



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

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

Fulfills the requirements of

ISO/IEC 17025:2017

and national standard

ANSI/NCSL Z540-1-1994 (R2002)

In the field of

CALIBRATION

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

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 07 September 2021
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)

Transcat – Los Angeles
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CALIBRATION

Valid to: **September 7, 2021**

Certificate Number: **AC-2489.08**

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 to 2.5 kHz (2.5 to 10) kHz (10 to 20) kHz	1.5 % of reading 1.4 % of reading 2.3 % of reading 5 % of reading	Comparison to Master Accelerometer
Sound Level Calibrators 31.5 Hz to 16 kHz	(94, 104, and 114) dB	0.6 dB	Brüel & Kjær 4226 Multifunction Acoustic 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) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	26 μ A/A + 0.92 nA 26 μ A/A + 5.8 nA 26 μ A/A + 58 nA 43 μ A/A + 0.58 μ A 0.01 % + 12 μ A	Agilent 3458A Multimeter w/ Current Source
	(1 to 100) A	0.01 % of reading + 0.5 mA	Ohms Labs CS-100 Precision Shunt w/ Agilent 3458A
	(100 to 300) A	0.05 % of reading	DC Current Shunts w/ DMM and Current Source
DC Current – Source ¹	(0 to 220) μ A 220 μ A 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	41 μ A/A + 6 nA 36 μ A/A + 7 nA 36 μ A/A + 40 nA 57 μ A/A + 0.7 μ A 0.2 mA/A + 12 μ A 0.4 mA/A + 0.5 mA	Fluke 5700A-EP Multimeter w/ Fluke 5725A Amplifier
	(11 to 20) A	0.1 % of reading + 0.58 mA	Fluke 5522A
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 Calibrator w/ Fluke 5500A/Coil
AC Current – Measure ¹	Up to 100 μ A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 μ A to 1 mA (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 0.07 % of reading + 35 nA 0.07 % of reading + 35 nA 0.46 % of reading + 0.23 μ A 0.17 % of reading + 0.23 μ A 0.07 % of reading + 0.23 μ A 0.04 % of reading + 0.23 μ A	Agilent 3458A Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure ¹	(1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % of reading + 2.3 μ A 0.17 % of reading + 2.3 μ A 0.07 % of reading + 2.3 μ A 0.04 % of reading + 2.3 μ A	Agilent 3458A Multimeter
	(10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % of reading + 23 μ A 0.17 % of reading + 23 μ A 0.07 % of reading + 23 μ A 0.04 % of reading + 23 μ A	
	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 + 0.23 mA 0.19 % of reading + 0.23 mA 0.1 % of reading + 0.23 mA 0.12 % of reading + 0.23 mA	
AC Current – Measure ¹	0 A to 10 A 50 Hz to 1 kHz 1 kHz	0.05 % of reading + 1.3 mA 0.12 % of reading + 1.3 mA	Ohms Labs CS-100 Precision Shunt w/ Agilent 3458A
	10 A to 100 A (50 to 100) Hz 100 Hz to 1 kHz 1 kHz	0.04 % of reading + 2.3 mA 0.04 % of reading + 2.3 mA 0.13 % of reading + 2.3 mA	
AC Current – Source ¹	Up to 220 μ A (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.03 % of reading + 16 nA 0.02 % of reading + 10 nA 0.01 % of reading + 8 nA 0.03 % of reading + 10 nA 0.11 % of reading + 65 nA	Fluke 5700A-EP Calibrator
	(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	0.03 % of reading + 40 nA 0.02 % of reading + 35 nA 0.01 % of reading + 35 nA 0.02 % of reading + 0.11 μ A 0.11 % of reading + 0.65 μ A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source ¹	(2.2 to 22) mA		Fluke 5700A-EP Calibrator
	(10 to 20) Hz	0.04 % of reading + 0.4 μ A	
	(20 to 40) Hz	0.02 % of reading + 0.35 μ A	
	40 Hz to 1 kHz	0.01 % of reading + 0.35 μ A	
	(1 to 5) kHz	0.02 % of reading + 0.55 μ A	
	(5 to 10) kHz	0.11 % of reading + 5 μ A	
	(22 to 220) mA		
	(10 to 20) Hz	0.03 % of reading + 4 μ A	
	(20 to 40) Hz	0.02 % of reading + 3.5 μ A	
	40 Hz to 1 kHz	0.01 % of reading + 2.5 μ A	
	(1 to 5) kHz	0.02 % of reading + 3.5 μ A	
	(5 to 10) kHz	0.11 % of reading + 10 μ A	
AC Current – Source ¹	(0.22 to 2.2) A		Fluke 5700A-EP Calibrator w/ Fluke 5725A Amplifier
	20 Hz to 1 kHz	0.03 % of reading + 35 μ A	
	(1 to 5) kHz	0.05 % of reading + 80 μ A	
	(5 to 10) kHz	0.7 % of reading + 0.16 mA	
AC Current – Source ¹	(2.2 to 11) A		Fluke 5700A-EP Calibrator w/ Fluke 5725A Amplifier
	40 Hz to 1 kHz	0.05 % of reading + 0.17 mA	
	(1 to 5) kHz	0.1 % 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 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 Multimeter and 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	
AC Current – Source Extended Frequency Ranges ¹	29 μ A to 329.99 μ A		Fluke 5522A Calibrator
	(10 to 30) kHz	1.2 % of reading + 0.31 μ A	
	330 μ A to 3.299 mA		
	(10 to 30) kHz	0.78 % of reading + 0.47 μ A	
	3.3 mA to 32.99 mA		
	(10 to 30) kHz	0.31 % of reading + 3.1 μ A	
	33 mA to 329.99 mA		
	(10 to 30) kHz	0.31 % of reading + 0.16 mA	

