω + 60 µΩ 12 µΩ/Ω + 0.6 mΩ 9.6 µΩ/Ω + 0.6 mΩ 9.6 µΩ/Ω + 6 mΩ 9.6 µΩ/Ω + 60 mΩ 14.5 µΩ/Ω + 2.4 Ω 60 µΩ/Ω + 120 Ω 0.6 mΩ/Ω + 1.2 kΩ 6 mΩ/Ω + 12 kΩ	Comparison to Keysight 3458A Multimeter
Resistance – Measure	(1 to 10) GΩ (10 to 100) GΩ (0.10 to 1.0) TΩ	2.9 mΩ/Ω + 1.2 kΩ 4.1 mΩ/Ω + 1.0 MΩ 4.2 mΩ/Ω + 0.42 GΩ	Comparison to an Electrometer
Resistance – Measure Fixed Points	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	12 µΩ 13 µΩ 47 µΩ 0.098 mΩ 0.32 mΩ 0.55 mΩ 2.8 mΩ 3.9 mΩ 19 mΩ 57 mΩ 0.29 Ω 0.7 Ω 4.2 Ω 9.4 Ω 50 Ω 0.24 kΩ 2.3 kΩ	Comparison to Keysight 3458A Multimeter
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	 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	Comparison to Fluke 5730A Multiproduct Calibrator

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Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source	Up to 22 mV		Comparison to Fluke 5730A Multiproduct Calibrator
	(10 to 20) Hz	250 µV/V + 4.1 µV	
	(20 to 40) Hz	94 µV/V + 4.1 µV	
	40 Hz to 20 kHz	83 µV/V + 4.1 µV	
	(20 to 50) kHz	210 µV/V + 4.1 µV	
	(50 to 100) kHz	520 µV/V + 4.1 µV	
	(100 to 300) kHz	1.1 mV/V + 4.1 µV	
	(300 to 500) kHz	1.4 mV/V + 4.1 µV	
	500 kHz to 1 MHz	2.8 mV/V + 4.1 µV	
	(22 to 220) mV		
	(10 to 20) Hz	250 µV/V + 39 µV	
	(20 to 40) Hz	94 µVV + 16 µV	
	40 Hz to 20 kHz	60 µV/V + 7 µV	
	(20 to 50) kHz	120 µV/V + 8 µV	
	(50 to 100) kHz	320 µV/V + 18 µV	
	(100 to 300) kHz	680 µV/V + 20 µV	
	(300 to 500) kHz	1.5 mV/V + 20 µV	
	500 kHz to 1 MHz	2.8 mV/V + 50 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	250 mV/V + 39 µV	
	(20 to 40) Hz	94 µVV + 16 µV	
	40 Hz to 20 kHz	43 µV/V + 8.8 µV	
	(20 to 50) kHz	70 µV/V + 10 µV	
	(50 to 100) kHz	89 µV/V + 30 µV	
	(100 to 300) kHz	350 µV/V + 83 µV	
	(300 to 500) kHz	1.1 mV/V + 190 µV	
	500 kHz to 1 MHz	1.8 mV/V + 300 µV	
	(2.2 to 22) V		
	(10 to 20) Hz	251 µV/V + 390 µV	
	(20 to 40) Hz	93 µV/V + 156 µV	
	40 Hz to 20 kHz	47 µV/V + 48 µV	
	(20 to 50) kHz	78 µV/V + 107 µV	
	(50 to 100) kHz	113 µV/V + 42 µV	
	(100 to 300) kHz	432 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	

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AC Voltage – Source	(22 to 220) V		Comparison to Fluke 5730A Multiproduct Calibrator
	(10 to 20) Hz	250 µV/V + 4.2 mV	
	(20 to 40) Hz	94 µV/V + 1.6 mV	
	40 Hz to 20 kHz	54 µV/V + 0.68 mV	
	(20 to 50) kHz	83 µV/V + 1.1 mV	
	(50 to 100) kHz	156 µV/V + 2.6 mV	
	(100 to 300) kHz	941 µV/V + 16 mV	
	(300 to 500) kHz	4.6 mV/V + 42 mV	
	500 kHz to 1 MHz	8.3 mV/V + 83 mV	
	(220 to 1 100) V		
	(15 to 50) Hz	313 µV/V + 17 mV	
	50 Hz to 1 kHz	73 µV/V + 3.7 mV	
AC Voltage – Source	(220 to 1 100) V		Comparison to Fluke 5730A Multiproduct Calibrator with Fluke 5725A Amplifier
	40 Hz to 1 kHz	80 µV/V + 18 mV	
	(1 to 20) kHz	173 µV/V + 5.3 mV	
	(20 to 30) kHz	625 µV/V + 12 mV	
	(250 to 750) V		
	(30 to 50) kHz	634 µV/V + 5.5 mV	
	(50 to 100) kHz	2.4 mV/V + 28 mV	
AC Voltage – Source	0.01 V		Comparison to Fluke 5700A or Fluke 5720A Multiproduct Calibrator disciplined with Keysight 3458A Multimeter
	1 kHz	870 nV	
	20 kHz	1.2 µV	
	100 kHz	4.5 µV	
	300 kHz	33 µV	
	1 MHz	21 µV	
	4 MHz	140 µV	
	0.1 V		
	1 kHz	4.6 µV	
	20 kHz	6.9 µV	
	100 kHz	36 µV	
	300 kHz	52 µV	
	1 MHz	170 µV	
	4 MHz	670 µV	
	8 MHz	690 µV	
	10 MHz	2.3 mV	

