



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**Transcat – Denver**  
**3251 Lewiston St, Suite 12**  
**Aurora, CO 80011**

Fulfills the requirements of

**ISO/IEC 17025:2017**

and the national standards

**ANSI/NCSL Z540-1-1994 (R2002) AND**  
**ANSI/NCSL Z540.3-2006 (R2013)**

In the fields of

**CALIBRATION & DIMENSIONAL MEASUREMENT**

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](http://www.anab.org).

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 07 September 2023  
Certificate Number: AC-2489.10



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,  
ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)**

**Transcat – Denver**  
3251 Lewiston St, Suite 12  
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**CALIBRATION AND DIMENSIONAL MEASUREMENT**

Valid to: **September 7, 2023**

Certificate Number: **AC-2489.10**

**CALIBRATION**

**Acoustics and Vibration**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Acceleration	(5 to 9) Hz	1.7 % of reading	Master Accelerometer
	(10 to 99) Hz	1.2 % of reading	
	100 Hz	0.75 % of reading	
	(101 to 920) Hz	1 % of reading	
	(921 to 5 000) Hz	1.4 % of reading	
	(5 001 to 10 000) Hz	1.8 % of reading	
	(10 to 15) kHz	2.2 % of reading	
(15 to 20) kHz	2.8 % of reading		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Wave Flatness <sup>1</sup>	Up to 3 V		Thermal Converters, HP 3458A 8.5 Digit Multimeter
	10 Hz to 1 MHz	0.06 % of reading	
	(1 to 10) MHz	0.1 % of reading	
	(10 to 30) MHz	0.18 % of reading	
	(30 to 50) MHz	0.41 % of reading	
	(50 to 80) MHz	0.71 % of reading	
	(80 to 100) MHz	0.84 % of reading	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source <sup>1</sup>	Up to 2 pA (2 to 20) pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA (0.2 to 2) $\mu$ A	0.8 % of reading + 10 fA 0.44 % of reading + 10 fA 0.3 % of reading + 30 fA 0.077 % of reading + 100 fA 0.076 % of reading + 1 pA 0.041 % of reading + 10 pA 0.029 % of reading + 0.1 nA	Keithley 263 Calibrator/Source
	(2 to 220) $\mu$ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	41 $\mu$ A/A + 6 nA 36 $\mu$ A/A + 7 nA 36 $\mu$ A/A + 40 nA 49 $\mu$ A/A + 0.7 $\mu$ A 0.02 % of reading + 12 $\mu$ A	Fluke 5700A/EP Multiproduct Calibrator
	(2.2 to 11) A	0.04 % of reading + 0.48 mA	Fluke 5700A/5725A Multiproduct Calibrator with Amplifier
	(11 to 20.5) A	0.082 % of reading + 0.75 mA	Fluke 5520A Multiproduct Calibrator
	(1 to 10) A (10 to 100) A (100 to 300) A	0.01 % of reading 0.06 % of reading 0.12 % of reading	Guideline 9211 Multi-tap DC Current Shunt, Current Source
DC Clamp-on Ammeters (Non-Toroidal Type) Transformer Type Sensor <sup>1</sup>	(20 to 150) A (150 to 1 000) A	0.5 % of reading + 0.14 A 0.51 % of reading + 0.5 A	Fluke 5520A Multiproduct Calibrator, 5500A/COIL 50-turn Coil
DC Current – Measure <sup>1</sup>	Up to 2 pA (2 to 20) pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA	2.1 % of reading + 6.6 fA 1.9 % of reading + 7 fA 1.9 % of reading + 10 fA 0.3 % of reading + 0.5 pA 0.3 % of reading + 1 pA 0.3 % of reading + 10 pA	Keithley 617 Programmable Electrometer
	(0.2 to 1) $\mu$ A (1 to 10) $\mu$ A (10 to 100) $\mu$ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	26 $\mu$ A/A + 0.4 pA 26 $\mu$ A/A + 0.1 nA 28 $\mu$ A/A + 0.8 nA 29 $\mu$ A/A + 5 nA 29 $\mu$ A/A + 50 nA 47 $\mu$ A/A + 0.5 $\mu$ A 0.11 % of reading + 10 $\mu$ A	Agilent 3458A Opt 002 8.5 Digit Multimeter
	(1 to 10) A (10 to 100) A (100 to 300) A	0.01 % of reading 0.06 % of reading 0.12 % of reading	Guideline 9211 Multi-tap DC Current Shunt, Digital Multimeter

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source <sup>1</sup>	Up to 220 $\mu$ A (10 to 20) Hz (20 to 40 Hz) 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 to 2.2) mA (10 to 20) Hz (20 to 40 Hz) 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (2.2 to 22) mA (10 to 20) Hz (20 to 40 Hz) 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (22 to 220) mA (10 to 20) Hz (20 to 40 Hz) 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.031 % of reading + 16 nA 0.019 % of reading + 10 nA 0.015 % of reading + 8 nA 0.03 % of reading + 12 nA 0.11 % of reading + 65 nA 0.03 % of reading + 40 nA 0.018 % of reading + 35 nA 0.014 % of reading + 35 nA 0.021 % of reading + 0.11 $\mu$ A 0.11 % of reading + 0.65 $\mu$ A 0.039 % of reading + 0.4 $\mu$ A 0.019 % of reading + 0.35 $\mu$ A 0.014 % of reading + 0.35 $\mu$ A 0.022 % of reading + 0.55 $\mu$ A 0.12 % of reading + 5 $\mu$ A 0.033 % of reading + 4 $\mu$ A 0.018 % of reading + 3.5 $\mu$ A 0.015 % of reading + 2.5 $\mu$ A 0.021 % of reading + 3.5 $\mu$ A 0.12 % of reading + 10 $\mu$ A 0.027 % of reading + 35 $\mu$ A 0.046 % of reading + 80 $\mu$ A 0.7 % of reading + 0.16 mA	Fluke 5700A/EP Multiproduct Calibrator
	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.048 % of reading + 0.17 mA 0.096 % of reading + 0.38 mA 0.036 % of reading + 0.75 mA	
AC Current – Source <sup>1</sup> Extended Frequency Ranges	(29 to 330) $\mu$ A (10 to 30) kHz (0.33 to 3.3) mA (10 to 30) kHz (3.3 to 33) mA (10 to 30) kHz (33 to 330) mA (10 to 30) kHz	1.2 % of reading + 0.4 $\mu$ A 0.78 % of reading + 0.6 $\mu$ A 0.31 % of reading + 4 $\mu$ A 0.31 % of reading + 0.2 mA	Fluke 5520A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Clamp-on Ammeters (Toroidal Type) Transformer Type Sensor <sup>1</sup>	(20 to 150) A (45 to 65) Hz (65 to 440) Hz (150 to 1 000) A (45 to 65) Hz (65 to 440) Hz	0.3 % of reading + 26 mA 0.83 % of reading + 47 mA 0.35 % of reading + 0.12 A 1.1 % of reading + 0.22 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil
AC Clamp-on Ammeters (Non-Toroidal Type) Hall Effect Sensor <sup>1</sup>	(20 to 150) A (45z to 65) Hz (65 to 440) Hz (150 to 1 000) A (45 to 65) Hz (65 to 440) Hz	0.57 % of reading + 0.25 A 1 % of reading + 0.25 A 0.6 % of reading + 0.9 A 1.3 % of reading + 0.92 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil
AC Current – Measure <sup>1</sup>	Up to 100 μA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (0.1 to 1) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.4 % of reading + 30 nA 0.15 % of reading + 30 nA 0.063 % of reading + 30 nA 0.063 % of reading + 30 nA 0.4 % of reading + 0.2 μA 0.15 % of reading + 0.2 μA 0.062 % of reading + 0.2 μA 0.034 % of reading + 0.2 μA 0.4 % of reading + 2 μA 0.15 % of reading + 2 μA 0.062 % of reading + 2 μA 0.034 % of reading + 2 μA 0.4 % of reading + 20 μA 0.15 % of reading + 20 μA 0.061 % of reading + 20 μA 0.033 % of reading + 20 μA 0.4 % of reading + 0.2 mA 0.16 % of reading + 0.2 mA 0.085 % of reading + 0.2 mA 0.1 % of reading + 0.2 mA	Agilent 3458A Opt 002 8.5 Digit Multimeter