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 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 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 k Ω (1 to 10) k Ω (10 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω	18 $\mu\Omega/\Omega$ + 58 $\mu\Omega$ 15 $\mu\Omega/\Omega$ + 0.58 m Ω 12 $\mu\Omega/\Omega$ + 0.58 m Ω 12 $\mu\Omega/\Omega$ + 5.8 m Ω 12 $\mu\Omega/\Omega$ + 58 m Ω 19 $\mu\Omega/\Omega$ + 2.3 Ω 62 $\mu\Omega/\Omega$ + 120 Ω 0.06 % of reading + 1.2 k Ω 0.58 % of reading + 12 k Ω	Agilent 3458A Multimeter w/ Decade Resistor
DC Resistance – Source Fixed ¹	1 m Ω	9.8 $\mu\Omega/\Omega$	L&N 4223B Standard Resistor
	10 m Ω	30 $\mu\Omega/\Omega$	L&N 4222B Standard Resistor
	100 m Ω	34 $\mu\Omega/\Omega$	L&N 4015B Standard Resistor
DC Resistance – Source Variable ¹	(2 to 10) G Ω (20 to 100) G Ω 200 G Ω to 1 T Ω	0.58 % of reading 1.2 % of reading 2.6 % of reading	IET HRRS-B-3-1G-5KV Decade Resistor
DC Resistance – RTD Measure ¹	(0 to 25) Ω (25 to 400) Ω 400 to 1 k Ω (1 to 40) k Ω	0.04 m Ω 1.3 $\mu\Omega/\Omega$ 4.1 $\mu\Omega/\Omega$ 10 $\mu\Omega/\Omega$	Hart 1590 Super Thermometer Readout
DC Voltage – Measure/Source ¹	(0 to 100) mV 100 mV to 10 V (10 to 100) V (100 to 500) V (500 to 800) V (800 to 1 000) V	8.3 $\mu\text{V}/\text{V}$ + 0.5 μV 5.1 $\mu\text{V}/\text{V}$ + 0.5 μV 7.6 $\mu\text{V}/\text{V}$ + 35 μV 11 $\mu\text{V}/\text{V}$ + 0.12 mV 16 $\mu\text{V}/\text{V}$ + 0.12 mV 21 $\mu\text{V}/\text{V}$ + 0.12 mV	Agilent 3458A opt 2 Multimeter w/ Fluke 5700A-EP Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 μ V 3.5 % of reading + 2.4 μ V 9.3 % of reading + 2.4 μ V 23 % of reading + 2.4 μ V 0.97 % of reading + 2 μ V 3.5 % of reading + 2 μ V 9.3 % of reading + 2 μ V 23 % of reading + 2 μ V 0.91 % of reading + 3 μ V 1.8 % of reading + 3 μ V 2.9 % of reading + 3 μ V 7 % of reading + 3 μ V 14 % of reading + 3 μ V	Rohde & Schwarz URE3 RMS Voltmeter
AC Voltage – Measure ¹	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (10 to 100) mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.04 % of reading + 3.5 μ V 0.04 % of reading + 1.2 μ V 0.04 % of reading + 1.2 μ V 0.15 % of reading + 1.2 μ V 0.59 % of reading + 1.2 μ V 4.6 % of reading + 2.3 μ V 1.5 % of reading + 5.8 μ V 0.01 % of reading + 4.6 μ V 0.01 % of reading + 2.3 μ V 0.02 % of reading + 2.3 μ V 0.04 % of reading + 2.3 μ V 0.09 % of reading + 2.3 μ V 0.36 % of reading + 12 μ V 1.2 % of reading + 12 μ V	Agilent 3458A Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure ¹	100 mV to 1 V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 10) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (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	0.01 % of reading + 46 μ V 0.01 % of reading + 23 μ V 0.02 % of reading + 23 μ V 0.04 % of reading + 23 μ V 0.09 % of reading + 23 μ V 0.35 % of reading + 0.12 mV 1.2 % of reading + 0.12 mV 0.01 % of reading + 0.46 mV 0.01 % of reading + 0.23 mV 0.02 % of reading + 0.23 mV 0.04 % of reading + 0.23 mV 0.09 % of reading + 0.23 mV 0.35 % of reading + 1.2 mV 1.2 % of reading + 1.2 mV 0.02 % of reading + 4.6 mV 0.02 % of reading + 2.3 mV 0.02 % of reading + 2.3 mV 0.04 % of reading + 2.3 mV 0.14 % of reading + 2.3 mV 0.46 % of reading + 12 mV 1.7 % of reading + 12 mV 0.05 % of reading + 46 mV 0.05 % of reading + 23 mV 0.07 % of reading + 23 mV 0.14 % of reading + 23 mV 0.35 % of reading + 23 mV	Agilent 3458A Multimeter
