CERTIFICATE OF ACCREDITATION

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Transcat – Los Angeles
1503 E. Orangethorpe Ave., Unit A
Fullerton, CA 92831

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 and DIMENSIONAL MEASUREMENT

This certificate is valid only when accompanied by a current scope of accreditation document.
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R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 07 September 2023
Certificate Number: AC-2489.08

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)

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CALIBRATION AND DIMENSIONAL MEASUREMENT

Valid to: **September 7, 2023** Certificate Number: **AC-2489.08**

CALIBRATION

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Acceleration – Dynamic Amplitude (1 to 10) g Sensitivity: 10 mV/g	(20 to 99) Hz 100 Hz (100 to 920) Hz 920 Hz to 2.5 kHz (2.5 to 5) kHz (5 to 10) kHz (10 to 15) kHz (15 to 20) kHz	1.4 % of reading 0.99 % of reading 1.2 % of reading 1.5 % of reading 1.5 % of reading 1.9 % of reading 2.3 % of reading 2.9 % of reading	Comparison to Master Accelerometer
Sound Measuring Equipment	125 Hz to 2 kHz (74 to 104) dB 114 dB 4 kHz (74 to 104) dB 114 dB	 0.46 dB 0.73 dB 0.37 dB 0.62 dB	GenRad 1986 Sound Level Calibrator
Sound Level – Measure	125 Hz to 2 kHz (74 to 104) dB 114 dB 4 kHz (74 to 104) dB 114 dB	 0.46 dB 0.73 dB 0.37 dB 0.62 dB	Sound Level Meters, GenRad 1986 Sound Level Calibrator

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH – Measuring Equipment [1]	4 pH 7 pH 10 pH	0.011 pH 0.011 pH 0.012 pH	Standard Buffer Solutions
Conductivity Meters	10 µS/cm 100 µS/cm 1000 µS/cm 10 000 µS/cm 100 000 µS/cm	0.5 µS/cm 2.2 µS/cm 3.7 µS/cm 36 µS/cm 440 µS/cm	Standard Solutions

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Wave Flatness [1]	Up to 3 V 10 Hz to 1 MHz (1 to 10) MHz (10 to 30) MHz (30 to 50) MHz (50 to 80) MHz (80 to 100) MHz	0.06 % of reading 0.1 % of reading 0.18 % of reading 0.41 % of reading 0.71 % of reading 0.84 % of reading	Thermal Voltage Converters
DC Current – Measure/Source [1]	(0 to 100) µA 100 µA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	33 µA/A + 0.92 nA 21 µA/A + 5.8 nA 29 µA/A + 58 nA 46 µA/A + 0.58 µA 0.013 % of reading + 12 µA	Agilent 3458A 8.5 Digit Multimeter w/ Current Source
	(1 to 100) A	0.01 % of reading + 0.5 mA	Ohms Labs CS-100 Precision Shunt w/ Agilent 3458A 8.5 Digit Multimeter
	(100 to 580) A	0.29 mA/A + 0.5 mA	DC Current Shunts w/ DMM and Current Source
DC Current – Measure [1]	(580 to 1 000) A	0.29 mA/A + 0.5 mA	DC Current Shunt w/ DMM
DC Current – Source [1]	(0 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA 0.22 A to 2.2 A (2.2 to 11) A	40 µA/A + 6 nA 36 µA/A + 7 nA 36 µA/A + 40 nA 48 µA/A + 0.7 µA 84 µA/A + 12 µA 0.036 % of reading + 0.48 mA	Fluke 5700A-EP Multiproduct Calibrator, w/ Fluke 5725A Amplifier

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source [1]	(11 to 20) A	0.1 % of reading + 0.58 mA	Fluke 5522A Multiproduct Calibrator
DC Clamp-on Ammeters (Non-Toroidal Type) Transformer Type Sensor [1]	(20 to 150) A (150 to 1 000) A	0.2 % of reading + 0.14 A 0.52 % of reading + 0.52 A	Fluke 5520A/1100 Multiproduct Calibrator w/ Fluke 5500A/Coil
AC Current – Measure [1]	Up to 100 µA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 µA 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 100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.46 % of reading + 35 nA 0.17 % of reading + 35 nA 0.072 % of reading + 35 nA 0.072 % of reading + 35 nA 0.46 % of reading + 0.23 µA 0.17 % of reading + 0.23 µA 0.071 % of reading + 0.23 µA 0.038 % of reading + 0.23 µA 0.46 % of reading + 2.3 µA 0.17 % of reading + 2.3 µA 0.071 % of reading + 2.3 µA 0.038 % of reading + 2.3 µA 0.48 % of reading + 23 µA 0.17 % of reading + 23 µA 0.071 % of reading + 23 µA 0.037 % of reading + 23 µA 0.46 % of reading + 0.23 mA 0.19 % of reading + 0.23 mA 0.097 % of reading + 0.23 mA 0.12 % of reading + 0.23 mA	Agilent 3458A 8.5 Digit Multimeter
AC Current – Measure [1]	Up to 10 A 50 Hz to 1 kHz 1 kHz 10 A to 100 A (50 to 100) Hz 100 Hz to 1 kHz 1 kHz	 0.05 % of reading + 1.3 mA 0.12 % of reading + 1.3 mA 0.04 % of reading + 2.3 mA 0.04 % of reading + 2.3 mA 0.13 % of reading + 2.3 mA	Ohms Labs CS-100 Precision Shunt w/ Agilent 3458A 8.5 Digit Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1]	Up to 220 µA		Fluke 5700A-EP Multiproduct Calibrator
	(10 to 20) Hz	0.031 % of reading + 16 nA	
	(20 to 40) Hz	0.019 % of reading + 10 nA	
	40 Hz to 1 kHz	0.015 % of reading + 8 nA	
	(1 to 5) kHz	0.03 % of reading + 12 nA	
	(5 to 10) kHz	0.11 % of reading + 65 nA	
	(0.22 to 2.2) mA		
	(10 to 20) Hz	0.03 % of reading + 40 nA	
	(20 to 40) Hz	0.018 % of reading + 35 nA	
	40 Hz to 1 kHz	0.013 % of reading + 35 nA	
	(1 to 5) kHz	0.021 % of reading + 0.11 µA	
	(5 to 10) kHz	0.11 % of reading + 0.65 µA	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.039 % of reading + 0.4 µA	
	(20 to 40) Hz	0.018 % of reading + 0.35 µA	
	40 Hz to 1 kHz	0.014 % of reading + 0.35 µA	
	(1 to 5) kHz	0.021 % of reading + 0.55 µA	
	(5 to 10) kHz	0.11 % of reading + 5 µA	
	(22 to 220) mA		
	(10 to 20) Hz	0.033 % of reading + 4 µA	
	(20 to 40) Hz	0.018 % of reading + 3.5 µA	
	40 Hz to 1 kHz	0.014 % of reading + 2.5 µA	
	(1 to 5) kHz	0.021 % of reading + 3.5 µA	
	(5 to 10) kHz	0.11 % of reading + 10 µA	
	(0.22 to 2.2) A		
	20 Hz to 1 kHz	0.027 % of reading + 35 µA	
	(1 to 5) kHz	0.046 % of reading + 80 µA	
	(5 to 10) kHz	0.7 % of reading + 0.16 mA	
AC Current – Source [1]	(2.2 to 11) A		Fluke 5700A-EP Multiproduct Calibrator w/ Fluke 5725A Amplifier
	40 Hz to 1 kHz	0.048 % of reading + 0.17 mA	
	(1 to 5) kHz	0.096 % of reading + 0.38 mA	
	(5 to 10) kHz	0.36 % of reading + 0.75 mA	
AC Current – Source [1]	(11 to 20.5) A		Fluke 5522A Multiproduct Calibrator
	(45 to 100) Hz	0.09 % of reading + 3.9 mA	
	100 Hz to 1 kHz	0.12 % of reading + 3.9 mA	
	(1 to 5) kHz	2.3 % of reading + 3.9 mA	
AC Current – Source [1]	Up to 10 A		Ohms Labs CS-100 Precision Shunt w/ Agilent 3458A 8.5 Digit Multimeter and Current Source
	50 Hz to 1 kHz	0.05 % of reading + 1.3 mA	
	1 kHz	0.12 % of reading + 1.3 mA	
	(10 to 100) A		
	(50 to 100) Hz	0.04 % of reading + 2.3 mA	
	(100 to 999) Hz	0.42 % of reading + 2.3 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source Extended Frequency Ranges [1]	29 µA to 329.99 µA (10 to 30) kHz 330 µA to 3.299 mA (10 to 30) kHz 3.3 mA to 32.99 mA (10 to 30) kHz 33 mA to 329.99 mA (10 to 30) kHz	1.2 % of reading + 0.31 µA 0.78 % of reading + 0.47 µA 0.31 % of reading + 3.1 µA 0.31 % of reading + 0.16 mA	Fluke 5522A Multiproduct Calibrator
AC Clamp-on Ammeters (Toroidal Type) Transformer Type Sensor [1]	(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	0.34 % of reading + 35 mA 0.95 % of reading + 66 mA 0.38 % of reading + 0.17 A 1.2 % of reading + 0.29 A	Fluke 5522A Multiproduct Calibrator w/ Fluke 5500A/Coil
AC Clamp-on Ammeters (Non-Toroidal Type) Hall Effect Sensor [1]	(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	0.66 % of reading + 0.26 A 1.2 % of reading + 0.29 A 0.68 % of reading + 1 A 1.4 % of reading + 1.1 A	
DC Resistance – Measure/Source [1]	(0 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	18 µΩ/Ω + 58 µΩ 15 µΩ/Ω + 0.58 mΩ 13 µΩ/Ω + 0.58 mΩ 21 µΩ/Ω + 5.8 mΩ 13 µΩ/Ω + 58 mΩ 21 µΩ/Ω + 2.3 Ω 62 µΩ/Ω + 120 Ω 0.059 % of reading + 1.2 kΩ 0.82 % of reading + 12 kΩ	Agilent 3458A 8.5 Digit Multimeter w/ Decade Resistor
DC Resistance – Source Fixed [1]	1 mΩ	9.8 µΩ/Ω	L&N 4223B Standard Resistor
	10 mΩ	30 µΩ/Ω	L&N 4222B Standard Resistor
	100 mΩ	34 µΩ/Ω	L&N 4015B Standard Resistor
DC Resistance – Source Variable [1]	(2 to 10) GΩ (20 to 100) GΩ 200 GΩ to 1 TΩ	0.58 % of reading 1.2 % of reading 2.6 % of reading	IET HRRS-B-3-1G-5KV Decade Resistor