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AC Voltage – Source	1 V		Comparison to Fluke 5700A or Fluke 5720A Multiproduct Calibrator disciplined with Keysight 3458A Multimeter
	1 kHz	26 µV	
	20 kHz	32 µV	
	50 kHz	59 µV	
	100 kHz	170 µV	
	300 kHz	410 µV	
	500 kHz	0.97 mV	
	1 MHz	1.7 mV	
	4 MHz	6.7 mV	
	8 MHz	6.9 mV	
	10 MHz	25 mV	
	3V		
	100 kHz	420 µV	
	(2, 4, 8) MHz	21 mV	
	10 MHz	75 mV	
	10 V		
	10 Hz	480 µV	
	20 Hz	270 µV	
	40 Hz	230 µV	
	200 Hz	460 µV	
	500 Hz	495 µV	
	1 kHz	260 µV	
	10 kHz	270 µV	
	20 kHz	320 µV	
	50 kHz	0.53 mV	
	100 kHz	1.1 mV	
	300 kHz	2.6 mV	
	500 kHz	6.3 mV	
	1 MHz	12 mV	
	100 V		
	1 kHz	4 mV	
	20 kHz	7.9 mV	
	50 kHz	7.5 mV	
	100 kHz	16 mV	
	700 V		
	1 kHz	60 mV	

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Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/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 1.3 mV/V 2.1 mV/V 3.9 mV/V 8.7 mV/V	Comparison to Fluke 5720A, Fluke 5700A, or Fluke 5700A-03 Multiproduct Calibrator (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 0.1 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	Comparison to Agilent 11049A, Agilent 11050A, Agilent 11051A Thermal Voltage Converters
AC Voltage Flatness – Measure	9 kHz to 2 GHz (-60 to 25) dBm	0.026 dB	Comparison to Agilent N1914A Power Meter, Agilent E9304A, Agilent 8491B Power Sensors, Keysight 3458A Multimeter

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AC Voltage – Measure	Up to 10 mV		Comparison to Keysight 3458A Multimeter
	(1 to 40) Hz	0.3 mV/V + 3.1 µV	
	40 Hz to 1 kHz	0.2 mV/V + 1.2 µV	
	(1 to 20) kHz	0.3 mV/V + 1.7 µV	
	(20 to 50) kHz	1 mV/V + 1.6 µV	
	(50 to 100) kHz	5 mV/V + 1.3 µV	
	(100 to 300) kHz	40 mV/V + 2.1 µV	
	300 kHz to 1 MHz	12 mV/V + 6.6 µV	
	(1 to 4) MHz	70 mV/V + 7.5 µV	
	(4 to 8) MHz	20 mV/V + 8.2 µV	
	(10 to 100) mV		
	(1 to 40) Hz	70 µV/V + 4.1 µV	
	40 Hz to 1 kHz	70 µV/V + 2.1 µV	
	(1 to 20) kHz	0.14 mV/V + 2.3 µV	
	(20 to 50) kHz	0.3 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	
	100 mV 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 + 0.3 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	