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure <sup>1</sup>	(1 to 20) A (50 to 100) Hz (100 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 4) kHz (4 to 5) kHz	0.02 % of reading 0.03 % of reading 0.03 % of reading 0.06 % of reading 0.07 % of reading 0.09 % of reading	Fluke Y5020 Precision AC Current Shunt, Precision Digital Multimeter
	(20 to 100) A 10 Hz to 1 kHz	0.12 % of reading	100 A AC Current Shunt, Agilent 3458A 8.5 Digit Multimeter
AC Resistance – Measure <sup>1</sup>	1 kHz 20 Ω to 100 kΩ	0.039 % of reading + 10 mΩ	General Radio 1689 Precision LCR Meter
AC Resistance – Measure	50 Hz to 100 kHz (0.1 to 15) Ω 100 Hz to 100 kHz (15 to 420) Ω 100 Hz to 10 kHz (0.42 to 32) kΩ 100 Hz to 100 kHz (32 to 320) kΩ (0.32 to 10) MΩ	0.12 % of reading 0.06 % of reading 0.06 % of reading 0.06 % of reading 0.12 % of reading	Agilent 4284A Precision LCR Meter
	0.1 Ω 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ	0.17 % of reading 0.12 % of reading 0.12 % of reading 0.05 % of reading 0.05 % of reading 0.13 % of reading 0.26 % of reading	Comparison to Impedance Standards
DC Resistance – Source <sup>1</sup> (Fixed Values)	333 μΩ 1 mΩ 10 mΩ 100 mΩ	0.12 % of reading 0.06 % of reading 0.01 % of reading 0.01 % of reading	Guideline 9211 Precision Multi-tap DC Current Shunt
	1 Ω 10 kΩ	10 μΩ 54 mΩ	Fluke 742A Resistance Standard
	1 GΩ 10 GΩ 100 GΩ 1 TΩ	0.2 % of reading 0.5 % of reading 0.55 % of reading 0.56 % of reading	IET Labs HRRS-Q-8-100k-10 kV Precision Decade Resistor



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance – Measure <sup>1</sup>	Up to 10 Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ (10 to 100) MΩ (0.1 to 1) GΩ	20 μΩ/Ω + 50 μΩ 15 μΩ/Ω + 0.5 mΩ 13 μΩ/Ω + 0.5 mΩ 12 μΩ/Ω + 5 mΩ 13 μΩ/Ω + 50 mΩ 19 μΩ/Ω + 2 Ω 62 μΩ/Ω + 0.1 kΩ 0.059 % of reading + 1 kΩ 0.58 % of reading + 10 kΩ	Agilent 3458A Opt 002 8.5 Digit Multimeter characterized with Standard Resistors.
	(1 to 2) GΩ (2 to 20) GΩ (20 to 200) GΩ	1.7 % of reading + 0.1 MΩ 1.7 % of reading + 1 MΩ 1.8 % of reading + 10 MΩ	Keithley 617 Electrometer
DC Current – Source <sup>1</sup>	Up to 2 pA (2 to 20) pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA (0.2 to 2) μA	0.8 % of reading + 10 fA 0.44 % of reading + 10 fA 0.3 % of reading + 30 fA 0.077 % of reading + 0.1 pA 0.076 % of reading + 1 pA 0.041 % of reading + 10 pA 0.029 % of reading + 0.1 nA	Keithley 263 5.5 Digit Calibrator/Source
	(2 to 20) μA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	41 μA/A + 6 nA 36 μA/A + 7 nA 36 μA/A + 40 nA 49 μA/A + 0.7 μA 0.02 % of reading + 12 μA	Fluke 5700A/EP Multiproduct Calibrator
	(2.2 to 11) A	0.04 % of reading + 0.48 mA	Fluke 5700A/EP Multiproduct Calibrator, Fluke 5725A Amplifier
	(11 to 20.5) A	0.082 % of reading + 0.75 mA	Fluke 5520A Multiproduct Calibrator
	(1 to 10) A (10 to 100) A (100 to 300) A	0.01 % of reading 0.06 % of reading 0.12 % of reading	Guideline 9211 Precision Multi-tap DC Current Shunt
	DC Current – Measure <sup>1</sup>	Up to 2 pA (2 to 20) pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA	2.1 % of reading + 6.6 fA 1.9 % of reading + 7 fA 1.9 % of reading + 10 fA 0.3 % of reading + 0.5 pA 0.3 % of reading + 1 pA 0.3 % of reading + 10 pA
(0.2 to 1) μA (1 to 10) μA		26 μA/A + 0.4 pA 26 μA/A + 0.1 nA	Agilent 3458A Opt 002 8.5 Digit Multimeter