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance – RTD Measure [1]	(0 to 25) Ω (25 to 400) Ω 400 to 1 kΩ (1 to 40) kΩ	0.04 mΩ 1.3 µΩ/Ω 4.1 µΩ/Ω 10 µΩ/Ω	Hart 1590 Super Thermometer Readout
DC Voltage – Source [1]	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	8.8 µV/V + 0.4 µV 5.1 µV/V + 0.7 µV 4 µV/V + 2.5 µV 3.9 µV/V + 4 µV 6.2 µV/V + 40 µV 7.6 µV/V + 0.4 mV	Fluke 5700A-EP Multiproduct Calibrator
DC Voltage – Measure [1]	Up 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	8.3 µV/V + 0.58 µV 5.3 µV/V + 0.58 µV 7.7 µV/V + 35 µV 15 µV/V + 0.12 mV 18 µV/V + 0.12 mV 21 µV/V + 0.12 mV	Agilent 3458A Opt. 002 8.5 Digit Multimeter
DC High Voltage – Measure [1]	(1 to 10) kV (10 to 35) kV (35 to 70) kV (70 to 100) kV	0.03 % of reading + 35 mV 0.06 % of reading + 81 mV 0.04 % of reading + 23 mV 0.17 % of reading + 1.3 V	Vitrek 4700 DVM w/ Associated High Voltage Probes
AC Voltage – Measure [1]	Up to 1 mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (1 to 3) mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (3 to 100) mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 1.8 % of reading + 2.4 µV 3.5 % of reading + 2.4 µV 9.3 % of reading + 2.4 µV 23 % of reading + 2.4 µV 0.97 % of reading + 2 µV 3.5 % of reading + 2 µV 9.3 % of reading + 2 µV 23 % of reading + 2 µV 0.91 % of reading + 3 µV 1.8 % of reading + 3 µV 2.9 % of reading + 3 µV 7 % of reading + 3 µV 14 % of reading + 3 µV	Rohde & Schwarz URE3 RMS Voltmeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	Up to 10 mV		Agilent 3458A 8.5 Digit Multimeter
	(1 to 40) Hz	0.04 % of reading + 3.5 µV	
	40 Hz to 1 kHz	0.03 % of reading + 1.2 µV	
	(1 to 20) kHz	0.04 % of reading + 1.2 µV	
	(20 to 50) kHz	0.15 % of reading + 1.2 µV	
	(50 to 100) kHz	0.59 % of reading + 1.2 µV	
	(100 to 300) kHz	4.6 % of reading + 2.3 µV	
	300 kHz to 1 MHz	1.5 % of reading + 5.8 µV	
	(1 to 4) MHz	8.1 % of reading + 8.1 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.013 % of reading + 4.8 µV	
	40 Hz to 1 kHz	0.009 7 % of reading + 2.3 µV	
	(1 to 20) kHz	0.017 % of reading + 2.3 µV	
	(20 to 50) kHz	0.038 % of reading + 2.3 µV	
	(50 to 100) kHz	0.093 % of reading + 2.3 µV	
	(100 to 300) kHz	0.36 % of reading + 12 µV	
	300 kHz to 1 MHz	1.8 % of reading + 12 µV	
	(1 to 2) MHz	1.8 % of reading + 12 µV	
	(2 to 4) MHz	4.7 % of reading + 81 µV	
	(4 to 8) MHz	4.7 % of reading + 92 µV	
	(8 to 10) MHz	17 % of reading + 0.12 mV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.008 8 % of reading + 46 µV	
	40 Hz to 1 kHz	0.008 3 % of reading + 23 µV	
	(1 to 20) kHz	0.017 % of reading + 23 µV	
	(20 to 50) kHz	0.036 % of reading + 23 µV	
	(50 to 100) kHz	0.093 % of reading + 23 µV	
	(100 to 300) kHz	0.36 % of reading + 0.12 mV	
	300 kHz to 1 MHz	1.2 % of reading + 0.12 mV	
	(1 to 2) MHz	1.8 % of reading + 0.12 mV	
	(2 to 4) MHz	4.6 % of reading + 0.81 mV	
	(4 to 8) MHz	4.6 % of reading + 0.92 mV	
	(8 to 10) MHz	17 % of reading + 1.2 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(1 to 10) V		Agilent 3458A 8.5 Digit Multimeter
	(1 to 40) Hz	0.009 5 % of reading + 0.46 mV	
	40 Hz to 1 kHz	0.002 3 % of reading + 0.23 mV	
	(1 to 20) kHz	0.017 % of reading + 0.23 mV	
	(20 to 50) kHz	0.036 % of reading + 0.23 mV	
	(50 to 100) kHz	0.093 % of reading + 0.23 mV	
	(100 to 300) kHz	0.36 % of reading + 1.2 mV	
	300 kHz to 1 MHz	1.2 % of reading + 1.2 mV	
	(1 to 2) MHz	1.8 % of reading + 2 mV	
	(2 to 4) MHz	4.6 % of reading + 8.1 mV	
	(4 to 8) MHz	4.6 % of reading + 9.2 mV	
	(8 to 10) MHz	17 % of reading + 12 mV	
	(10 to 100) V		
	(1 to 40) Hz	0.024 % of reading + 4.6 mV	
	40 Hz to 1 kHz	0.024 % of reading + 2.3 mV	
	(1 to 20) kHz	0.024 % of reading + 2.3 mV	
	(20 to 50) kHz	0.041 % of reading + 2.3 mV	
	(50 to 100) kHz	0.14 % of reading + 2.3 mV	
	(100 to 300) kHz	0.46 % of reading + 12 mV	
	300 kHz to 1 MHz	1.7 % of reading + 12 mV	
	(100 to 700) V		
	(1 to 40) Hz	0.048 % of reading + 46 mV	
	40 Hz to 1 kHz	0.048 % of reading + 23 mV	
	(1 to 20) kHz	0.071 % of reading + 23 mV	
	(20 to 50) kHz	0.19 % of reading + 23 mV	
	(50 to 100) kHz	0.35 % of reading + 23 mV	
	(700 to 1 050) V		Fluke 8508A 8.5 Digit Multimeter
	(1 to 10) Hz	0.02 % of reading + 85 mV	
	(10 to 40) Hz	0.02 % of reading + 24 mV	
	40 Hz to 10 kHz	0.02 % of reading + 24 mV	
	(10 to 30) kHz	0.03 % of reading + 48 mV	
	(30 to 100) kHz	0.06 % of reading + 0.24 V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC High Voltage – Measure/Source [1]	(1.05 to 10) kV (10 to 200) Hz (200 to 450) Hz (10 to 30) kV (30 to 200) Hz (200 to 450) Hz (30 to 50) kV (30 to 100) Hz (100 to 450) Hz (50 to 100) kV 60 Hz	 0.14 % of reading + 0.12 V 0.46 % of reading + 0.12 V 0.06 % of reading + 0.23 V 0.7 % of reading + 0.23 V 0.09 % of reading + 0.46 V 2.9 % of reading + 0.46 V 0.23 % of reading + 1.4 V	Vitrek 4700 DVM w/ Associated High Voltage Probes
AC Voltage – Source [1]	Up to 2.2 mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 o 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (2.2 to 22) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 o 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 o 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	 0.16 % of reading + 4 µV 0.01 % of reading + 4 µV 0.078 % of reading + 4 µV 0.13 % of reading + 4 µV 0.17 % of reading + 5 µV 0.33 % of reading + 10 µV 0.47 % of reading + 20 µV 0.58 % of reading + 20 µV 0.042 % of reading + 4 µV 0.03 % of reading + 4 µV 0.014 % of reading + 4 µV 0.3 % of reading + 4 µV 0.057 % of reading + 5 µV 0.12 % of reading + 10 µV 0.16 % of reading + 20 µV 0.27 % of reading + 20 µV 0.028 % of reading + 12 µV 0.011 % of reading + 7 µV 0.008 5 % of reading + 7 µV 0.021 % of reading + 7 µV 0.047 % of reading + 17 µV 0.091 % of reading + 20 µV 0.14 % of reading + 26 µV 0.28 % of reading + 45 µV	Fluke 5700A-EP Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	220 mV to 2.2 V		Fluke 5700A-EP Multiproduct Calibrator
	(10 to 20) Hz	0.027 % of reading + 40 µV	
	(20 to 40) Hz	0.01 % of reading + 15 µV	
	40 Hz to 20 kHz	0.004 8 % of reading + 8 µV	
	(20 o 50) kHz	0.008 % 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 + 0.31 mV	
	(2.2 to 22) V		
	(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	0.005 % of reading + 50 µV	
	(20 o 50) kHz	0.008 3 % of reading + 0.1 mV	
	(50 to 100) kHz	0.011 % of reading + 0.2 mV	
	(100 to 300) kHz	0.03 % of reading + 0.6 mV	
	(300 to 500) kHz	0.1 % 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	0.006 % of reading + 0.6 mV	
	(20 o 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 [1]	(220 to 1 100) V		Fluke 5700A-EP Calibrator w/ Fluke 5725A Amplifier
	40 Hz to 1 kHz	0.011 % of reading + 4.1 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
	(20 to 30) kHz	0.061 % of reading + 11 mV	
	(30 to 50) kHz	0.061 % of reading + 11 mV	
	(50 to 100) kHz	0.23 % of reading + 45 mV	
Capacitance – Measure [1] 1 kHz	Up to 10 pF	0.47 % of reading + 0.05 pF	GenRad 1689-9700 RLC Digibridge
	(10 to 100) pF	0.06 % of reading + 0.05 pF	
	100 pF to 25 µF	0.02 % of reading + 0.05 pF	
	(25 to 100) µF	0.03 % of reading	
	(100 to 1 000) µF	0.24 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure	0.1 pF		Agilent E4980A LCR Meter
	100 kHz	1.4 % of reading	
	1 MHz	1.8 % of reading	
	1 pF		
	10 kHz	1.4 % of reading	
	100 kHz	0.37 % of reading	
	1 MHz	0.44 % of reading	
	2 MHz	1.1 % of reading	
	10 pF		
	1 kHz	1.4 % of reading	
	10 kHz	0.28 % of reading	
	100 kHz	0.28 % of reading	
	1 MHz	0.3 % of reading	
	2 MHz	0.75 % of reading	
	100 pF		
	100 Hz	2.1 % of reading	
	1 kHz	0.23 % of reading	
	10 kHz	0.18 % of reading	
	100 kHz	0.21 % of reading	
	1 MHz	0.23 % of reading	
	2 MHz	0.3 % of reading	
	1 nF		
	20 Hz	1.8 % of reading	
	100 Hz	0.3 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.1 % of reading	
	100 kHz	0.1 % of reading	
	1 MHz	0.14 % of reading	
	2 MHz	0.53 % of reading	
	10 nF		
	20 Hz	0.31 % of reading	
	100 Hz	0.12 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.1 % of reading	
	100 kHz	0.1 % of reading	
	1 MHz	0.25 % of reading	
	2 MHz	0.67 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure	100 nF		Agilent E4980A LCR Meter
	20 Hz	0.16 % of reading	
	100 Hz	0.1 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.1 % of reading	
	100 kHz	0.18 % of reading	
	1 MHz	0.33 % of reading	
	2 MHz	0.97 % of reading	
	1 µF		
	20 Hz	0.15 % of reading	
	100 Hz	0.09 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.18 % of reading	
	100 kHz	0.25 % of reading	
	1 MHz	0.79 % of reading	
	10 µF		
	20 Hz	0.15 % of reading	
	100 Hz	0.09 % of reading	
	1 kHz	0.16 % of reading	
	10 kHz	0.28 % of reading	
	100 kHz	0.73 % of reading	
	100 µF		
	20 Hz	0.16 % of reading	
	100 Hz	0.17 % of reading	
	1 kHz	0.29 % of reading	
	10 kHz	0.8 % of reading	
Capacitance – Source [1] (Simulation)	190 pF to 1.1 nF	0.39 % of reading + 7.8 pF	Fluke 5520A/1100 Multiproduct Calibrator
	(1.1 to 3.3) nF	0.39 % of reading + 7.8 pF	
	(3.3 to 11) nF	0.2 % of reading + 7.8 pF	
	(11 to 110) nF	0.2 % of reading + 78 pF	
	(110 to 330) nF	0.2 % of reading + 0.23 nF	
	330 nF to 1.1 µF	0.2 % of reading + 0.78 nF	
	(1.1 to 3.3) µF	0.2 % of reading + 2.3 nF	
	(3.3 to 11) µF	0.2 % of reading + 7.8 nF	
	(11 to 33) µF	0.31 % of reading + 23 nF	
	(33 to 110) µF	0.35 % of reading + 78 nF	
	(110 to 330) µF	0.35 % of reading + 0.23 µF	
	330 µF to 1.1 mF	0.35 % of reading + 0.78 µF	
	(1.1 to 3.3) mF	0.35 % of reading + 2.3 µF	
	(3.3 to 11) mF	0.35 % of reading + 7.8 µF	
	(11 to 33) mF	0.58 % of reading + 23 µF	
	(33 to 110) mF	0.86 % of reading + 78 µF	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source [1] (Fixed) 1 kHz	1 nF 2 nF 5 nF 10 nF 20 nF 50 nF 0.1 µF 0.2 µF 0.5 µF 1 µF	0.17 pF 0.34 pF 0.85 pF 1.7 pF 3.4 pF 8.5 pF 17 pF 34 pF 85 pF 0.17 nF	GenRad 1409 Series Standard Capacitors
Inductance – Measure [1] 100 Hz to 1 kHz	(1 to 10) mH 10 mH to 10 H	0.03 % of reading + 0.1 µH 0.03 % of reading + 1.4 µH	GenRad 1689-9700 RLC Digibridge
Inductance – Measure	1 µH 10 kHz 100 kHz 1 MHz 2 MHz 10 µH 10 kHz 100 kHz 1 MHz 2 MHz 100 µH 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz 1 mH 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	 1.6 % of reading 0.36 % of reading 0.27 % of reading 0.66 % of reading 0.37 % of reading 0.20 % of reading 0.20 % of reading 0.30 % of reading 0.40 % of reading 0.20 % of reading 0.12 % of reading 0.14 % of reading 0.72 % of reading 0.55 % of reading 0.18 % of reading 0.12 % of reading 0.09 % of reading 0.23 % of reading 0.88 % of reading	Agilent E4980A LCR Meter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure	10 mH		Agilent E4980AL LCR Meter
	20 Hz	0.85 % of reading	
	100 Hz	0.22 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.09 % of reading	
	100 kHz	0.10 % of reading	
	1 MHz	0.35 % of reading	
	2 MHz	1.3 % of reading	
	100 mH		
	20 Hz	0.28 % of reading	
	100 Hz	0.10 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.09 % of reading	
	100 kHz	0.21 % of reading	
	1 MHz	0.88 % of reading	
	1 H		
	20 Hz	0.16 % of reading	
	100 Hz	0.09 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.10 % of reading	
	100 kHz	0.31 % of reading	
	10 H		
	20 Hz	0.15 % of reading	
	100 Hz	0.10 % of reading	
	1 kHz	0.11 % of reading	
	10 kHz	0.21 % of reading	
	100 kHz	0.69 % of reading	
	100 H		
	20 Hz	0.15 % of reading	
	100 Hz	0.10 % of reading	
	1 kHz	0.15 % of reading	
	10 kHz	0.62 % of reading	
AC Resistance – Measure	0.1 Ω		Agilent E4980A LCR Meter
	1 kHz	1.8 % of reading	
	10 kHz	1.6 % of reading	
	100 kHz	1.0 % of reading	
	1 MHz	1.5 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance – Measure	1 Ω		Agilent E4980A LCR Meter
	20 Hz	0.67 % of reading	
	100 Hz	0.43 % of reading	
	1 kHz	0.33 % of reading	
	10 kHz	0.32 % of reading	
	100 kHz	0.31 % of reading	
	1 MHz	0.38 % of reading	
	2 MHz	0.92 % of reading	
	10 Ω		
	20 Hz	0.29 % of reading	
	100 Hz	0.20 % of reading	
	1 kHz	0.17 % of reading	
	10 kHz	0.19 % of reading	
	100 kHz	0.19 % of reading	
	1 MHz	0.27 % of reading	
	2 MHz	0.67 % of reading	
	100 Ω		
	20 Hz	0.16 % of reading	
	100 Hz	0.09 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.12 % of reading	
	100 kHz	0.12 % of reading	
	1 MHz	0.2 % of reading	
	2 MHz	0.53 % of reading	
	1 kΩ		
	20 Hz	0.15 % of reading	
	100 Hz	0.09 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.09 % of reading	
	100 kHz	0.09 % of reading	
	1 MHz	0.14 % of reading	
	2 MHz	0.3 % of reading	
	10 kΩ		
	20 Hz	0.15 % of reading	
	100 Hz	0.09 % of reading	
	1 kHz	0.09 % of reading	
	10 kHz	0.09 % of reading	
	100 kHz	0.1 % of reading	
	1 MHz	0.29 % of reading	
	2 MHz	0.87% of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance – Measure	100 kΩ 20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	 0.17 % of reading 0.1 % of reading 0.1 % of reading 0.17 % of reading 0.28 % of reading 0.38 % of reading 1.3 % of reading	Agilent E4980AL LCR Meter
Inductance – Source [1]	100 µH 1 mH 10 mH 100 mH 1 H 10 H	0.025 µH 0.25 µH 2.5 µH 25 µH 0.25 mH 2.5 mH	Standard Inductors w/ GenRad 1689-9700 RLC Digibridge
Electrical Simulation of Thermocouple Indicating Devices – Measure/Source [1]	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	 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 0.09 °C 0.08 °C 0.08 °C 0.06 °C 0.07 °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 [1]	Type J		Ectron 1140A Thermocouple Calibrator/Simulator
	(-210 to -180) °C	0.15 °C	
	(-180 to -120) °C	0.12 °C	
	(-120 to -50) °C	0.09 °C	
	(-50 to 990) °C	0.08 °C	
	(990 to 1 200) °C	0.09 °C	
	Type K		
	(-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	0.09 °C	
	(1 000 to 1 372) °C	0.1 °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	0.35 °C	
	(380 to 775) °C	0.3 °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	