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AC Voltage – Measure	(1 to 10) V		Comparison to Keysight 3458A Multimeter
	(1 to 40) Hz	70 µV/V + 0.42 mV	
	40 Hz to 1 kHz	70 µV/V + 0.22 mV	
	(1 to 20) kHz	0.14 mV/V + 0.24 mV	
	(20 to 50) kHz	0.3 mV/V + 0.25 mV	
	(50 to 100) kHz	0.8 mV/V + 0.22 mV	
	(100 to 300) kHz	3 mV/V + 1.1 mV	
	300 kHz to 1 MHz	10 mV/V + 1.1 mV	
	(1 to 2) MHz	15 mV/V + 1.1 mV	
	(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	
AC Voltage – Measure	(500 to 1 000) V		Comparison to Keysight PA2201A Power Analyzer
	(1.0 to 100) Hz	92 µV/V + 2.6 mV	
	(0.10 to 1.0) kHz	56 µV/V + 1 mV	
	(1.0 to 10) kHz	54 µV/V + 3 mV	
	(10 to 100) kHz	0.89 mV/V + 20 mV	
	(0.10 to 1.0) MHz	0.88 mV/V + 86 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Source	Up to 220 µA		Comparison to Fluke 5720A or 5730A Multiproduct Calibrator
	(10 to 20) Hz	230 µA/A + 17 nA	
	(20 to 40) Hz	150 µA/A + 10 nA	
	40 Hz to 1 kHz	108 µA/A + 8.4 nA	
	(1 to 5) kHz	266 µA/A + 12.5 nA	
	(5 to 10) kHz	915 µA/A + 66 nA	
	220 µA to 2.2 mA		
	(10 to 20) Hz	233 µA/A + 42 nA	
	(20 to 40) Hz	150 µA/A + 34 nA	
	40 Hz to 1 kHz	108 µA/A + 34 nA	
	(1 to 5) kHz	183 µA/A + 109 nA	
	(5 to 10) kHz	915 µA/A + 655 nA	
	(2.2 to 22) mA		
	(10 to 20) Hz	233 µA/A + 422 nA	
	(20 to 40) Hz	149 µA/A + 342 nA	
	40 Hz to 1 kHz	108 µA/A + 343 nA	
	(1 to 5) kHz	183 µA/A + 588 nA	
	(5 to 10) kHz	915 µA/A + 5 µA	
	(22 to 220) mA		
	(10 to 20) Hz	233 µA/A + 4.2 µA	
	(20 to 40) Hz	149 µA/A + 3.4 µA	
	40 Hz to 1 kHz	108 µA/A + 2.6 µA	
	(1 to 5) kHz	183 µA/A + 3.4 µA	
	(5 to 10) kHz	915 µA/A + 10 µA	
	220 mA to 2.2 A		
	20 Hz to 1 kHz	249 µA/A + 34 µA	
	(1 to 5) kHz	383 µA/A + 83 µA	
	(5 to 10) kHz	5.8 mA/A + 166 µA	
	(2.2 to 11) A		
	40 Hz to 1 kHz	332 µA/A + 149 µA	
	(1 to 5) kHz	707 µA/A + 320 µA	
	(5 to 10) kHz	2.8 mA/A + 600 µA	
AC Current Source	(0 to 0.33) mA		Comparison to Fluke 552xA Multiproduct Calibrator
	(10 to 30) kHz	10 mA/A + 330 nA	
	(0.33 to 3.3) mA		
	(10 to 30) kHz	6.6 mA/A + 550 nA	
	(3.3 to 33) mA		
	(10 to 30) kHz	2.7 mA/A + 2.7 µA	
	(33 to 330) mA		
	(10 to 30) kHz	2.7 mA/A + 160 µA	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Source	(2.2 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 830 µA/A + 4.2 mA 1.1 mA/A + 3.9 mA 21 mA/A + 1 mA	Comparison to Fluke 552xA Multiproduct Calibrator
AC Current – Source	(10 to 20) A (45 to 65) Hz (65 to 440) Hz (20 to 100) A (45 to 65) Hz (65 to 100) Hz (100 to 440) Hz (100 to 1 000) A (45 to 65) Hz (65 to 100) Hz (100 to 440) Hz	 0.3 % of reading + 27 mA 0.33 % of reading + 50 mA 0.85 % of reading + 3.6 mA 0.85 % of reading + 29 mA 0.85 % of reading + 100 mA 0.85 % of reading + 3.6 mA 0.85 % of reading + 28 mA 1 % of reading + 0.25 A	Comparison to Fluke 5520A Multiproduct Calibrator, Fluke Current Coil
AC Current – Source	1 kHz 10 µA 100 µA 1 mA 10 mA 100 mA 1 A	 7.3 nA 14 nA 85 nA 0.87 µA 8.7 µA 200 µA	Comparison to Fluke 5720A or 5730A Multiproduct Calibrator disciplined with Keysight 3458A Multimeter
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	 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	Comparison to Keysight 3458A Multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure	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 + 0.22 mA 1.6 mA/A + 0.22 mA 0.8 mA/A + 0.22 mA 1 mA/A + 0.22 mA	Comparison to Keysight 3458A Multimeter
AC Current – Measure	(1 to 3) A 3.0 Hz to 5.0 kHz (5.0 to 10) kHz (3 to 10) A 3.0 Hz to 5.0 kHz (5.0 to 10) kHz	 0.028 % of reading + 0.19 mA 0.044 % of reading + 0.37 mA 0.035 % of reading + 0.58 mA 0.076 % of reading + 0.63 mA	Comparison to Keysight 34470A Multimeter
AC Current – Measure	(1 to 2) A (1.0 to 100) Hz (0.10 to 1) kHz (1 to 10) kHz (10 to 100) kHz (2 to 50) A (1 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz (10 to 100) kHz	 0.01 % of reading + 73 µA 0.021 % of reading + 8.0 µA 0.11 % of reading + 19 µA 0.11 % of reading + 20 µA 0.044 % of reading + 1.9 mA 0.045 % of reading + 1.6 mA 0.046 % of reading + 2.3 mA 0.043 % of reading + 3.7 mA	Comparison to Keysight PA2201A Power Analyzer
Oscilloscope Calibration – Generate Voltage – DC to 1 MW DC to 50 W Square Wave – 50 W Rise Time Timing	 1 mV to 200 V 1 mV to 5 V (0.04 to 1) mV 1 mV to 5 V 150 ps @ 5 mV to 3 V 70 ps @ 25 mV to 2 V 25 ps @ (425 to 575) mV Narrow Triangle 900.91 ns to 55 s	 0.03 % of reading + 25 µV 0.03 % of reading + 25 µV 1.5 % of reading + 10 µV 0.12 % of reading + 10 µV 27 ps 20 ps 8.1 ps 3.4 µs/s	Comparison to Fluke 9500 oscilloscope calibration system, Fluke 9500B with 9530, 9550 and 9560 heads

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscope Calibration – Leveled Sine Wave – Amplitude	4.44 mV to 5.56 V	1.5 % of reading	Comparison to Fluke 9500 oscilloscope calibration system, Fluke 9500B with 9530, 9550 and 9560 heads
Single	Flatness		
	0.1 Hz to 300 MHz	2 % of reading	
	(300 to 550) MHz	2.5 % of reading	
	550 MHz to 3 GHz	3.5 % of reading	
	(3 to 6) GHz	5 % of reading	
Dual	Flatness wrt Reference Frequency:		
	0.1 Hz to 1 GHz	10 % of reading	
	(1 to 3.2) GHz	25 % of reading	
Pulse Width	(1 to 100) ns	5 % of reading + 200 ps	
Time Marker Output – Measuring Equipment	50 kHz to 2.5 GHz	0.004 % of reading	
Bandwidth Measurement	1 MHz to 2.5 GHz	2.3 % of reading	