	(700 to 1 050) V (1 to 10) Hz (10 to 40) Hz 40 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.02 % + 85 mV 0.02 % + 24 mV 0.02 % + 24 mV 0.03 % + 48 mV 0.06 % + 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		Vitretek 4700 DVM w/ Associated High Voltage Probes
	(10 to 200) Hz	0.14 % of reading + 0.12 V	
	(200 to 450) Hz	0.46 % of reading + 0.12 V	
	(10 to 30) kV		
	(30 to 200) Hz	0.06 % of reading + 0.23 V	
	(200 to 450) Hz	0.7 % of reading + 0.23 V	
	(30 to 50) kV		
AC Voltage – Source ¹	(30 to 100) Hz	0.09 % of reading + 0.46 V	Fluke 5700A-EP Calibrator
	(100 to 450) Hz	2.9 % of reading + 0.46 V	
	(50 to 100) kV		
	60 Hz	0.23 % of reading + 1.4 V	
	Up to 2.2 mV		
	(10 to 20) Hz	0.04 % of reading + 4.1 μ V	
	(20 to 40) Hz	0.03 % of reading + 4.1 μ V	
	40 Hz to 20 kHz	0.03 % of reading + 4.1 μ V	
	(20 to 50) kHz	0.03 % of reading + 4.1 μ V	
	(50 to 100) kHz	0.06 % of reading + 5.1 μ V	
	(100 to 300) kHz	0.13 % of reading + 10 μ V	
	(300 to 500) kHz	0.2 % of reading + 20 μ V	
	500 kHz to 1 MHz	0.31 % of reading + 20 μ V	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.04 % of reading + 4.1 μ V	
	(20 to 40) Hz	0.03 % of reading + 4.1 μ V	
	40 Hz to 20 kHz	0.01 % of reading + 4.1 μ V	
	(20 to 50) kHz	0.02 % of reading + 4.1 μ V	
	(50 to 100) kHz	0.05 % of reading + 5.1 μ V	
	(100 to 300) kHz	0.11 % of reading + 10 μ V	
	(300 to 500) kHz	0.14 % of reading + 20 μ V	
	500 kHz to 1 MHz	0.28 % of reading + 20 μ V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source ¹	(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 220 mV to 2.2 V (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	0.02 % of reading + 12 μ V 0.01 % of reading + 7.1 μ V 0.01 % of reading + 7.1 μ V 0.02 % of reading + 7.1 μ V 0.05 % of reading + 17 μ V 0.09 % of reading + 20 μ V 0.14 % of reading + 26 μ V 0.28 % of reading + 46 μ V 0.02 % of reading + 41 μ V 0.01 % of reading + 15 μ V 0.05 % of reading + 8.2 μ V 0.01 % of reading + 10 μ V 0.01 % of reading + 31 μ V 0.04 % of reading + 82 μ V 0.1 % of reading + 0.2 mV 0.17 % of reading + 0.31 mV	Fluke 5700A-EP Calibrator
AC Voltage – Source ¹	(2.2 to 22) V (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) V (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	0.02 % of reading + 0.41 mV 0.01 % of reading + 0.15 mV 0.01 % of reading + 51 μ V 0.01 % of reading + 0.1 mV 0.01 % of reading + 0.2 mV 0.03 % of reading + 0.61 mV 0.1 % of reading + 2 mV 0.15 % of reading + 3.3 mV 0.02 % of reading + 4.1 mV 0.01 % of reading + 1.5 mV 0.01 % of reading + 0.61 mV 0.01 % of reading + 1.0 mV 0.01 % of reading + 2.5 mV 0.09 % of reading + 16 mV 0.45 % of reading + 41 mV 0.82 % of reading + 82 mV	Fluke 5700A-EP Calibrator
AC Voltage – Source ¹	(220 to 1 100) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (30 to 50) kHz (50 to 100) kHz	0.01 % of reading + 4.1 mV 0.02 % of reading + 6.1 mV 0.06 % of reading + 11 mV 0.06 % of reading + 11 mV 0.24 % of reading + 46 mV	Fluke 5700A-EP Calibrator w/ Fluke 5725A Amplifier