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 [1]	Type T (-270 to -255) °C (-255 to -240) °C (-240 to -210) °C (-210 to -150) °C (-150 to -40) °C (-40 to 100) °C (100 to 400) °C	 1.9 °C 0.6 °C 0.36 °C 0.22 °C 0.15 °C 0.09 °C 0.08 °C	Ectron 1140A Thermocouple Calibrator/Simulator
Scope Voltage – Source [1] DC Signal into 50 Ω into 1 MΩ	 (-5.0 to 5.0) V (-200 to 200) V	 0.023 % of reading + 19 µV 0.023 % of reading + 19 µV	Fluke 9500B Oscilloscope Calibrator
Scope Voltage – Source [1] Square Wave 10 Hz to 100 kHz into 50 Ω 10 Hz to 10 kHz into 1 MΩ 10 Hz to 100 kHz into 1 MΩ	 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 200 Vp-p	 0.78 % of reading + 7.8 µV 0.08 % of reading + 7.8 µV 0.78 % of reading + 7.8 µV 0.08 % of reading + 7.8 µV	Fluke 9500B Oscilloscope Calibrator
Scope – Time Markers [1] 100 mVp-p to 1 Vp-p (into 50 Ω) Square Wave Sine Wave Pulse Triangle Wave 	 9.009 1 ns to 83 µs 83 µs to 55 s 450.5 ps to 9.009 ns 900.91 ns to 83 µs 83 µs to 55 s 900.91 ns to 83 µs 83 µs to 55 s	 0.19 µs/s 2.3 µs/s 0.19 µs/s 0.19 µs/s 2.3 µs/s 0.19 µs/s 2.3 µs/s	Fluke 9500B Oscilloscope Calibrator
Rise Time – Measure [1]	> 5 ns	0.41 ns	Rigol MSO8104 Digital Oscilloscope
Scope Rise Time – Source [1,4] (into 50 Ω) 10 Hz to 2 MHz 10 Hz to 1 MHz	 5 mVp-p to 3 Vp-p 500 ps (Nominal) 150 ps (Nominal) 25 mVp-p to 2 Vp-p 70 ps (Nominal)	 290 ps 34 ps 21 ps	Fluke 9500B Oscilloscope Calibrator with Fluke 9530 Active Head