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Inductance – Measure	(100 to 1 000) µH		Comparison to an LCR meter
	100 Hz	2.3 % of reading + 0.7 nH	
	1 kHz	0.4 % of reading + 0.82 nH	
	10 kHz	0.23 % of reading + 0.001 5 µH	
	100 kHz	0.14 % of reading + 0.001 7 µH	
	(1.0 to 10) mH		
	100 Hz	0.4 % of reading + 0.082 µH	
	1 kHz	0.23 % of reading	
	10 kHz	0.14 % of reading	
	100 kHz	0.058 % of reading	
	(10 to 100) mH		
	100 Hz	0.23 % of reading + 0.12 µH	
	1 kHz	0.12% of reading	
	10 kHz	0.058 % of reading	
	100 kHz	0.1 % of reading + 0.016 mH	
	(100 to 1 000) mH		
	100 Hz	0.092 % of reading + 1.8 µH	
	1 kHz	0.058 % of reading + 0.021 µH	
	10 kHz	0.058 % of reading + 0.54 µH	
	(1.0 to 10) H		
	100 Hz	0.058 % of reading + 0.011 mH	
	1 kHz	0.058 % of reading	
	10 kHz	0.094 % of reading + 1.2 mH	
Capacitance – Source	(0.19 to 3.29) nF	3.1 mF/F + 7.7 pF	Comparison to Fluke 5520A or 5522A Multiproduct Calibrator
	(3.3 to 10.99) nF	1.4 mF/F + 8.2 pF	
	(11 to 109.99) nF	1.4 mF/F + 80 pF	
	(110 to 329.99) nF	1.5 mF/F + 0.24 nF	
	(0.33 to 1.099) µF	1.4 mF/F + 0.82 nF	
Capacitance – Source	(1.1 to 3.299) µF	1.5 mF/F + 2.4 nF	Comparison to Fluke 5520A or 5522A Multiproduct Calibrator
	(3.3 to 10.99) µF	1.4 mF/F + 8.1 nF	
	(11 to 32.99) µF	2.4 mF/F + 24 nF	
	(33 to 109.99) µF	2.6 mF/F + 83 nF	
	(110 to 329.99) µF	2.7 mF/F + 0.24 µF	
	(0.33 to 1.099) mF	2.6 mF/F + 0.82 µF	
	(1.1 to 3.299) mF	2.7 mF/F + 2.4 µF	
	(3.3 to 10.00) mF	3.3 mF/F + 5.2 µF	
	(11 to 32.99) mF	5.5 mF/F + 24 µF	
	(33 to 110) mF	7.9 mF/F + 79 µF	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure	(10 to 100) pF (0.10 to 1) nF (1 to 100) nF (0.1 to 1.0) µF (1 to 100) µF (100 to 1 000) µF (1 to 10) mF (10 to 100) mF	0.029 % of reading + 0.000 11 pF 0.026 % of reading + 0.029 pF 0.029 % of reading + 0.006 1 pF 0.015 % of reading + 0.000 31 nF 0.022 % of reading + 0.008 9 nF 0.029 % of reading + 0.000 55 µF 0.029 % of reading + 0.005 4 µF 0.029 % of reading + 0.054 µF	Comparison to Keysight Technologies E4980A
Electrical Simulation of Thermocouple Indicating Devices	Type B (600 to 800) °C (800 to 1 000) °C (1 000 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 316) °C Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C 650 °C Type J (-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1 200) °C Type K (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1 000) °C (1 000 to 1 372) °C	 0.47 °C 0.36 °C 0.32 °C 0.35 °C 0.32 °C 0.28 °C 0.33 °C 0.53 °C 0.88 °C 0.53 °C 0.18 °C 0.16 °C 0.18 °C 0.23 °C 0.29 °C 0.18 °C 0.16 °C 0.19 °C 0.25 °C 0.35 °C 0.2 °C 0.18 °C 0.28 °C 0.42 °C	Comparison to Fluke 5520A Fluke 5522A Multiproduct Calibrator

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Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices	Type L (-200 to -100) °C (-100 to 800) °C (800 to 900) °C Type N (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1 300) °C Type R (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (0 000 to 1 767) °C Type S (0 to 250) °C (250 to 1 000) °C (1 000 to 1 400) °C (1 400 to 1 767) °C 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	 0.39 °C 0.28 °C 0.19 °C 0.42 °C 0.24 °C 0.21 °C 0.2 °C 0.29 °C 0.6 °C 0.37 °C 0.35 °C 0.42 °C 0.5 °C 0.38 °C 0.39 °C 0.49 °C 0.66 °C 0.26 °C 0.18 °C 0.16 °C 0.59 °C 0.29 °C	Comparison to Fluke 5520A Fluke 5522A Multiproduct Calibrator
DC High Voltage – Measure and Source	(1 to 10) kV	44 µV/V + 0.42 V	Comparison to Vitrek 4700 Precision High Voltage Meter
DC High Voltage – Measure and Source	(10 to 35) kV (35 to 50) kV (50 to 70) kV	20 µV/V + 5.5 V 34 µV/V + 11 V 47 µV/V + 30 V	Comparison to Vitrek 4700 Precision High Voltage Meter and Probe Vitrek 4700 & HVP-35 Vitrek 4700 & HVL-70 Vitrek 4700 & HVL-70
AC High Voltage – Measure and Source	(DC to 1 kHz) (1.0 to 10) kV	0.013 % of reading + 2.6 V	Comparison to Vitrek 4700 Precision High Voltage Meter