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure <sup>1</sup>	(10 to 100) $\mu$ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	28 $\mu$ A/A + 0.8 nA 29 $\mu$ A/A + 5 nA 29 $\mu$ A/A + 50 nA 47 $\mu$ A/A + 0.5 $\mu$ A 0.11 % of reading + 10 $\mu$ A	Agilent 3458A Opt 002 8.5 Digit Multimeter
	(1 to 10) A (10 to 100) A (100 to 300) A	0.01 % of reading 0.06 % of reading 0.12 % of reading	Guideline 9211 Precision Multi-tap DC Current Shunt, Precision Multimeter
DC Clamp-on Ammeters (Non-Toroidal Type) Hall Effect Sensor <sup>1</sup>	(20 to 150) A (150 to 1 000) A	0.5 % of reading + 0.14 A 0.51 % of reading + 0.5 A	Fluke 5520A Multiproduct Calibrator, 5500A/COIL 50-turn Coil
DC Voltage – Source <sup>1</sup>	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V	8.5 $\mu$ V/V + 0.5 $\mu$ V 5.1 $\mu$ V/V + 0.7 $\mu$ V 4 $\mu$ V/V + 2.5 $\mu$ V 4 $\mu$ V/V + 4 $\mu$ V 6.2 $\mu$ V/V + 40 $\mu$ V	Fluke 5700A/EP Multiproduct Calibrator
	(220 to 1 100) V	7.6 $\mu$ V/V + 0.5 mV	Fluke 5700A/EP Multiproduct Calibrator, Fluke 5725A Amplifier
DC Voltage – Measure <sup>1</sup>	(0 to 100) mV (0.1 to 10) V (10 to 100) V (100 to 500) V (500 to 800) V (800 to 1 000) V	10 $\mu$ V/V + 0.5 $\mu$ V 5.2 $\mu$ V/V + 0.5 $\mu$ V 7.9 $\mu$ V/V + 30 $\mu$ V 12 $\mu$ V/V + 0.1 mV 15 $\mu$ V/V + 0.1 mV 21 $\mu$ V/V + 0.1 mV	Agilent 3458A Opt 002 8.5 Digit Multimeter
DC High Voltage – Measure <sup>1</sup>	(1 to 5) kV (5 to 10) kV (10 to 20) kV (20 to 50) kV (50 to 70) kV (70 to 100) kV	0.04 % of reading + 0.26 V 0.04 % of reading + 1.7 V 0.065 % of reading + 1.1 V 0.066 % of reading + 10 V 0.067 % of reading + 28 V 0.069 % of reading + 81 V	Vitrek 4700 Digital HV Meter, Associated High Voltage Probes