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scope Leveled Sine Wave – Source [1] (50 kHz Ref. Frequency) into 50 Ω	5 mVp-p to 5 Vp-p 50 kHz to 10 MHz	1.2 % of reading	Fluke 9500B Oscilloscope Calibrator with Fluke 9530 Active Head
Scope Bandwidth/Flatness – Source [1] into VSWR (1.2:1) (wrt Reference Frequency)	5 mVp-p to 5 Vp-p 0.1 Hz to 300 MHz (300 to 550) MHz 5 mVp-p to 3 Vp-p 550 MHz to 2.5 GHz 5 mVp-p to 2 Vp-p (2.5 to 3.2) GHz	 1.6 % of reading 1.9 % of reading 2.7 % of reading 3.1 % of reading	Fluke 9500B Oscilloscope Calibrator with Fluke 9530 Active Head
Scope Input Impedance – Measure [1]	(10 to 40) Ω (40 to 90) Ω (90 to 150) Ω (50 to 800) kΩ 800 kΩ to 1.2 MΩ (1.2 to 12) MΩ	0.39 % of reading 0.08 % of reading 0.39 % of reading 0.39 % of reading 0.08 % of reading 0.39 % of reading	Fluke 9500B Oscilloscope Calibrator
Scope Input Capacitance – Measure [1]	(1 to 35) pF (35 to 95) pF	1.6 % of reading + 0.19 pF 2.3 % of reading + 0.19 pF	Fluke 9500B/3200 Oscilloscope Calibrator
AC Voltage Harmonics – Source [1,3] Carrier Range: 45 V Carrier Range: 90 V Carrier Range: 180 V Carrier Range: Up to 360 V Carrier Range: 650 V 	 Up to 13.5 V (16 to 850) Hz 850 Hz to 6.5 kHz Up to 27 V (16 to 850) Hz 850 Hz to 6.5 kHz Up to 54 V (16 to 850) Hz 850 Hz to 6.5 kHz Up to 108 V (16 to 850) Hz 850 Hz to 6.5 kHz Up to 195 V (16 to 850) Hz 850 Hz to 6.5 kHz	 67 µV/V + 2 mV 0.52 mV + 2 mV 69 µV/V + 2 mV 0.52 mV + 2 mV 69 µV/V + 6 mV 0.52 mV + 6 mV 69 µV/V + 13 mV 0.52 mV/V + 13 mV 70 µV/V + 22 mV 0.52 mV/V + 22 mV	Fluke 6105A Electrical Power Quality Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage Harmonics – Source [1,3]			Fluke 6105A Electrical Power Quality Calibrator
Carrier Range: 1 008 V	Up to 302 V		
	(16 to 850) Hz	70 µV/V + 33 mV	
	850 Hz to 6.5 kHz	0.52 mV/V + 33 mV	
AC Current Harmonics – Source [1,3]			Fluke 6105A Electrical Power Quality Calibrator
Carrier Range: 0.25 A	Up to 75 mA		
	(16 to 850) Hz	61 µA/A + 21 µA	
	850 Hz to 6.5 kHz	0.46 mA/A + 22 µA	
Carrier Range: 0.5 A	Up to 0.15 A		
	(16 to 850) Hz	70 µA/A + 21 µA	
	850 Hz to 6.5 kHz	0.46 mA/A + 23 µA	
Carrier Range: 1 A	Up to 0.3 A		
	(16 to 850) Hz	70 µA/A + 29 µA	
	850 Hz to 6.5 kHz	0.46 mA/A + 29 µA	
Carrier Range: 2 A	Up to 0.6 A		
	(16 to 850) Hz	70 µA/A + 0.1 mA	
	850 Hz to 6.5 kHz	0.46 mA/A + 0.1 mA	
Carrier Range: 5 A	Up to 1.5 A		
	(16 to 850) Hz	70 µA/A + 0.1 mA	
	850 Hz to 6.5 kHz	0.46 mA/A + 0.1 mA	
Carrier Range: 10 A	Up to 3 A		
	(16 to 850) Hz	74 µA/A + 0.29 mA	
	850 Hz to 6.5 kHz	0.46 mA/A + 0.29 mA	
Carrier Range: 20 A	Up to 6 A		
	(16 to 850) Hz	75 µA/A + 0.45 mA	
	850 Hz to 6.5 kHz	0.46 mA/A + 0.45 mA	
LF Phase – Source [1]	(0 to 90)°		Fluke 5520A/1100 Multiproduct Calibrator
	(10 to 65) Hz	0.09°	
	(65 to 500) Hz	0.2°	
	500 Hz to 1 kHz	0.39°	
	(1 to 5) kHz	1.9°	
	(5 to 10) kHz	3.9°	
	(10 to 30) kHz	7.8°	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Power – Source [1]			
330 µA to 3.3 mA	11 µW to 3.4 W	0.02 % of reading	
(3.3 to 33) mA	110 mW to 34 W	0.01 % of reading	
(33 to 330) mA	1.1 mW to 340 W	0.01 % of reading	Fluke 5520A/1100 Multiproduct Calibrator
330 mA to 1.1 A	11 mW to 3.4 kW	0.03 % of reading	
(1.1 to 3) A	36 mW to 3.1 kW	0.03 % of reading	
(3 to 11) A	0.99 W to 11 kW	0.06 % of reading	
(11 to 20.5) A	360 mW to 21 kW	0.09 % of reading	
AC Power – Source [1, 5]			
PF = 1			
(3.3 to 9) mA	(45 to 65) Hz 0.11 mW to 9.2 W	0.09 % of reading	
(9 to 33) mA	(45 to 65) W 3 mW to 34 W	0.06 % of reading	
(33 to 90) mA	(45 to 65) Hz 1.1 mW to 92 W	0.09 % of reading	
(90 to 330) mA	(45 to 65) Hz 3 mW to 340 W	0.06 % of reading	
330 mA to 1.1 A	(45 to 65) Hz 11 mW to 1.1 kW	0.07 % of reading	
(1.1 to 3) A	(45 to 65) Hz 36 mW to 3.1 kW	0.06 % of reading	Fluke 5520A/11 Multiproduct Calibrator
(3 to 5.4) A	(45 to 65) Hz 99 mW to 5.5 kW	0.11 % of reading	
(5.4 to 11) A	(45 to 65) Hz 180 mW to 11 kW	0.08 % of reading	
(11 to 15) A	(45 to 100) Hz 360 mW to 15 kW	0.14 % of reading	
(15 to 20.5) A	100 Hz to 1 kHz 360 mW to 15 kW	0.16 % of reading	
	(45 to 100) Hz 500 mW to 21 kW	0.13 % of reading	
	100 Hz to 1 kHz 500 mW to 21 kW	0.13 % of reading	
AC Power – Source [1,5]			
PF = 1			Fluke 6105A Electrical Power Quality Calibrator
(0.5 to 20) A	(65 to 850) Hz 23 W to 13 kW	0.024 % of reading	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Source [1]	DC to 12.4 GHz		Agilent 8496H Programmable Attenuator w/ Type -N
	1 dB	0.3 dB	
	2 dB	0.3 dB	
	3 dB	0.4 dB	
	4 dB	0.4 dB	
	5 dB	0.5 dB	
	6 dB	0.5 dB	
	7 dB	0.6 dB	
	8 dB	0.6 dB	
	9 dB	0.6 dB	
	10 dB	0.6 dB	
	11 dB	0.7 dB	
	(12.4 to 18) GHz		
	1 dB	0.7 dB	
	2 dB	0.7 dB	
	3 dB	0.7 dB	
	4 dB	0.7 dB	
	5 dB	0.8 dB	
	6 dB	0.8 dB	
	7 dB	0.8 dB	
	8 dB	0.8 dB	
	9 dB	0.9 dB	
	10 dB	0.9 dB	
	11 dB	0.5 dB	
	DC to 12.4 GHz		
	10 dB	0.5 dB	
	20 dB	0.7 dB	
	30 dB	0.9 dB	
	40 dB	1.2 dB	
	50 dB	1.5 dB	
	60 dB	1.8 dB	
	70 dB	2.1 dB	
	80 dB	2.4 dB	
	90 dB	2.7 dB	
	100 dB	3.0 dB	
	110 dB	3.3 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Source [1]	(12.4 to 18) GHz 10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	 0.6 dB 0.8 dB 1.2 dB 1.6 dB 2.0 dB 2.4 dB 2.8 dB 3.2 dB 3.6 dB 4.0 dB 4.4 dB	Agilent 8496H Programmable Attenuator w/ Type -N
RF Absolute Power – Measure [1]	10 Hz to 20 kHz (-10 to 30) dBm	0.13 % of reading	Fluke 8846A Multimeter
	9 kHz to 18 GHz (-60 to 20) dBm	2.6 % of reading	Agilent E9304A-H18 RF Power Sensor w/ RF Power Meter
	(18 to 40) GHz (-70 to -30) dBm (40 to 50) GHz (-70 to -30) dBm	3.8 % of reading 5.5 % of reading	Agilent 8487D RF Power Sensor w/ RF Power Meter
	(18 to 40) GHz (-30 to 20) dBm (40 to 50) GHz (-30 to 20) dBm	4.4 % of reading 5.5 % of reading	Agilent 8487D RF Power Sensor w/ RF Power Meter
	30 MHz to 50 GHz (20 to 30) dBm	4.8 % of reading	Agilent E5532A-550 RF Power Sensor Module w/ RF Power Meter
RF Absolute Power – Source [1]	(-70 to -10) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz (-10 to 0) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz	 0.8 dB 1.1 dB 1.2 dB 1.8 dB 0.7 dB 0.9 dB 1.1 dB 1.1 dB	Agilent E8257D Analog Signal Generator