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Electrical – DC/Low Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC High Voltage – Measure and Source	(DC to 1 kHz) (10 to 30) kV (30 to 50) kV	0.016 % of reading + 1.6 V 66µV/V + 13 V	Comparison to Vitrek 4700 Precision High Voltage Meter and Probe Vitrek 4700 & HVP-35 Vitrek 4700 & HVL-70

Electrical – RF/Microwave Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure Rate: (0.05 to 10) kHz Rate: (0.05 to 50) kHz Rate: (0.05 to 10) kHz	Up to 99% Depth (0.15 to 10) MHz (0.01 to 1.3) GHz (1.3 to 26.5) GHz	 2.1 % Depth 1.1 % Depth 1.6 % Depth	Comparison to Agilent 8902A Measuring Receiver
Frequency Modulation – Measure Rate: (0.02 to 10) kHz Rate: (0.05 to 100) kHz	≤ 40 kHz $_{peak}$ (0.25 to 10) MHz ≤ 400 kHz $_{peak}$ (0.01 to 26.5) GHz	 2.2 % Deviation 1.2 % Deviation	Comparison to HP 8902A Measuring Receiver
Digital Modulation RF Quality Error Vector Magnitude (EVM)	Mod Frequency Span: f ≤ 100 kHz 100 kHz ≤ f ≤ 1 MHz f > 1 MHz	 0.43 % of reading 0.48 % of reading 0.82 % of reading	Comparison to HP 89441A Vector Signal Analyzer
Digital Modulation RF Quality Phase Error	Up to 180 ° Mod Frequency Span: f ≤ 100 kHz 100kHz ≤ f ≤ 1MHz f > 1 MHz	 0.17 ° rms 0.34 ° rms 0.57 ° rms	Comparison to HP 89441A Vector Signal Analyzer
Digital Modulation RF Quality Frequency Error	(0 to 5) % error Mod Frequency 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz	 0.063 % error 0.068 % error 0.079 % error 0.099 % error 0.33 % error 0.39 % error	Comparison to HP 89441A Vector Signal Analyzer

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Electrical – RF/Microwave Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Modulation RF Quality Modulation Accuracy (Rho)	Mod Frequency Span: f ≤ 100 kHz 0.999 9 ≤ r ≤ 1 0.997 5 ≤ r< 0.999 9 0.993 6 ≤ r< 0.997 5 0.99 ≤ r< 0.993 6 0.978 ≤ r< 0.99 0.96 ≤ r< 0.978 100 kHz ≤ f ≤ 1 MHz 0.999 9 ≤ r≤ 1 0.997 5 ≤ r< 0.999 9 0.993 6 ≤ r< 0.997 5 0.99 ≤ r< 0.993 6 0.978 ≤ r< 0.99 0.96 ≤ r< 0.978	 $8.6E^{-5}$ r 0.000 43 r 0.000 68 r 0.000 84 r 0.001 2 r 0.001 6 r 9.6^{E-5} r 0.000 48 r 0.000 76 r 0.000 94 r 0.001 4 r 0.001 8 r	Comparison to HP 89441A Vector Signal Analyzer
Digital Modulation RF Quality Modulation Accuracy (Rho)	Mod Frequency Span: f > 1 MHz 0.999 9 ≤ r ≤ 1 0.997 5 ≤ r< 0.999 9 0.993 6 ≤ r< 0.997 5 0.99 ≤ r< 0.993 6 0.978 ≤ r< 0.99 0.96 ≤ r< 0.978	 1.6^{E-4} r 0.000 82 r 0.001 3 r 0.001 6 r 0.002 4 r 0.003 r	Comparison to HP 89441A Vector Signal Analyzer
Phase Modulation – Measure	(0.15 to 10) MHz Rate: (0.02 to 10) kHz <40 Radians Deviation (0.01 to 26.5) GHz Rate: (0.2 to 20) kHz <400 Radians Deviation	 4.1 % Deviation 3.1 % Deviation	Comparison to HP 8902A Measuring Receiver
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	 3.1 % Deviation 1 % Deviation 3.1 % Deviation 1 % Deviation 3.1 % Deviation	Comparison to Keysight E444xA with Opt. 233 Spectrum Analyzer
Distortion Measure	(-99.99 to 0) dB 20 Hz to 20 kHz (20 to 100) kHz	 1.2 dB 2.4 dB	Comparison to HP 8903A/B Audio Analyzer