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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup>	Up to 2.2 mV		Fluke 5700A/EP Multiproduct Calibrator
	(10 to 20) Hz	0.16 % of reading + 4 μV	
	(20 to 40) Hz	0.1 % of reading + 4 μV	
	40 Hz to 20 kHz	0.078 % of reading + 4 μV	
	(20 to 50) kHz	0.13 % of reading + 4 μV	
	(50 to 100) kHz	0.17 % of reading + 5 μV	
	(100 to 300) kHz	0.33 % of reading + 10 μV	
	(300 to 500) kHz	0.47 % of reading + 20 μV	
	500 kHz to 1 MHz	0.58 % of reading + 20 μV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.042 % of reading + 4 μV	
	(20 to 40) Hz	0.03 % of reading + 4 μV	
	40 Hz to 20 kHz	0.014 % of reading + 4 μV	
	(20 to 50) kHz	0.03 % of reading + 4 μV	
	(50 to 100) kHz	0.058 % of reading + 5 μV	
	(100 to 300) kHz	0.12 % of reading + 10 μV	
	(300 to 500) kHz	0.16 % of reading + 20 μV	
	500 kHz to 1 MHz	0.27 % of reading + 20 μV	
	(22 to 220) mV		
	(10 to 20) Hz	0.028 % of reading + 12 μV	
	(20 to 40) Hz	0.011 % of reading + 7 μV	
	40 Hz to 20 kHz	0.008 % of reading + 7 μV	
	(20 to 50) kHz	0.021 % of reading + 7 μV	
	(50 to 100) kHz	0.047 % of reading + 17 μV	
	(100 to 300) kHz	0.091 % of reading + 20 μV	
	(300 to 500) kHz	0.14 % of reading + 25 μV	
	500 kHz to 1 MHz	0.28 % of reading + 45 μV	
	(0.22 to 2.2) V		
(10 to 20) Hz	0.027 % of reading + 40 μV		
(20 to 40) Hz	0.011 % of reading + 15 μV		
40 Hz to 20 kHz	0.0048 % of reading + 8 μV		
(20 to 50) kHz	0.0084 % of reading + 10 μV		
(50 to 100) kHz	0.012 % of reading + 30 μV		
(100 to 300) kHz	0.043 % of reading + 80 μV		
(300 to 500) kHz	0.1 % of reading + 0.2 mV		
500 kHz to 1 MHz	0.18 % of reading + 0.3 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup>	(2.2 to 22) V		Fluke 5700A/EP Multiproduct Calibrator
	(10 to 20) Hz	0.028 % of reading + 0.4 mV	
	(20 to 40) Hz	0.01 % of reading + 0.15 mV	
	40 Hz to 20 kHz	0.004 9 % of reading + 50 μV	
	(20 to 50) kHz	0.008 3 % of reading + 0.1 mV	
	(50 to 100) kHz	0.012 % of reading + 0.2 mV	
	(100 to 300) kHz	0.03 % of reading + 0.6 mV	
	(300 to 500) kHz	0.11 % of reading + 2 mV	
	500 kHz to 1 MHz	0.17 % of reading + 3.2 mV	
	(22 to 220) V		
	(10 to 20) Hz	0.028 % of reading + 4 mV	
	(20 to 40) Hz	0.01 % of reading + 1.5 mV	
	40 Hz to 20 kHz	0.005 6 % of reading + 0.6 mV	
	(20 to 50) kHz	0.009 3 % of reading + 1 mV	
(50 to 100) kHz	0.016 % of reading + 2.5 mV		
(100 to 300) kHz	0.09 % of reading + 16 mV		
(300 to 500) kHz	0.44 % of reading + 40 mV		
500 kHz to 1 MHz	0.8 % of reading + 80 mV		
AC Voltage – Source <sup>1</sup>	(220 to 750) V		Fluke 5700A/EP Multiproduct Calibrator, Fluke 5725A Amplifier
	(30 to 50) kHz	0.061 % of reading + 11 mV	
	(50 to 100) kHz	0.23 % of reading + 45 mV	
	(220 to 1 100) V		
	40 Hz to 1 kHz	0.011 % of reading + 4 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
(20 to 30) kHz	0.067 % of reading + 11 mV		
AC Voltage – Measure <sup>1</sup>	Up to 1 mV		Rohde & Schwarz URE3 RMS Voltmeter
	100 kHz to 1 MHz	1.8 % of reading + 2.4 μV	
	(1 to 3) MHz	3.5 % of reading + 2.4 μV	
	(3 to 10) MHz	9.3 % of reading + 2.4 μV	
	(10 to 20) MHz	23 % of reading + 2.4 μV	
	(1 to 3) mV		
	100 kHz to 1 MHz	0.97 % of reading + 2 μV	
	(1 to 3) MHz	3.5 % of reading + 2 μV	
	(3 to 10) MHz	9.3 % of reading + 2 μV	
	(10 to 20) MHz	23 % of reading + 2 μV	
	(3 to 100) mV		
	100 kHz to 1 MHz	0.91 % of reading + 3 μV	
	(1 to 3) MHz	1.8 % of reading + 3 μV	
	(3 to 10) MHz	2.9 % of reading + 3 μV	
(10 to 20) MHz	6.9 % of reading + 3 μV		
(20 to 30) MHz	14 % of reading + 3 μV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure <sup>1</sup>	Up to 10 mV		Agilent 3458A Opt 002 8.5 Digit Multimeter
	(1 to 40) Hz	0.039 % of reading + 3 μV	
	40 Hz to 1 kHz	0.028 % of reading + 1 μV	
	(1 to 20) kHz	0.038 % of reading + 1 μV	
	(20 to 50) kHz	0.15 % of reading + 1 μV	
	(50 to 100) kHz	0.59 % of reading + 1 μV	
	(100 to 300) kHz	4.6 % of reading + 2 μV	
	(10 to 100) mV		
	(1 to 40) Hz	0.013 % of reading + 4 μV	
	40 Hz to 1 kHz	0.009 5 % of reading + 2 μV	
	(1 to 20) kHz	0.017 % of reading + 2 μV	
	(20 to 50) kHz	0.037 % of reading + 2 μV	
	(50 to 100) kHz	0.093 % of reading + 2 μV	
	(100 to 300) kHz	0.36 % of reading + 10 μV	
	300 kHz to 1 MHz	1.2 % of reading + 10 μV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.009 8 % of reading + 40 μV	
	40 Hz to 1 kHz	0.009 4 % of reading + 20 μV	
	(1 to 20) kHz	0.017 % of reading + 20 μV	
	(20 to 50) kHz	0.036 % of reading + 20 μV	
	(50 to 100) kHz	0.093 % of reading + 20 μV	
	(100 to 300) kHz	0.35 % of reading + 0.1 mV	
	300 kHz to 1 MHz	1.2 % of reading + 0.1 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.009 5 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.009 5 % of reading + 0.2 mV	
	(1 to 20) kHz	0.017 % of reading + 0.2 mV	
	(20 to 50) kHz	0.036 % of reading + 0.2 mV	
(50 to 100) kHz	0.093 % of reading + 0.2 mV		
(100 to 300) kHz	0.35 % of reading + 1 mV		
300 kHz to 1 MHz	1.2 % of reading + 1 mV		
(10 to 100) V			
(1 to 40) Hz	0.024 % of reading + 4 mV		
40 Hz to 1 kHz	0.024 % of reading + 2 mV		
(1 to 20) kHz	0.024 % of reading + 2 mV		
(20 to 50) kHz	0.041 % of reading + 2 mV		
(50 to 100) kHz	0.14 % of reading + 2 mV		
(100 to 300) kHz	0.46 % of reading + 10 mV		
300 kHz to 1 MHz	1.7 % of reading + 10 mV		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure <sup>1</sup>	(100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.047 % of reading + 40 mV 0.047 % of reading + 20 mV 0.071 % of reading + 20 mV 0.14 % of reading + 20 mV 0.35 % of reading + 20 mV	Agilent 3458A Opt 002 8.5 Digit Multimeter
AC High Voltage – Measure <sup>1</sup>	(0.7 to 5) kV (10 to 200) Hz (200 to 450) Hz (5 to 10) kV (10 to 200) Hz (200 to 450) Hz (10 to 20) kV (30 to 70) Hz (70 to 200) Hz (200 to 450) Hz (20 to 50) kV (30 to 70) Hz (70 to 200) Hz (200 to 450) Hz (50 to 70) kV (30 to 70) Hz (70 to 200) Hz	0.14 % of reading + 0.34 V 0.47 % of reading + 0.34 V 0.16 % of reading + 1.9 V 0.47 % of reading + 1.9 V 0.16 % of reading + 1.4 V 1.2 % of reading + 1.4 V 2.9 % of reading + 1.8 V 0.16 % of reading + 11 V 1.2 % of reading + 11 V 2.9 % of reading + 21 V 0.16 % of reading + 28 V 1.2 % of reading + 28 V	Vitrek 4700 Digital HV Meter, Associated High Voltage Probes
Capacitance – Source <sup>1</sup> (Artifact)	1 kHz (0.1 to 0.5) nF 0.5 nF to 1.4 μF	0.59 pF 0.12 % of reading + 0.018 pF	Arco SS32 Capacitor Set
	1 kHz to 1 MHz 1 pF 10 pF 100 pF 1 nF 120 Hz to 100 kHz 10 nF 100 nF 1 μF	0.06 % of reading 0.004 % of reading 0.004 % of reading 0.007 % of reading 0.007 % of reading 0.007 % of reading 0.007 % of reading 0.007 % of reading	HP 16380A Series Standard Air Capacitor Set
Capacitance – Source <sup>1</sup> (Simulated)	10 Hz to 10 kHz (0.19 to 1.1) nF 10 Hz to 3 kHz (1.1 to 3.3) nF	0.39 % of reading + 7.8 pF 0.39 % of reading + 7.8 pF	Fluke 5520A Multiproduct Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment		
Capacitance – Source <sup>1</sup> (Simulated)	10 Hz to 1 kHz (3.3 to 11) nF	0.2 % of reading + 7.8 pF	Fluke 5520A Multiproduct Calibrator		
	(11 to 110) nF	0.2 % of reading + 78 pF			
	(110 to 330) nF	0.2 % of reading + 0.23 nF			
	(10 to 600) Hz (0.33 to 1.1) μF	0.2 % of reading + 0.78 nF			
	(10 to 300) Hz (1.1 to 3.3) μF	0.2 % of reading + 2.3 nF			
	(10 to 150) Hz (3.3 to 11) μF	0.2 % of reading + 7.8 nF			
	(10 to 120) Hz (11 to 33) μF	0.32 % of reading + 23 nF			
	(10 to 80) Hz (33 to 110) μF	0.35 % of reading + 78 nF			
	DC to 50 Hz (110 to 330) μF	0.37 % of reading + 0.23 μF			
	DC to 20 Hz (0.33 to 1.1) mF	0.37 % of reading + 0.78 μF			
	DC to 6 Hz (1.1 to 3.3) mF	0.35 % of reading + 2.3 μF			
	DC to 2 Hz (3.3 to 11) mF	0.35 % of reading + 7.8 μF			
	DC to 0.6 Hz (11 to 33) mF	0.58 % of reading + 23 μF			
	DC to 0.2 Hz (33 to 110) mF	0.85 % of reading + 78 μF			
	Capacitance – Measure <sup>1</sup>	1 kHz Up to 10 pF		0.47 % of reading + 0.05 pF	General Radio 1689 Precision LCR Meter
		(10 to 100) pF		0.058 % of reading + 0.05 pF	
(0.1 to 1) μF		0.024 % of reading + 0.05 pF			
(1 to 100) μF		0.04 % of reading			
(0.1 to 1) mF		0.24 % of reading			
1 MHz		(10 to 90) pF	0.12 % of reading	Agilent 4284A Precision LCR Meter	
		90 pF to 10 nF	0.06 % of reading		
		100 kHz (12 to 90) pF	0.12 % of reading		
		90 pF to 100 nF	0.06 % of reading		
		(0.1 to 100) μF	0.12 % of reading		