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source [1]	(0 to 10 dBm) 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (40 to 50) GHz (10 to 14 dBm) 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (14 to 19 dBm) 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	 0.7 dB 0.9 dB 1.1 dB 1.5 dB 0.7 dB 0.9 dB 1.2 dB 0.9 dB 0.9 dB 1.2 dB	Agilent E8257D Analog Signal Generator
RF Relative Power – Measure [1] (Tuned RF Level)	100 kHz to 50 GHz (-10 to 0) dB (-20 to -10) dB (-30 to -20) dB (-40 to -30) dB (-50 to -40) dB (-60 to -50) dB (-70 to -60) dB (-80 to -70) dB (-90 to -80) dB 100 kHz to 45 GHz (-100 to -90) dB (-110 to -100) dB 100 kHz to 31.15 GHz (-120 to -110) dB (-130 to -120) dB	 0.02 dB 0.02 dB 0.03 dB 0.04 dB 0.04 dB 0.09 dB 0.10 dB 0.14 dB 0.15 dB 0.16 dB 0.29 dB 0.29 dB 0.29 dB	Agilent E4448A Spectrum Analyzer
S11/S22 Reflection Magnitude – Measure [1] (Linear)	9 kHz to 10 MHz (0 to 0.5) lin (0.5 to 1) lin 10 MHz to 9 GHz (0 to 0.5) lin (0.5 to 1) lin	 0.009 0.019 0.012 0.022	Agilent E5071C Network Analyzer (Corrected with Agilent 85032F Calibration Kit)
	50 MHz to 2 GHz (0 to 0.5) lin (0.5 to 1) lin (2 to 40) GHz (0 to 0.5) lin (0.5 to 1) lin	 0.015 0.023 0.028 0.04	Agilent E5235A Network Analyzer (Corrected with Agilent 85056K Calibration Kit)