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure ¹ 1 kHz	Up to 10 pF (10 to 100) pF 100 pF to 25 μ F (25 to 100) μ F (100 to 1 000) μ F	0.47 % of reading + 0.05 pF 0.06 % of reading + 0.05 pF 0.02 % of reading + 0.05 pF 0.03 % of reading 0.24 % of reading	GenRad 1689-9700 RLC Digibridge
Capacitance – Measure	0.1 pF 100 kHz 1 MHz 1 pF 10 kHz 100 kHz 1 MHz 2 MHz 10 pF 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz 100 pF 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz 1 nF 20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz 10 nF 20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	1.4 % of reading 1.8 % of reading 1.4 % of reading 0.37 % of reading 0.44 % of reading 1.1 % of reading 1.4 % of reading 0.28 % of reading 0.28 % of reading 0.3 % of reading 0.75 % of reading 2.1 % of reading 0.23 % of reading 0.18 % of reading 0.21 % of reading 0.23 % of reading 0.3 % of reading 1.8 % of reading 0.3 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.14 % of reading 0.53 % of reading 0.31 % of reading 0.12 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.25 % of reading 0.67 % of reading	Agilent E4980A LCR Meter

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 μ F		
	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 μ F		
	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 μ F		
	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 Simulation ¹	190 pF to 1.1 nF	0.39 % of reading + 7.8 pF	Fluke 5520A/1100 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 μ F	0.2 % of reading + 0.78 nF	
	(1.1 to 3.3) μ F	0.2 % of reading + 2.3 nF	
	(3.3 to 11) μ F	0.2 % of reading + 7.8 nF	
	(11 to 33) μ F	0.31 % of reading + 23 nF	
	(33 to 110) μ F	0.35 % of reading + 78 nF	
	(110 to 330) μ F	0.35 % of reading + 0.23 μ F	
	330 μ F to 1.1 mF	0.35 % of reading + 0.78 μ F	
	(1.1 to 3.3) mF	0.35 % of reading + 2.3 μ F	
	(3.3 to 11) mF	0.35 % of reading + 7.8 μ F	
	(11 to 33) mF	0.58 % of reading + 23 μ F	
	(33 to 110) mF	0.86 % of reading + 78 μ F	