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure <sup>1</sup>	10 kHz (10 to 80) pF 80 pF to 1 μF 400 Hz 10 nF to 10 μF (100 to 120) Hz 10 nF to 100 μF 100 μF to 12 mF	0.12 % of reading 0.06 % of reading 0.06 % of reading 0.06 % of reading 0.12 % of reading	Agilent 4284A Precision LCR Meter
Inductance – Source <sup>1</sup> (Artifact)	1 kHz 100 mH	0.14 mH	Standard Inductor
Inductance – Measure <sup>1</sup>	100 Hz to 1 kHz (1 to 100) mH (0.1 to 10) H 400 Hz 5 μH to 5 mH 5 mH to 10 H (100 to 120) Hz (0.12 to 20) mH 20 mH to 10 H 1 kHz 1 μH to 1 mH 10 kHz 5 nH to 120 μH 120 μH to 100 mH	0.04 % of reading + 0.1 μH 0.057 % of reading + 1.4 μH 0.12 % of reading 0.06 % of reading 0.12 % of reading 0.06 % of reading 0.12 % of reading 0.12 % of reading 0.06 % of reading	Agilent 4284A Precision LCR Meter
Oscilloscopes <sup>1</sup> Amplitude – DC into 50 Ω load into 1 MΩ load Amplitude – Square Wave Rate: 10 Hz to 10 kHz into 50 Ω load into 1 MΩ load Rate: 10 Hz to 100 kHz into 50 Ω load into 1 MΩ load	(-5 to 5) V (-200 to 200) V 40 μVp-p to 1 mVp-p 1 mVp-p to 5 Vp-p 40 μVp-p to 1 mVp-p 1 mVp-p to 5 Vp-p 1 mVp-p to 200 Vp-p	0.023 % of reading + 19 μV 0.023 % of reading + 19 μV 0.78 % of reading + 7.8 μV 0.078 % of reading + 7.8 μV 0.78 % of reading + 7.8 μV 0.16 % of reading + 7.8 μV 0.78 % of reading + 7.8 μV	Fluke 9500B Oscilloscope Calibrator, Fluke 9530 3.2 GHz Active Head, Fluke 9560 Active Head w/ 70 ps Capability

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes <sup>1,2</sup>			
Time Markers			
100 mVp-p to 1 Vp-p into 50 Ω load	9.009 1 ns to 83 μs	0.19 μs/s	
Square Wave	83 μs to 55s	2.3 μs/s	
	450.5 ps to 9.009 ns	0.19 μs/s	
Sine Wave	900.91 ns to 83 μs	0.19 μs/s	
	83 μs to 55s	2.3 μs/s	
Pulse	900.91 ns to 83 μs	0.19 μs/s	
	83 μs to 55s	2.3 μs/s	
Triangle Wave	83 μs to 55 s	2.3 μs	
Rise Time into 50 Ω load	5 mVp-p to 3 Vp-p		
Rate: 10 Hz to 2 MHz	500 ps (nominal)	290 ps	
	150 ps (nominal)	34 ps	
	25 mVp-p to 2 Vp-p		
Rate: 10 Hz to 1 MHz	70 ps (nominal)	21 ps	
	425 mVp-p to 575 mVp-p		
	25 ps (nominal)	5.7 ps	
	200 mVp-p		
	16 ps (nominal)	2.1 ps	
Leveled Sine Wave			
50 kHz Reference into 50 Ω load	5 mVp-p to 5 Vp-p		
	50 kHz to 10 MHz	1.2 % of reading	
Input Impedance Measure	(10 to 40) Ω	0.39 % of reading	
	(40 to 90) Ω	0.083 % of reading	
	(90 to 150) Ω	0.39 % of reading	
	(50 to 800) kΩ	0.39 % of reading	
	(0.8 to 1.2) MΩ	0.083 % of reading	
	(1.2 to 12) MΩ	0.39 % of reading	
Input Capacitance Measure	(1 to 35) pF	1.6 % of reading + 0.19 pF	
	(35 to 95) pF	2.3 % of reading + 0.19 pF	
			Fluke 9500B Oscilloscope Calibrator, Fluke 9530 3.2 GHz Active Head, Fluke 9550 Active Head w/ 25 ps Capability, Fluke 9560 Active Head w/ 70 ps Capability, Tektronix 067-1330-000 Calibration Fixture



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase – Source <sup>1</sup>	Up to 180 ° (10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 20) kHz	0.11 ° 0.2 ° 0.4 ° 1.9 ° 3.9 ° 7.8 °	Fluke 5520A Multiproduct Calibrator
DC Power – Source <sup>1</sup> (0.33 to 330) mA	11 μW to 1.1 mW 1.1 mW to 0.11 W (0.11 to 110) W (110 to 330) W	0.024 % of reading 0.027 % of reading 0.024 % of reading 0.018 % of reading	Fluke 5520A Multiproduct Calibrator
(0.33 to 3) A	11 μW to 110 mW (0.11 to 990) W (0.99 to 3) kW	0.044 % of reading 0.053 % of reading 0.009 6 % of reading	
(3 to 20.5) A	99 mW to 0.99 W 0.99 W to 6.8 kW (6.8 to 20.5) kW	0.088 % of reading 0.07 % of reading 0.04 % of reading	
AC Power – Source <sup>1,3</sup> PF = 1			Fluke 5520A Multiproduct Calibrator
(3.3 to 9) mA	(10 to 65) Hz (0.11 mW to 3) mW 3 mW to 9 W	0.13 % of reading 0.077 % of reading	
(9 to 33) mA	(10 to 65) W (0.3 to 10) mW 10 mW to 33 W	0.089 % of reading 0.077 % of reading	
(33 to 90) mA	(10 to 65) Hz (1 to 30) mW 30 mW to 90 W	0.071 % of reading 0.057 % of reading	
(90 to 330) mA	(10 to 65) Hz (3 to 100) mW 100 mW to 300 W	0.089 % of reading 0.078 % of reading	
(0.33 to 0.9) A	(10 to 65) Hz (11 to 300) mW (0.3 to 900) W	0.071 % of reading 0.081 % of reading	
(0.9 to 2.2) A	(10 to 65) Hz (30 to 720) mW 0.72 W to 2 kW	0.089 % of reading 0.079 % of reading	