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
S12/S21 Transmission Magnitude – Measure [1] (dB)	9 kHz to 10 MHz (-30 to 0) dB (-60 to -30) dB 10 MHz to 9 GHz (-30 to 0) dB (-60 to -30) dB	 0.09 dB 0.45 dB 0.09 dB 0.26 dB	Agilent E5071C Network Analyzer (Corrected with Agilent 85032F Calibration Kit)
	(10 to 500) MHz (-30 to 0) dB (-60 to -30) dB 500 MHz to 2 GHz (-30 to 0) dB (-60 to -30) dB (2 to 50) GHz (-30 to 0) dB (-60 to -30) dB	 0.07 dB 1.6 dB 0.05 dB 0.18 dB 0.14 dB 0.55 dB	Agilent E5235A Network Analyzer (Corrected with Agilent 85056K Calibration Kit)
Amplitude Modulation – AM Depth Measure [1] Rate: 100 kHz to 20 MHz 10 MHz to 3 GHz (3 to 26.5) GHz (26.5 to 31.15) GHz	 50 Hz to 10 kHz (5 to 99) % Depth 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.9 % Depth 0.8 % Depth 2.6 % Depth 1.6 % Depth 4.5 % Depth 2.1 % Depth 6.8 % Depth	Agilent E4448A Spectrum Analyzer
Amplitude Modulation – AM Depth Measure [1] Rate: (31.15 to 50) GHz	50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 6 % Depth 26 % Depth	Agilent E4448A Spectrum Analyzer

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation Distortion – Measure [1]			
100 kHz to 10 kHz	20 Hz to 1 kHz		
	> 1 %	0.85 % of reading	
	> 3 %	0.42 % of reading	
10 MHz to 26.5 GHz	20 Hz to 1 kHz		Agilent E4448A Spectrum Analyzer
	> 1 %	1 % of reading	
	> 3 %	0.5 % of reading	
(26.5 to 50) GHz	20 Hz to 1 kHz		
	> 1 %	6.2 % of reading	
	> 3 %	2 % of reading	
	> 5 %	1.5 % of reading	
Amplitude Modulation – AM Depth – Source [1] 250 kHz to 50 GHz	(0 to 90) % Depth	6.6 % Depth	Agilent E8257D Analog Signal Generator
Frequency Modulation Deviation – Measure [1]			
Rate: 250 kHz to 10 MHz	20 Hz to 10 kHz		
	Dev/Rate > 0.2	1.5 % Deviation	
	Dev/Rate > 1.2	1 % Deviation	
10 MHz to 6.6 GHz	50 Hz to 200 kHz		
	Dev/Rate > 0.2	1.5 % Deviation	
	Dev/Rate > 0.45	1 % Deviation	
(6.6 to 13.2) GHz	50 Hz to 200 kHz		Agilent E4448A Spectrum Analyzer
	Dev/Rate > 0.2	2.5 % Deviation	
	Dev/Rate > 8	1 % Deviation	
(13.2 to 31.15) GHz	50 Hz to 200 kHz		
	Dev/Rate > 0.2	3.8 % Deviation	
	Dev/Rate > 16	1 % Deviation	
(31.5 to 50) GHz	50 Hz to 200 kHz		
	Dev/Rate > 0.2	8.5 % Deviation	
	Dev/Rate > 32	1 % Deviation	
Frequency Modulation Distortion – Measure [1] 1 MHz to 6.6 GHz	20 Hz to 1 kHz		Agilent E4448A Spectrum Analyzer
	Dev 500 Hz to 2 kHz	0.3 % of reading	
	Dev ≥ 2 kHz	0.11 % of reading	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation Distortion – Measure [1]			
(6.6 to 13.2) GHz	20 Hz to 1 kHz		
	Dev > 2.3 kHz	0.3 % of reading	
	Dev ≥ 4.5 kHz	0.11 % of reading	
(13.2 to 31.15) GHz	20 Hz to 1 kHz		Agilent E4448A Spectrum Analyzer
	Dev > 2.7 kHz	0.31 % of reading	
	Dev ≥ 6 kHz	0.12 % of reading	
(31.5 to 50) GHz	20 Hz to 1 kHz		
	Dev > 4 kHz	0.32 % of reading	
	Dev ≥ 12 kHz	0.14 % of reading	
Frequency Modulation – Deviation Source [1]			
250 kHz to 50 GHz	DC to 10 MHz		Agilent E8257D Analog Signal Generator
	Dev ≤ 128 MHz	3.9 % Deviation	
Phase Modulation Deviation – Measure [1]			
Rate: 100 kHz to 6.6 GHz	> 0.7 rad	1.1 % Deviation	
	> 0.3 rad	3.2 % Deviation	
(6.6 to 13.2) GHz	> 2 rad	1.1 % Deviation	
	> 0.6 rad	3.2 % Deviation	
(13.2 to 26.5) GHz	> 4.0 rad	1.1 % Deviation	
	> 1.2 rad	3.2 % Deviation	
(26.5 to 31.15) GHz	> 4 rad	1.1 % Deviation	
	> 1.3 rad	3.2 % Deviation	
(31.15 to 50) GHz	> 8 rad	1.1 % Deviation	
	> 2.4 rad	3.2 % Deviation	
Phase Modulation Distortion – Measure [1]			
1 MHz to 6.6 GHz	(20 to 500) Hz		
	> 0.8 rad	0.31 % of reading	
	≥ 2.5 rad	0.13 % of reading	
	500 Hz to 1 kHz		
	> 0.4 rad	0.31 % of reading	Agilent E4448A Spectrum Analyzer
	≥ 1.0 rad	0.13 % of reading	
(6.6 to 13.2) GHz	(20 to 500) Hz		
	> 1.8 rad	0.31 % of reading	
	≥ 5.5 rad	0.13 % of reading	
	500 Hz to 1 kHz		
	≥ 0.8 rad	0.31 % of reading	
	≥ 2.5 rad	0.13 % of reading	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation Distortion – Measure [1]			Agilent E4448A Spectrum Analyzer
(13.2 to 31.15) GHz	(20 to 500) Hz		
	> 3.5 rad	0.31 % of reading	
	≥ 10 rad	0.13% of reading	
(31.15 to 50) GHz	(20 to 500) Hz		
	> 7.5 rad	0.31 % of reading	
	≥ 19 rad	0.13 % of reading	
	500 Hz to 1 kHz		
	> 3 rad	0.31 % of reading	
	≥ 8 rad	0.13 % of reading	
Phase Modulation Distortion – Source [1]	(250 to 500) MHz		Agilent E8257D Analog Signal Generator
	(0 to 10) rad	5.8 % of reading	
	500 MHz to 1 GHz		
	(0 to 20) rad	5.8 % of reading	
	(1 to 2) GHz		
	(0 to 40) rad	5.8 % of reading	
	(2 to 3.2) GHz		
	(0 to 80) rad	5.8 % of reading	
	(3.2 to 10) GHz		
	(0 to 160) rad	5.8 % of reading	
	(10 to 20) GHz		
	(0 to 320) rad	5.8 % of reading	
	(20 to 40) GHz		
	(0 to 640) rad	5.8 % of reading	
	(40 to 50) GHz		
	(0 to 1 280) rad	5.8 % of reading	
Single Sideband Phase Noise – Measure [1]			Agilent E4448A Spectrum Analyzer
CW Frequency:	Markers:		
3 Hz to 3 GHz	100 Hz to 1 MHz	0.6 dB	
(3 to 6.6) GHz	100 Hz to 1 MHz	1 dB	
(6.6 to 22) GHz	100 Hz to 1 MHz	1.6 dB	
(22 to 26.8) GHz	100 Hz to 1 MHz	1.7 dB	
(26.8 to 31.15) GHz	100 Hz to 1 MHz	1.1 dB	
(31.15 to 50) GHz	100 Hz to 1 MHz	1.4 dB	
Total Harmonic Distortion – Measure [1]	10 Hz to 100 kHz	8.4 % of reading	Agilent U8903A Audio Analyzer
	20 Hz to 20 kHz	1.1 dB	
(-100 to 0) dB	(20 to 100) kHz	2 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Harmonic Distortion – Measure [1] Rate: 5 Hz to 600 kHz Level: (0.3 to 100) %	10 Hz to 1 MHz (1 to 3) MHz	3 % of reading 6 % of reading	Agilent 334A Distortion Analyzer