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Electrical – RF/Microwave Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Power Meter Reference	1 mW 50 MHz	0.23 % of reading	Comparison to Keysight N1914A or E4419A/B Power Meter and N8482A or 8482A Power Sensor
Tuned RF Power - Absolute – Measure 2.5 MHz to 26.5 GHz	(-22 to +10) dBm (-42 to -22) dBm (-50 to -42) dBm (-60 to-50) dBm (-72 to -60) dBm (-80 to -72) dBm (-92 to -80) dBm (-102 to -92) dBm (-110 to -102) dBm (-120 to -110) dBm (-127 to -120) dBm	0.17 dB 0.18 dB 0.2 dB 0.21 dB 0.22 dB 0.23 dB 0.24 dB 0.27 dB 0.28 dB 0.31 dB 0.34 dB	Comparison to HP 8902A Measuring Receiver with HP 11722A or with HP 11792A and HP 11793A Power Sensor
Tuned RF Power - Relative – Measure 2.5 MHz to 26.5 GHz	(+2 to +10) dBm (-12 to +2) dBm (-22 to -12) dBm (-31 to -22) dBm (-40 to -31) dBm (-50 to -40) dBm (-61 to -50) dBm (-71 to -61) dBm (-80 to -71) dBm (-90 to -80) dBm (-100 to -90) dBm (-110 to -100) dBm (-120 to -110) dBm (-127 to -120) dBm	0.08 dB 0.07 dB 0.08 dB 0.09 dB 0.1 dB 0.12 dB 0.15 dB 0.16 dB 0.17 dB 0.19 dB 0.22 dB 0.23 dB 0.27 dB 0.3 dB	Comparison to HP 8902A Measuring Receiver with HP 11722A or with HP 11792A and HP 11793A Power Sensor
RF Absolute Power - Source 50 MHz	(-11 to -1) dB (-30 to -10) dB (-50 to -40) dB -60 dB (-90 to -70) dB -100 dB -110 dB	0.025 dB 0.025 dB 0.027 dB 0.028 dB 0.033 dB 0.04 dB 0.048 dB	Comparison to Signal Source and Step Attenuators PSG, ESG, 8496G/H and 8494G/H

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Electrical – RF/Microwave Elk Horn, IA

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

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source	7 dBm ≥ P ≥ 0 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz 0 dBm > P ≥ -25 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz -25 dBm > P ≥ -70 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz -70 dBm > P ≥ -95 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz -95 dBm > P ≥ -125 dBm 0.3 MHz ≤ f ≤ 1.1 GHz 1.1 GHz ≤ f ≤ 2.985 GHz 2.985 GHz < f ≤ 4 GHz 4 GHz < f ≤ 6 GHz	 0.49 dB 0.58 dB 0.69 dB 0.79 dB 0.49 dB 0.59 dB 0.69 dB 0.8 dB 0.5 dB 0.59 dB 0.69 dB 0.8 dB 0.5 dB 0.6 dB 0.7 dB 0.8 dB 0.51 dB 0.6 dB 0.7 dB 1.5 dB	Comparison to Signal Source PSG, ESG
Harmonic Measurements	(0 to 90) dB 30 Hz to 25 GHz 200 Hz to 80 MHz (10 to 25) GHz	 0.5 dB 1.2 dB 0.8 dB	Comparison to Agilent 8565E Spectrum Analyzer Agilent 3335A Agilent 83650B (based on Agilent 8565E) Signal Generators
Source Errors for CISPR Impulse Spectral Amplitude	(-20 to 45) dB Band A (9 to 150) kHz Band B (0.15 to 30) MHz Band C and D (30 to 1 000) MHz	 0.17 dB 0.22 dB 0.22 dB	CISPR 16-1-1 IGUU 2916 IGUU 2918 Pulse Generators
Source Errors for CISPR Impulse Spectral Amplitude	(-30 to 20) dB Band E (1 to 18) GHz	 0.27 dB	Comparison to Agilent 83650B, Agilent 33250A Signal Generators

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Source Errors for Sinewave Output	(40 to 80) dB Band A Band B Band C/D	 0.17 dB 0.22 dB 0.22 dB	CISPR 16-1-1 IGUU 2916 IGUU 2918 Pulse Generators
Source Errors for Sinewave Output	(40 to 80) dB Band E	 0.27 dB	Comparison to Agilent 83650B, Agilent 33250A Signal Generators
Relative Pulse Response	(0 to 40) dB Band A Band B Band C/D	 0.17 dB 0.22 dB 0.22 dB	CISPR 16-1-1 IGUU 2916 IGUU 2918 Pulse Generators
Relative Pulse Response	(0 to 40) dB Band E	 0.27 dB	Comparison to Agilent 83650B, Agilent 33250A Signal Generators
Impulse Flatness of Spectral Amplitude	(0 to 5) dB Band A Band B Band C/D	 0.14 dB 0.13 dB 0.13 dB	CISPR 16-1-1 Agilent E4440 Spectrum Analyzer
EFT/Burst Generator – Voltage Rise Time Impulse Duration Burst Duration Burst Period Repetition Rate	10 V to 6 kV 5 ns 150 ns 15 ms 0.75 ms 300 ms 5.0 kHz 100 kHz	0.7 % of reading 0.067 ns 0.095 ns 1.4 µs 0.033 µs 0.016 ms 0.23 Hz 5 Hz	EN 61000-4-4; IEC 61000-4-4, IEC 61000-4-4(2004, 2011); GR 1089 CORE ISO 7637-2 Tektronix TDS 5104B Oscilloscope