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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Source <sup>1,3</sup> PF = 1 (2.2 to 4.5) A (4.5 to 20.5) A	(10 to 65) Hz 80 mW to 1.4 W 1.4 W to 4.5 kW (10 to 65) Hz 150 mW to 230 kW	0.088 % of reading 0.18 % of reading 0.17 % of reading	Fluke 5520A Multiproduct Calibrator
Electrical Simulation of Thermocouple Indicating Devices – Measure/Source <sup>1</sup>	Type B (250 to 350) °C (350 to 445) °C (445 to 580) °C (580 to 750) °C (750 to 1 000) °C (1 000 to 1 820) °C Type C (0 to 250) °C (250 to 1 000) °C (1 000 to 1 500) °C (1 500 to 1 800) °C (1 800 to 2 000) °C (2 000 to 2 250) °C (2 250 to 2 315) °C Type E (-270 to -245) °C (-245 to -195) °C (-195 to -155) °C (-155 to -90) °C (-90 to 0) °C (0 to 15) °C (15 to 890) °C (890 to 1 000) °C Type J (-210 to -180) °C (-180 to -120) °C (-120 to -50) °C (-50 to 990) °C (990 to 1 200) °C	1.2 °C 0.9 °C 0.71 °C 0.55 °C 0.45 °C 0.35 °C 0.24 °C 0.19 °C 0.21 °C 0.24 °C 0.27 °C 0.33 °C 0.37 °C 1.6 °C 0.24 °C 0.12 °C 0.095 °C 0.08 °C 0.076 °C 0.064 °C 0.074 °C 0.15 °C 0.12 °C 0.093 °C 0.08 °C 0.094 °C	Ectron 1140A Thermocouple Calibrator/Simulator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices – Measure/Source <sup>1</sup>	Type K		Ectron 1140A Thermocouple Calibrator/Simulator
	(-270 to -255) °C	2.5 °C	
	(-255 to -195) °C	0.85 °C	
	(-195 to -115) °C	0.16 °C	
	(-115 to -55) °C	0.12 °C	
	(-55 to 1 000) °C	0.08 °C	
	(1 000 to 1 372) °C	0.094 °C	
	Type N		
	(-270 to -260) °C	5.4 °C	
	(-260 to -200) °C	1.5 °C	
	(-200 to -140) °C	0.29 °C	
	(-140 to -70) °C	0.18 °C	
	(-70 to 25) °C	0.14 °C	
	(25 to 160) °C	0.12 °C	
	(160 to 1 300) °C	0.11 °C	
	Type R		
	(-50 to -30) °C	0.8 °C	
	(-30 to 45) °C	0.69 °C	
	(45 to 160) °C	0.49 °C	
	(160 to 380) °C	0.41 °C	
	(380 to 775) °C	0.35 °C	
	(775 to 1 768) °C	0.26 °C	
	Type S		
	(-50 to -30) °C	0.76 °C	
	(-30 to 45) °C	0.68 °C	
	(45 to 105) °C	0.49 °C	
	(105 to 310) °C	0.41 °C	
	(310 to 615) °C	0.35 °C	
(615 to 1 768) °C	0.31 °C		
Type T			
(-270 to -255) °C	1.9 °C		
(-255 to -240) °C	0.6 °C		
(-240 to -210) °C	0.36 °C		
(-210 to -150) °C	0.22 °C		
(-150 to -40) °C	0.15 °C		
(-40 to 100) °C	0.095 °C		
(100 to 400) °C	0.08 °C		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bandwidth Flatness Measure <sup>1</sup> into VSWR (1.2:1) (wrt Reference Frequency)	5 mVp-p to 5 Vp-p 100 Hz to 300 MHz (300 to 550) MHz	1.6 % of reading 1.9 % of reading	Fluke 9500B/3200 Oscilloscope Calibrator, Fluke 9530 3.2 GHz Active Head
	5 mVp-p to 3 Vp-p 550 MHz to 1.1 GHz (1.1 to 2.5) GHz	2.7 % of reading 3.1 % of reading	
	5 mVp-p to 2 Vp-p (2.5 to 3.2) GHz	3.1 % of reading	
Bandwidth Flatness Measure <sup>1</sup> into VSWR (1.2:1)	5 mVp-p to 5 Vp-p 100 Hz to 300 MHz (300 to 550) MHz	1.6 % of reading 1.9 % of reading	Fluke 9500B/1100 Oscilloscope Calibrator, Fluke 9560 6 GHz Active Head
	5 mVp-p to 3 Vp-p 550 MHz to 1.1 GHz (1.1 to 2.5) GHz	2.3 % of reading 2.3 % of reading	
	5 mVp-p to 2 Vp-p (2.5 to 3) GHz	2.3 % of reading	
	25 mVp-p to 2 Vp-p (3 to 6) GHz	3.1 % of reading	
Rise Time – Source <sup>1</sup>			

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – AM Depth Measure <sup>1</sup> Rate: 50 Hz to 10 kHz	150 kHz to 10 MHz (5 to 40) % Depth (40 to 99) % Depth	0.85 % Depth 2.22 % Depth	HP 8902A Measuring Receiver, HP 11722A Power Sensor
	Rate: (20 to 50) Hz 150 kHz to 10 MHz (5 to 40) % Depth (40 to 99) % Depth	1.25 % Depth 3.21 % Depth	
	Rate: 50 Hz to 50 kHz 10 MHz to 1.3 GHz (5 to 40) % Depth (40 to 99) % Depth	0.45 % Depth 1.23 % Depth	



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**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – AM Depth Measure <sup>1</sup> Rate: 50 Hz to 50 kHz	(1.3 to 26.5) GHz (5 to 40) % Depth (40 to 99) % Depth	0.65 % Depth 1.72 % Depth	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
	10 MHz to 26.5 GHz (5 to 40) % Depth (40 to 99) % Depth	1.25 % Depth 3.21 % Depth	
FM Modulation – Measure <sup>1</sup> Rate: 20 Hz to 10 kHz	Up to 4 kHz 250 kHz to 10 MHz (4 to 40) kHz (40 to 400) kHz	2.1 of reading + 20 Hz 2.1 % of reading + 22 Hz 2.1 % of reading + 100 Hz 2.1 % of reading + 100 Hz	HP 8902A Measuring Receiver, HP 11722A Power Sensor
FM Modulation – Measure <sup>1</sup> Rate: 50 Hz to 100 kHz	Up to 4 kHz 100 MHz to 26.5 GHz	1.1 % of reading + 20 Hz	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
	(4 to 40) kHz 100 MHz to 26.5 GHz	1.1 % of reading + 22 Hz	
	(40 to 400) kHz 100 MHz to 26.5 GHz	1.1 % of reading + 100 Hz	
FM Modulation – Measure <sup>1</sup> Rate: (20 to 50) Hz	Up to 4 kHz 100 MHz to 26.5 GHz	5 % of reading + 20 Hz	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
	(4 to 40) kHz 100 MHz to 26.5 GHz	5 % of reading + 22 Hz	
	(40 to 400) kHz 100 MHz to 26.5 GHz	5 % of reading + 100 Hz	
FM Modulation – Measure <sup>1</sup> Rate: (100 to 200) kHz	Up to 4 kHz 100 MHz to 26.5 GHz	5 % of reading + 100 Hz	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
	(4 to 40) kHz 100 MHz to 26.5 GHz	5 % of reading + 100 Hz	
	(40 to 400) kHz 100 MHz to 26.5 GHz	5 % of reading + 100 Hz	
Phase Modulation – Measure <sup>1</sup> Rate: 200 Hz to 10 kHz	Up to 4 rad 150 kHz to 10 MHz	4.2 % of reading + 0.03 rad	HP 8902A Measuring Receiver, HP 11722A Power Sensor
	(4 to 40) rad 150 kHz to 10 MHz	4.2 % of reading + 0.03 rad	
	(40 to 400) rad 150 kHz to 10 MHz	4.2 % of reading + 0.1 rad	
	150 kHz to 10 MHz	4.2 % of reading + 0.1 rad	