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle Measuring Devices (Protractors, Inclinometers, Squares, Angle Gages)	5° (5 to 20)° (20 to 35)° (35 to 45)° (45 to 60)° (60 to 75)° (75 to 85)°	1.4″ 2.1″ 3.5″ 4.9″ 8.3″ 18″ 54″	10 in Sine Bar, Gage Blocks, Surface Plate
	≥ 90°	1.4″	Master Square, Surface Plate
Micrometers [1,2] Outside, Inside, Depth	Up to 1 in (1 to 4) in (4 to 15) in (15 to 40) in	(13 + 1*L*) µin (9 + 4*L*) µin (10 + 4*L*) µin (13 + 4*L*) µin	Comparison to Grade 0 Gage Blocks
Anvil Flatness	Up to in*D*	4.4 µin	Optical Flats
Anvil Parallelism	Up to in*D*	6.5 µin	Optical Parallels
Calipers [1,2] Outside, Inside, Depth, Step	Up to 1 in (1 to 4) in (4 to 15) in (15 to 40) in	(13 + 1*L*) µin (9 + 4*L*) µin (10 + 4*L*) µin (13 + 4*L*) µin	Comparison to Grade 0 Gage Blocks
Jaw Flatness	Up to 1 in	4.2 µin	Optical Flats
Jaw Parallelism	Up to 1 in	7.2 µin	Optical Parallels
Linear Displacement [2]	Up to 12 ft	(1 + 2.1*L*) µin	Laser Interferometer
Dial Indicators [1, 2]	Up to 0.1 in (0.1 to 6) in	4.5 µin (4 + 4*L*) in	Comparison to Gage Blocks

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length – Single Axis [2]			
Outside Dimension	Up to 1 in	(6.1 + 1*L*) µin	Universal Length Measuring Machine
	(1 to 7) in	(4.5 + 3.5*L*) µin	
	(7 to 12) in	(2 + 4*L*) µin	
Inside Dimension	(0.04 to 1) in	(9 + 1*L*) µin	
	(1 to 2.5) in	(10 + 3*L*) µin	
	(2.5 to 10) in	(15 + 3*L*) µin	
	(10 to 14) in	(26 + 3*L*) µin	
Height Measuring Equipment [2]	Up to 8 in	(6 + 4*L*) µin	Gage Blocks w/ Surface Plate
	(8 to 26) in	(12 + 4*L*) µin	
Rulers [2]	Up to 12 in	(130 + 10*L*) µin	OGP Flash-500 Vision System
	(12 to 26) in	(80 + 15*L*) µin	
Measuring Tapes and Rulers [2]	Up to 1 ft	(460 + 3*L*) µin	Accu-Gage Single Axis Vision System
	(1 to 3) ft	(390 + 9*L*) µin	
	(3 to 1 000) ft	(20*L*) µin	
Plug Gages [2] (Outside Diameter)	Up to 1 in	12 µin	Universal Length Measuring Machine
	(1 to 7) in	(10 + 3*L*) µin	
Pin Gages [2] (Outside Diameter)	(0.003 to 1) in	30 µin	Laser Micrometer
Laser Micrometers [1,2]	Up to 0.1 in	13 µin	Characterized Master Pin Gages
	(0.1 to 0.4 in)	8 µin	
	(0.4 to 1) in	(11 + 5*L*) µin	
Threaded Plugs [2]			
Pitch Diameter – 60° Thread	Up to 1 in	79 µin	Universal Length Measuring Machine, Thread Wires
	(1 to 4) in	80 µin	
	(4 to 7) in	83 µin	
Major Diameter	Up to 1 in	13 µin	Universal Length Measuring Machine
	(1 to 7) in	(10 + 3*L*) µin	
Step Height	Up to 1 in	32 µin	Gage Probe, Amplifier, Gage Blocks
Threaded Rings			
Inner Pitch Diameter	Up to 1 in	79 µin	Master Plug Uncertainty
	(1 to 4) in	80 µin	
	(4 to 7) in	83 µin	

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Plain Ring Gages [2] Inside Diameter	(0.04 to 1) in (1 to 2.5) in (2.5 to 10) (10 to 14) in	(9 + 1*L*) µin (10 + 3*L*) µin (15 + 3*L*) µin (26 + 3*L*) µin	Universal Length Measuring Machine

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Measuring Equipment [1]	(0.03 to 600) lbf	0.017 % of reading	NIST Class F Weights
	(0 to 500) lbf (500 to 2 000) lbf (2 000 to 10 000) lbf (10 000 to 25 000) lbf (25 000 to 100 000) lbf	0.035 lbf 0.12 lbf 1.4 lbf 5.1 lbf 28 lbf	Load Cells
Mass Determination Metric (SI)	30 kg 25 kg 20 kg 10 kg 5 kg 3 kg 2 kg 1 kg 500 g 300 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 3 g 2 g 1 g 500 mg 300 mg 200 mg 100 mg	13 mg 12 mg 10 mg 3.5 mg 1.6 mg 1.2 mg 0.66 mg 0.32 mg 0.15 mg 0.1 mg 67 µg 36 µg 16 µg 12 µg 11 µg 8.2 µg 4.7 µg 4.7 µg 4.7 µg 4.7 µg 2 µg 2 µg 2 µg 2 µg	Echelon II

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass Determination Metric (SI)	50 mg 30 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	2 µg 2 µg 2 µg 2 µg 2 µg 2 µg 2 µg 2 µg	Echelon II
Mass Determination Metric (SI)	50 kg 30 kg 25 kg 20 kg 10 kg 5 kg 3 kg 2 kg 1 kg 500 g 300 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 3 g 2 g 1 g 500 mg 300 mg 200 mg 100 mg 50 mg 30 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	150 mg 100 mg 100 mg 100 mg 12 mg 5.8 mg 4 mg 2.5 mg 1.1 mg 0.51 mg 0.37 mg 0.21 mg 0.1 mg 45 µg 30 µg 27 µg 24 µg 12 µg 12 µg 12 µg 12 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg 4.9 µg	Echelon III