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Electrical – RF/Microwave Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surge Generator – Ring/ Impulse/ PQF Front Time Open Short Rise Time Open Circuit Short Circuit Time to Half-Value Impulse Duration	(0.1 to 50) µs (0.1 to 50) µs (20 to 1 500) µs	0.004 % of reading + 0.2 ns 0.004 % of reading + 0.2 ns 0.004 % of reading + 0.2 ns	IEC/EN61000-4-5; IEC/EN 61000-4-8; IEC/EN 61000-4-9; IEC/EN 61000-4-10; IEC/EN 61000-4-11; IEC/EN 61000-4-12 UL 864; UL 1449; ISO 7637-2
Surge Generator – Ring/ Impulse/ PQF Voltage Current	10 V to 6.0 kV (6.0 to 18) kV (0.001 to 5) kA	0.7 % of reading 1.1 % of reading 1.1 % of reading	ITU Rec K.17, K.20, ITU Rec K.21; SBC-TP-76200; GR1089CORE
Surge Generator – Ring/ Impulse/ PQF Phase Synchronization	50 Hz 60 Hz 400 Hz	0.11 ° 0.095 ° 0.21 °	IEC/EN 61000-4-18 Tektronix TDS 5104B Oscilloscope PDP8000, P6015A,110 Voltage Probes ANSI C62.41
Mains Harmonic Emissions	(100 to 280) V (0.1 to 20) A (20 to 60) A (0.5 to 179.5)°	0.07 % of reading + 270 mV 0.2 % of reading 0.1 A 0.1°	IEC/EN 61000-3-2; IEC/EN 61000-4-7; IEC/EN 61000-4-13; IEC/EN 61000-4-14
Voltage Fluctuations (Flicker)	(100 to 280) V (0.1 to 20) A (20 to 60) A	0.1 % of reading + 370 mV 0.2 % of reading 0.1 A	IEC/EN 61000-3-3 IEC/EN 61000-3-12 IEC/EN 61000-4-15

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Electrical – RF/Microwave Elk Horn, IA

Parameter/ Equipment	Attenuation – Source [1]										
Reference Standard, Method, and/or Equipment	Comparison to 8494H Attenuator										
Range	**Expanded Uncertainty of Measurement (+/-)**										
Frequency Ranges	Step Attenuation Level in dB										
	1	2	3	4	5	6	7	8	9	10	11
20 Hz ≤ f < 300 kHz	0.002 8	0.002 7	0.002 7	0.002 8	0.002 9	0.002 8	0.002 9	0.002 8	0.002 8	0.002 8	0.003 3
300 kHz ≤ f < 80 MHz	0.002 9	0.002 8	0.002 8	0.003	0.003	0.003	0.003	0.003 4	0.003 7	0.003 7	0.003 8
80 MHz ≤ f < 1 GHz	0.005 4	0.005 4	0.005 4	0.005 3	0.005 4	0.005 4	0.005 1	0.005 4	0.005 4	0.005 9	0.005 3
1 GHz ≤ f < 4 GHz	0.066	0.068	0.068	0.069	0.071	0.071	0.072	0.073	0.073	0.074	0.074
4 GHz ≤ f < 10 GHz	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.11	0.11	0.11
10 GHz ≤ f < 14 GHz	0.14	0.14	0.14	0.14	0.15	0.14	0.14	0.15	0.15	0.14	0.14
14 GHz ≤ f ≤ 18 GHz	0.19	0.18	0.19	0.17	0.2	0.19	0.19	0.19	0.18	0.19	0.2

Electrical – RF/Microwave Elk Horn, IA

Parameter/ Equipment	Attenuation – Source [1]										
Reference Standard, Method, and/or Equipment	Comparison to 8496H Attenuator										
Range	**Expanded Uncertainty of Measurement (+/-)**										
Frequency Ranges	Step Attenuation Level in dB										
	10	20	30	40	50	60	70	80	90	100	110
1 kHz ≤ f < 100 MHz	0.0037	0.0071	0.052	0.064	0.049	0.089	0.083	0.12	0.14	0.16	0.2
100 MHz ≤ f < 300 MHz	0.0042	0.0092	0.058	0.071	0.055	0.089	0.083	0.12	0.14	0.17	0.18
300 MHz ≤ f < 500 MHz	0.0073	0.014	0.065	0.079	0.062	0.096	0.088	0.13	0.14	0.18	0.19
500 MHz ≤ f < 1 GHz	0.0073	0.016	0.082	0.086	0.071	0.1	0.094	0.13	0.15	0.22	0.24
1 GHz ≤ f < 4 GHz	0.0096	0.02	0.097	0.1	0.086	0.11	0.1	0.15	0.16	0.22	0.24
4 GHz ≤ f < 8 GHz	0.011	0.023	0.1	0.11	0.089	0.15	0.14	0.19	0.21	0.36	0.37
8 GHz ≤ f < 10 GHz	0.016	0.032	0.12	0.13	0.11	0.19	0.18	0.27	0.28	0.42	0.45
10 GHz ≤ f < 12 GHz	0.019	0.039	0.12	0.12	0.1	0.16	0.15	0.2	0.23	0.38	0.46
12 GHz ≤ f < 14 GHz	0.022	0.045	0.14	0.14	0.12	0.2	0.19	0.27	0.29	0.43	0.51
14 GHz ≤ f < 18 GHz	0.032	0.063	0.14	0.14	0.12	0.21	0.2	0.27	0.29	0.36	0.5
18 GHz	0.039	0.075	0.16	0.17	0.14	0.26	0.24	0.34	0.36	0.56	0.58