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
Phase Modulation – Measure <sup>1</sup> 200 Hz to 20 kHz	Up to 4 rad 10 MHz to 26.5 GHz	3.6 % of reading + 0.03 rad	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter	
	(4 to 40) rad 10 MHz to 26.5 GHz	3.6 % of reading + 0.03 rad		
	(40 to 400) rad 10 MHz to 26.5 GHz	3.6 % of reading + 0.1 rad		
Harmonic Distortion <sup>1</sup>	(-80 to 0) dBc 30 Hz to 6.5 GHz	1.7 dB	Agilent 8563E Spectrum Analyzer	
	(6.5 to 22) GHz	2.6 dB		
	(22 to 26.5) GHz	3.4 dB		
Total Harmonic Distortion – Measure <sup>1</sup>	(-80 to 0) dB 20 Hz to 20 kHz	1.2 dB	Agilent 8903B Audio Analyzer	
	(20 to 100) kHz	2.3 dB		
AM Total Harmonic Distortion – Measure <sup>1</sup>	(-80 to 0) dB 20 Hz to 100 kHz	2.7 dB	Agilent 8903B Audio Analyzer	
Total Harmonic Distortion - Measure <sup>1</sup> Input Voltage Range 5 Hz to 1.2 MHz	< 30 V	(0.3 to 100) % THD 10 Hz to 1 MHz	3 % of reading	Agilent 334A Distortion Analyzer
		(1 to 3) MHz	6 % of reading	
		0.1 % THD (10 to 20) Hz	12 % of reading	
		(20 to 30) Hz	6 % of reading	
		30 Hz to 300 kHz	3 % of reading	
	> 30 V	(300 to 500) kHz	6 % of reading	
		500 kHz to 1.2 MHz	12 % of reading	
		(0.3 to 100) % THD 10 Hz to 300 kHz	3 % of reading	
		(300 to 500) kHz	6 % of reading	
		500 kHz to 3 MHz	12 % of reading	
0.1 % THD	(20 Hz to 30) Hz	12 % of reading		
	30 Hz to 300 kHz	3 % of reading		
	(300 to 500) kHz	6 % of reading		
	500 kHz to 1.2 MHz	12 % of reading		
Rise Time – Source <sup>1,2</sup>	≥ 14 ps	2.4 ps	Pulser	

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rise Time – Measure	≥ 17 ps	3.9 ps	Sampling System
Absolute RF Power – Measure <sup>1</sup>	50 MHz 1 mW (0 dBm) (Reference)	0.028 dB	Agilent 478A-H75 Thermistor, Agilent 432A Power Meter, Agilent 3458A 8.5 Digit Multimeter
Absolute RF Power – Measure <sup>1</sup>	100 kHz to 2.6 GHz (-20 to -10) dBm (-10 to 0) dBm (0 to 10) dBm (10 to 20) dBm (20 to 30) dBm (2.6 to 12) GHz (-20 to -10) dBm (-10 to 0) dBm (0 to 10) dBm (10 to 20) dBm (20 to 30) dBm (12 to 18) GHz (-20 to -10) dBm (-10 to 0) dBm (0 to 10) dBm (10 to 20) dBm (20 to 30) dBm (18 to 26.5) GHz (-20 to -10) dBm (-10 to 0) dBm (0 to 5) dBm	0.15 dB 0.12 dB 0.12 dB 0.12 dB 0.12 dB 0.14 dB 0.13 dB 0.13 dB 0.13 dB 0.13 dB 0.15 dB 0.13 dB 0.13 dB 0.13 dB 0.13 dB 0.15 dB 0.15 dB 0.16 dB	Agilent 8902A Measuring Receiver, Agilent 11722A Power Sensor, Agilent 11792A Microwave Converter, Agilent 11793A Microwave Converter
Reflection (VSWR) <sup>1,4</sup> 10 MHz to 18 GHz	(Rho) 0.022 to 0.1 0.1 to 0.2 0.2 to 0.3 0.3 to 0.4	(Rho) 0.022 0.027 0.033 0.042	VSWR Bridge

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Tuned RF Power – Measure <sup>1</sup>	2.5 MHz to 26 GHz		HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11793A Microwave Converter
	(-120 to -100) dB	0.37 dB	
	(-100 to -80) dB	0.34 dB	
	(-80 to -60) dB	0.23 dB	
	(-60 to -40) dB	0.18 dB	
	(-40 to -20) dB	0.14 dB	
	(-20 to 0) dB	0.12 dB	
	(18 to 26) GHz		
	(-80 to -60) dB	0.22 dB	
	(-60 to -40) dB	0.18 dB	
(-40 to -20) dB	0.15 dB		
(-20 to 0) dB	0.13 dB		

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle Measuring Devices <sup>5</sup>	Up to 85 °	1.5"	Master Angle Blocks
	90 °	1.9"	Master Square
Micrometers, Calipers <sup>1,5</sup> (Outside, Inside, and Depth)	(0.05 to 48) in	(8 + 8L) μin	Gage Blocks
Anvil Flatness <sup>1</sup>	Up to 1 in	4.5 μin	Optical Flats
Indicators <sup>1,5</sup> (Dial and Digital)	Up to 0.05 in	28 μin	Dial Indicator Calibrator
	(0.05 to 5) in	(44 + 4L) μin	Horizontal Comparator
Length – Single Axis <sup>5</sup> Outside Measurement	Up to 5 in	(6 + 8L) μin	Horizontal Comparator
	Inside Dimension	Up to 5 in	
Height Measuring Equipment <sup>1,5</sup>	(0.4 to 8) in	(29 + 6L) μin	Gage Blocks
	(8 to 48) in	(12 + 8L) μin	
Cylindrical Plug Gages <sup>5</sup> Outside Diameter	Up to 5 in	(6 + 8L) μin	Horizontal Comparator
Cylindrical Ring Gages <sup>5</sup> Inside Diameter	Up to 5 in	(22 + 3L) μin	Horizontal Comparator
Rulers, Tape Measures <sup>5</sup>	Up to 16 in	(120 + 10L) μin	Vision System

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Plug Gages <sup>5</sup> Pitch Diameter 60°	Up to 1 in (1 to 3) in (3 to 5) in	79 μin 84 μin 94 μin	Universal Length Measuring System, Master Thread Wires
Major Diameter	Up to 5 in	(6 + 8L) μin	Horizontal Comparator
Thread Ring Gages Pitch Diameter	Up to 1 in (1 to 3) in (3 to 5) in	79 μin 84 μin 94 μin	Master Thread Plug Uncertainty

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Measuring Equipment	(1 to 200) lbf	0.06 % of reading	Deadweight
Torque Measuring Devices <sup>1</sup> (Wrenches, Electronic, etc.)	(0.5 to 15) ozf·in (15 to 200) ozf·in (4 to 80) lbf·in (80 to 1 000) lbf·in (20 to 2 000) lbf·ft (1 000 to 5 000) lbf·ft	0.83 % of reading 0.4 % of reading 0.43 % of reading 0.4 % of reading 0.4 % of reading 1 % of reading	Torque Calibration System
Torque Calibration System (Analyzers, Transducers, etc.)	(0.5 to 16) ozf·in (1 to 40) lbf·in (40 to 260) lbf·in (260 to 3 000) lbf·in	0.83 % of reading 0.08 % of reading 0.07 % of reading 0.07 % of reading	Torque Wheels, Torque Arms, NIST Class F Weights
Torque Multipliers	(150 to 2 700) N·m (110 to 2 000) lbf·ft (2 700 to 4 000) N·m (2 000 to 3 000) lbf·ft (4 000 to 27 000) N·m (3 000 to 20 000) lbf·ft	1.1 % of reading 1.1 % of reading 1.3 % of reading 1.3 % of reading 1.4 % of reading 1.4 % of reading	Torque Calibration System
Hydraulic Torque Devices	(150 to 2 700) N·m (110 to 2 000) lbf·ft (2 700 to 4 000) N·m (2 000 to 3 000) lbf·ft (4 000 to 27 000) N·m (3 000 to 20 000) lbf·ft	1.1 % of reading 1.1 % of reading 1.3 % of reading 1.3 % of reading 1.3 % of reading 1.3 % of reading	Torque Calibration System