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass Determination Avoirdupois	50 lb 30 lb 20 lb 10 lb 5 lb 3 lb 2 lb 1 lb 8 oz 4 oz 2 oz 1 oz 0.5 oz	100 mg 13 mg 12 mg 5.8 mg 2.6 mg 1.2 mg 1.1 mg 0.51 mg 0.22 mg 0.1 mg 51 µg 36 µg 27 µg	Echelon III
Torque – Measure [1]	15 ozf·in to 2 000 lbf·ft	1 % of reading	CDI Torque Measuring System
Torque Measuring Equipment	(5 to 200) ozf·in (4 to 400) lbf·in (75 to 1 000) lbf·in (25 to 250) lbf·ft (60 to 2 000) lbf·ft	0.06 % of reading 0.01 % of reading + 0.6*R* lbf·in 0.06 % of reading + 0.6*R* lbf·in 0.04 % of reading + 0.6*R* lbf·in 0.12 % of reading + 0.6*R* lbf·in	Torque Wheels/Arms w/ Weights
Balances [1] Metric (SI)	5 kg 2 kg 1 kg 500 g 300 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 3 g 2 g 1 g	3.7 mg 1.4 mg 0.72 mg 0.38 mg 0.21 mg 0.14 mg 80 µg 42 µg 24 µg 20 µg 14 µg 8.3 µg 7.8 µg 7.7 µg 7.7 µg	ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system.

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Balances [1] Metric (SI)	500 mg 200 mg 100 mg 50 mg 20 mg 10 mg 5 mg 1 mg	2.4 µg 2.4 µg 2.4 µg 2.4 µg 2.4 µg 2.4 µg 2.4 µg 2.4 µg	ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system.
Balance/Scales[1] Avoirdupois	50 lb 30 lb 20 lb 10 lb 5 lb 3 lb 2 lb 1 lb 8 oz 4 oz 2 oz 1 oz 0.5 oz	2.3 g 1.4 g 0.91 g 0.45 g 0.23 g 0.14 g 91 mg 45 mg 23 mg 12 mg 5.7 mg 2.8 mg 1.4 mg	NIST Class F weights and internal calibration procedure utilized for the calibration of the weighing system.
Absolute Pressure – Source [1]	(0 to 14.7) psia (14.7 to 139.7) psia (139.7 to 2 514.7) psia	0.002 5 psi 0.001 % of reading + 0.007 5 psi 0.007 % of reading	Fluke/Ruska 7250xi Pressure Controller/Calibrator
Pressure – Source Pneumatic [1]	(-14.7 to 0) psig (0 to 125) psig (125 to 2 500) psig	0.001 3 psi 0.001 4 % of reading + 0.007 psi 0.007 % of reading	Fluke/Ruska 7250xi Pressure Controller/Calibrator
	(-60 to -22) inH_2O (-22 to 22) inH_2O (22 to 60) inH_2O (60 to 72) inH_2O (72 to 804) inH_2O	0.009 % of reading + 0.000 15 inH_2O 0.002 inH_2O 0.009 % of reading + 0.000 15 inH_2O 0.006 inH_2O 0.009 % of reading + 0.000 15 inH_2O	Fluke/DHI PPC4-ui Pressure Measurement System
	Up to 6 000 psig	0.72 psi	Comparison to Mensor 2101 Digital Pressure Indicator
	Up to 10 000 psig	1.2 psi	Comparison to Mensor CPR2550 Digital Pressure Indicator
Pressure – Source Hydraulic [1]	(5 to 1 500) psig (1 500 to 15 000) psig	0.008 % of reading 0.008 % of reading	Ametek T-150 Dead Weight Tester

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure – Source Hydraulic [1]	(1 000 to 25 000) psig	15 psi	Comparison to Heise 901B Digital Pressure Indicator
	(60 to 4 000) psig (4 000 to 40 000) psig	0.25 psi 0.006 3 % of reading	Fluke/Ruska 2450 Hydraulic Deadweight Tester

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity – Measure [1] (10 to 30) °C	(20 to 90) % RH	1.3 % RH	Vaisala HMI41/HMP46 Thermohygrometer
Relative Humidity – Source	(-10 to 15) °C (10 to 75) % RH (75 to 95) %RH (15 to 35) °C (10 to 95) %RH (35 to 70) °C (10 to 50) %RH (50 to 75) %RH (75 to 95) %RH	 0.5 %RH 0.65 %RH 0.5 %RH 0.5 %RH 0.7 %RH 0.85 %RH	Thunder Scientific 2500 Two-Pressure Humidity Generator
Temperature – Measure [1]	(-195 to 660) °C	0.003 % of reading + 0.009 °C	Hart 5628 PRT w/ Black Stack Thermometer Indicator
	(600 to 1 000) °C (1 000 to 1 200) °C	0.93 °C 1.2 °C	Accu-Mac AM1210 Type S Reference Thermocouple w/ Hart 2565 Thermocouple Module and Black Stack
Temperature – Source	(-80 to 0) °C (0 to 100) °C (100 to 200) °C (200 to 300) °C	0.003 % of reading + 0.014 ºC 0.003 % of reading + 0.017 ºC 0.003 % of reading + 0.025 ºC 0.003 % of reading + 0.035 ºC	Hart 5628 PRT w/ Black Stack and Fluke 7381, 7321, and 6331 Baths
	(300 to 425) ºC (425 to 660) °C	0.003 % of reading + 0.043 ºC 0.003 % of reading + 0.06 ºC	Hart 5628 PRT w/ Black Stack and Fluke 9173 Dry Well

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source	(660 to 1 200) °C	3.1 °C	Accu-Mac AM1210 Type S Reference Thermocouple w/ Hart 2565 Thermocouple Module, Black Stack and Furnace

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure and Measuring Equipment	10 MHz	3.7 pHz/Hz	Fluke 910R GPS Frequency Secondary Standard
Frequency – Measure and Measuring Equipment [1]	10 MHz	6.6 nHz/Hz	HP 53131A (10) Frequency Counter
Scope Waveform Generator Frequency – Source [1] (Sine, Square, Triangle)	10 Hz to 10 kHz	0.001 9% of reading + 12 mHz	Fluke 55xxA/11 Multiproduct Calibrator
Stopwatches/Timers	Up to 599 s/mon	59 ms/d	Vibrograf 4500 Timometer
AC Duty Cycle – Source [1] Square Wave: < 3.3 Vp-p Freq: 0.1 Hz to 100 kHz	(1 to 10) % Duty Cycle 10 µs to 100 s (10 to 49) % Duty Cycle 10 µs to 100 s 50 % Duty Cycle 10 µs to 100 s (51 to 90) % Duty Cycle 10 µs to 100 s (90 to 99) % Duty Cycle 10 µs to 100 s	0.62 % of reading + 78 ns 0.039 % of reading + 78 ns 0.001 6 % of reading + 78 ns 0.039 % of reading + 78 ns 0.62 % of reading + 78 ns	Fluke 5522A Multiproduct Calibrator

DIMENSIONAL MEASUREMENT

2 Dimensional

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Measurement – 2D	Up to 12 in (0 to 360)°	0.015°	OGP Flash-500 Vision System utilized for Angle Measurements
Two Dimensional Gages [2] X-Y Axis	Up to 19 in x 17 in Up to 12 in (12 to 26) in	(130 + 12*L*) µin (80 + 15*L*) µin	OGP Flash-500 Vision System utilized for Dimensional Measurements

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. L = length in inches; D = diameter in inches.
3. As frequency & amplitude deviate from the listed values, uncertainty may be higher than stated. If needed, contact laboratory for more information regarding uncertainties at frequency and range combinations other than the ones shown.
4. The stated uncertainty is the laboratory's ability to source a fast rise pulse that is approximately 500 ps, 150 ps, or 70 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 UUT. The known source rise time is mathematically removed from the total observed UUT rise time.
5. 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.
6. The reference standards found in this parameter are used for the calibration of pressure gages, pressure transducers, pressure transmitters and for cross-floating comparison calibration method for deadweight testers.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.08.

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