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Electrical – RF/Microwave Elk Horn, IA

Parameter/ Equipment	RF Power Measure										
Reference Standard, Method, and/or Equipment	Comparison to 8487A, 8487D, E9304A-H18 Power Sensors										
Range	**Expanded Uncertainty of Measurement (+/-)**										
Power Range	Frequency Ranges (uncertainties in dB)										
	9 kHz To 50 MHz	50 MHz to 500 MHz	500 MHz to 1.2 GHz	1.2 GHz to 6.0 GHz	6.0 GHz to 14 GHz	14 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz	45 GHz to 50 GHz
-70 to -60 dBm	-	0.819	0.819	0.82	0.821	0.822	0.823	0.824	0.830	0.841	0.843
-60 to -50 dBm	1.789	0.257	0.257	0.258	0.266	0.269	0.28	0.284	0.313	0.360	0.369
-50 to -40 dBm	0.257	0.092	0.093	0.096	0.117	0.125	0.146	0.155	0.205	0.273	0.285
-40 to -30 dBm	0.145	0.094	0.094	0.97	0.118	0.126	0.147	0.156	0.206	0.274	0.286
-30 to -20 dBm	0.108	0.111	0.111	0.113	0.125	0.131	0.175	0.183	0.226	0.275	0.301
-20 to -10 dBm	0.108	0.086	0.080	0.087	0.092	0.101	0.123	0.140	0.145	0.198	0.218
-10 to 0 dBm	0.108	0.087	0.080	0.088	0.093	0.103	0.127	0.145	0.150	0.207	0.228
0 to 10 dBm	0.099	0.087	0.080	0.088	0.093	0.103	0.127	0.145	0.150	0.207	0.228
10 to 20 dBm	0.096	0.100	0.100	0.097	0.109	0.122	0.160	0.170	0.173	0.252	0.270

Mass and Mass Related Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Barometers	(22 to 34) inHg (750 to 1 150) mBar	0.011 inHg 0.39 mBar	Comparison to DPI 740 Barometer

Thermodynamic Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity	(0 to 90) %RH (90 to 100) %RH	1.3 %RH 2.4 %RH	Comparison to Vaisala hygrometer
Relative Humidity	(5 to 90) %RH (90 to 95) %RH	0.81 %RH 1 %RH	Comparison to Rotronic HG2-S101 Humidity Generator and Rotronic H290D sensor

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Thermodynamic Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature	(5 to 60) °C	0.14 °C	Comparison to Rotronics HG2-S101 Humidity Generator and Rotronics H290D sensor
Temperature	(-200 to 0) °C (0 to 200) °C (200 to 660) °C	0.021 °C 0.022 °C 0.027 °C	Comparison to Fluke 5618B, 5628B RTD Probes and 1523 Temperature Indicator
Temperature	(-70 to 0) °C (0 to 180) °C	0.021 °C 0.022 °C	Comparison to Fluke 5628B RTD Probe and 1523 Temperature Indicator, comparison to reference thermometer, in temperature chambers

Time and Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measuring Equipment	1 mHz to 80 MHz	2.5 µHz/Hz + 1 µHz	Comparison to Agilent 33250 Signal Generator with GPS conditioning
Frequency – Measuring Equipment	10 Hz to 4 GHz	0.03 nHz/Hz + 0.6 mHz	Comparison to Fluke 9640 Reference Source with GPS conditioning
Frequency – Measuring Equipment	10 MHz to 50 GHz	0.03 nHz/Hz + 0.6 Hz	Comparison to Agilent 83650B w/ option 008 Signal Generator with GPS conditioning
Frequency – Measuring Equipment 10 MHz Source (Rubidium)	10 MHz	0.03 nHz/Hz	Comparison to Rubidium frequency standard referenced to GPS
Frequency – Measure	1 Hz to 225 MHz 225 MHz to 50 GHz	0.06 nHz/Hz + 25 pHz 0.04 nHz/Hz + 2 Hz	Comparison to Agilent 5335A, 53132A, Agilent 53151A, 53132A Counters, 8565E Spectrum Analyzer with GPS conditioning

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Time and Frequency Elk Horn, IA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure	10 MHz	0.003 nHz/Hz	Comparison to Agilent 53132A Counter referenced to GPS
Time Interval – Measure	120 ps to 400 s	19 µs/s + 24 ps	Comparison to Tektronix TDS 7404B oscilloscope
Time Interval – Measure	(1 to 3 600) s	0.008 8 s	Comparison to Agilent 33250A Signal Generator, with photo comparison

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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. Unitless linear measure.
2. Capability only available in Malaysia.
3. D = diameter in inches, f = frequency, L = length in inches, M = modulation rate, P = power applied, R = resolution of device under test, "ρ" = modulation accuracy or rho, S = step(dB) , T = Temperature in °C, τ = applied toque lbf in.
4. The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The uncertainties presented here do not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
5. Korea: High Wattage Power Supplies are calibrated at Rm 501, 11 Gasan digital 2-ro, Geumcheon-gu, SEOUL Korea, Republic of, 08593.

Jason Stine, Vice President

1899 L Street NW, Suite 1100-A, Washington, DC 20036
414-501-5494
www.anab.org