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**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances <sup>1,6</sup>	(5 to 500) mg (0.5 to 5) g (5 to 10) g (10 to 30) g 30 g to 9 kg (9 to 15) kg	12 µg 40 µg 58 µg 89 µg 0.000 32 % of reading 0.000 34 % of reading	ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system.
	Up to 100 mg (100 to 500) mg (0.5 to 5) g (5 to 10) g (10 to 20) g (20 to 30) g (30 to 100) g 100 g to 20 kg	16 µg 29 µg 58 µg 82 µg 0.12 mg 0.18 mg 0.35 mg 0.005 9 % of reading	ASTM E617 Class 2 weights and internal calibration procedure utilized for the calibration of the weighing system.
	Up to 0.02 lb (0.02 to 1) lb (1 to 5) lb (5 to 977) lb	2.3 mg 0.041 % of reading 0.038 % of reading 0.036 % of reading	NIST Class F weights and internal calibration procedure utilized for the calibration of the weighing system.
Absolute Pressure Devices	Up to 25 psia (25 to 500) psia	0.001 9 psi 0.006 8 % of reading	Ruska 7250xi Pressure Controller/Calibrator
Pneumatic Pressure Gages	(-36 to -22) inH <sub>2</sub> O (-22 to 22) inH <sub>2</sub> O (22 to 60) inH <sub>2</sub> O (60 to 72) inH <sub>2</sub> O (72 to 804) inH <sub>2</sub> O	0.01 % of reading 0.002 inH <sub>2</sub> O 0.01 % of reading 0.006 5 inH <sub>2</sub> O 0.01 % of reading	DHI PPC4 Pressure Controller
	(-14.7 to 25) psi (25 to 500) psig	0.001 6 psi 0.007 6 % of reading	Ruska 7250xi Pressure Controller/Calibrator
	(10 to 3 000) psig (3 000 to 30 000) psig	0.38 psi 0.01 % of reading	Comparison to Fluke RPM 4 Reference Pressure Monitor
Hydraulic Pressure Gages	(5 to 15 000) psig	0.02 % of reading	Fluke P3125-PSI Oil Deadweight Tester



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**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity – Measure <sup>1</sup>	(10 to 30) °C (10 to 90) %RH	1.3 %RH	Vaisala HMI70/HMP76 Temp/Humidity Indicator/Probe
Relative Humidity – Source	(10 to 30) °C (10 to 90) %RH	1.3 % of reading	Humidity Source, Vaisala HMI70/HMP76 Temp/Humidity Indicator/Probe
Temperature – Source <sup>1</sup>	(-25 to 140) °C (140 to 660) °C	0.06 °C 0.03 °C	AccuMac AM1760 Secondary SPRT, Hart 1575 Super Thermometer, Hart Drywell
Temperature – Measure <sup>1</sup>	(-195 to 0) °C (0 to 420) °C (420 to 660) °C	0.001 % of reading + 0.011 °C 0.001 % of reading + 0.025 °C 0.001 % of reading + 0.037 °C	AccuMac AM1760 Secondary SPRT, Hart Black Stack
	(-195 to 0) °C (0 to 420) °C (420 to 660) °C	0.001 % of reading + 0.01 °C 0.001 % of reading + 0.02 °C 0.001 % of reading + 0.031 °C	AccuMac AM1760 Secondary SPRT, Hart 1575 Super Thermometer
Infrared Temperature – Measuring Equipment <sup>1</sup>	(-15 to 0) °C (0 °C to 50) °C (50 °C to 100) °C (100 °C to 120) °C (120 °C to 200) °C (200 °C to 350) °C (350 °C to 500) °C	0.8 °C 0.65 °C 0.7 °C 0.76 °C 0.95 °C 1.6 °C 2.1 °C	Blackbody Source (Plate) $\epsilon = (0.9 \text{ to } 1)$ $\lambda = (8 \text{ to } 14) \mu\text{m}$

**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source/Measure <sup>1</sup>	10 MHz	3.8 pHz/Hz	Fluke 910R GPS Frequency Standard

## DIMENSIONAL MEASUREMENT

### 2 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dimensional Measurement <sup>5</sup> 2D	X-Y Axis: Up to 16 in	$(120 + 10L) \mu\text{in}$	Vision System
Angles <sup>5</sup>	Up to 2 in Up to 360 ° (2 to 16) in Up to 360 °	0.072 °  $(0.062 + 0.000 5L) °$	Vision System

### 3 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dimensional Measurement <sup>5</sup> 3D	X: Up to 24 in Y: Up to 24 in Z: Up to 24 in	$(90 + 8.8L) \mu\text{in}$	Zeiss CONTURA G2 Coordinate Measuring Machine utilized for Dimensional Measurement.
	X: Up to 30 in Y: Up to 30 in Z: Up to 24 in	300 $\mu\text{in}$	
	X: Up to 39 in Y: Up to 36 in Z: Up to 24 in	390 $\mu\text{in}$	
	X: Up to 39 in Y: Up to 48 in Z: Up to 24 in	430 $\mu\text{in}$	
	X: Up to 39 in Y: Up to 54 in Z: Up to 24 in	450 $\mu\text{in}$	
	X: Up to 39 in Y: Up to 62 in Z: Up to 24 in	490 $\mu\text{in}$	

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 ( $k=2$ ), corresponding to a confidence level of approximately 95%.

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. The stated uncertainty is the laboratory's ability to source a fast rise pulse that is approximately 500 ps, 150 ps, 70 ps, and 25 ps. In the typical application of measuring rise time of an oscilloscope, this value is one of the contributing factors, but other factors are derived from the DUT. The known source rise time is mathematically removed from the total measured rise time measured on the DUT.
3. The uncertainties shown are for the most favorable conditions. There is an increase in uncertainty that corresponds to the laboratory's AC voltage and current uncertainties at different frequencies other than the ones shown. Power factors (PF) other than the one shown contribute to the power uncertainty. PF is related to the cosine of phase. Therefore, uncertainties track the laboratory's phase uncertainty closely at PF near one but are magnified heavily as PF approaches zero. The lab may also report reactive power, apparent power, and power factor under this accreditation. If needed, contact laboratory for more information regarding uncertainties at frequency and power factor combinations other than the ones shown.
4. This parameter is a unitless measurement.
5. " = arc-minute; L = length in inches.
6. The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The CMC presented here does not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.10.



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