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 μ F 0.2 μ F 0.5 μ F 1 μ F	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 μ H 0.03 % of reading + 1.4 μ H	GenRad 1689-9700 RLC Digibridge
Inductance – Measure	1 μ H 10 kHz 100 kHz 1 MHz 2 MHz 10 μ H 10 kHz 100 kHz 1 MHz 2 MHz 100 μ H 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 k Ω		
	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 k Ω		
	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 k Ω		Agilent E4980AL LCR Meter
	20 Hz	0.17 % of reading	
	100 Hz	0.1 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.17 % of reading	
	100 kHz	0.28 % of reading	
	1 MHz	0.38 % of reading	
Inductance – Source ¹	2 MHz	1.3 % of reading	Standard Inductors w/ GenRad 1689-9700
	100 μ H	0.025 μ H	
	1 mH	0.25 μ H	
	10 mH	2.5 μ H	
	100 mH	25 μ H	
	1 H	0.25 mH	
Electrical Simulation of Thermocouple Indicating Devices – Measure/Source ¹	10 H	2.5 mH	Ectron 1140A Thermocouple Calibrator/Simulator
	Type B		
	(250 to 350) °C	0.95 °C	
	(350 to 445) °C	0.74 °C	
	(445 to 580) °C	0.58 °C	
	(580 to 750) °C	0.45 °C	
	(750 to 1 000) °C	0.37 °C	
	(1 000 to 1 820) °C	0.29 °C	
	Type C		
	(0 to 250) °C	0.2 °C	
	(250 to 1 000) °C	0.16 °C	
	(1 000 to 1 500) °C	0.18 °C	
	(1 500 to 1 800) °C	0.21 °C	
	(1 800 to 2 000) °C	0.23 °C	
	(2 000 to 2 250) °C	0.29 °C	
	(2 250 to 2 315) °C	0.32 °C	
	Type E		
	(-270 to -245) °C	1.2 °C	
	(-245 to -195) °C	0.18 °C	
	(-195 to -155) °C	0.11 °C	
	(-155 to 1 000) °C	0.09 °C	
	Type J		
	(-210 to -180) °C	0.13 °C	
	(-180 to -120) °C	0.11 °C	
	(-120 to -50) °C	0.09 °C	
	(-50 to 1 200) °C	0.08 °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 K		Ectron 1140A Thermocouple Calibrator/Simulator
	(-270 to -255) °C	2.2 °C	
	(-255 to -195) °C	0.7 °C	
	(-195 to -115) °C	0.13 °C	
	(-115 to -55) °C	0.1 °C	
	(-55 to 1 000) °C	0.08 °C	
	(1 000 to 1 372) °C	0.09 °C	
	Type N		
	(-270 to -260) °C	5 °C	
	(-260 to -200) °C	1 °C	
	(-200 to -140) °C	0.23 °C	
	(-140 to -70) °C	0.16 °C	
	(-70 to 25) °C	0.13 °C	
	(-25 to 1 300) °C	0.11 °C	
	Type R		
	(-50 to -30) °C	0.65 °C	
	(-30 to 45) °C	0.55 °C	
	(45 to 160) °C	0.40 °C	
	(160 to 775) °C	0.30 °C	
	(775 to 1 768) °C	0.22 °C	
	Type S		
	(-50 to -30) °C	0.62 °C	
	(-30 to 45) °C	0.56 °C	
	(45 to 105) °C	0.4 °C	
	(105 to 310) °C	0.33 °C	
	(310 to 1 768) °C	0.29 °C	
	Type T		
	(-270 to -255) °C	1.8 °C	
	(-255 to -240) °C	0.5 °C	
	(-240 to -210) °C	0.3 °C	
	(-210 to -150) °C	0.18 °C	
	(-150 to -40) °C	0.13 °C	
	(-40 to 100) °C	0.09 °C	
	(100 to 400) °C	0.08 °C	
Scope Voltage – Source ¹ DC Signal into 50 Ω load into 1 MΩ load	(-6 to 6) V (-130 to 130) V	0.2 % of reading + 31 μV 0.2 % of reading + 31 μV	Fluke 55xxA/11 Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scope Voltage – Source ¹ Square Wave into 50 Ω load	10 Hz to 100 kHz 1 mV p-p to 6.6 Vp-p	0.19 % of reading + 31 μ V	Fluke 55xxA/11 Multiproduct Calibrator
into 1 M Ω load	10 Hz to 1 kHz 1 mV p-p to 6.6 Vp-p (1 kHz to 10) kHz	0.08 % of reading + 31 μ V	
	1 mV p-p to 6.6 Vp-p	0.19 % of reading + 31 μ V	
Scope – Time Markers ¹ into 50 Ω load	1 ns to 20 ms 50 ms 0.1 s 0.2 s 0.5 s 1 s 2 s 5 s	0.002 2 % of reading 2.3 μ s 7.6 μ s 28 μ s 0.16 ms 0.62 ms 2.4 ms 15 ms	Fluke 55xxA/11 Multiproduct Calibrator
Rise Time – Measure ¹	≥ 5 ns	0.41 ns	Rigol MSO8104 Oscilloscope
Scope Rise Time – Source ^{1, 4} into 50 Ω load Rate: 1 kHz to 2 MHz Rate: 2 MHz to 10 MHz	5 mVp-p to 2.5 Vp-p 250 ps (nominal) 250 ps (nominal)	50 ps 50 ps	Fluke 55xxA/11 Multiproduct Calibrator
Scope Levelled Sine Wave – Source ¹ into 50 Ω load	5 mVp-p to 5 Vp-p 50 kHz 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz	1.8 % of reading + 0.23 mV 2.8 % of reading + 0.23 mV 3.2 % of reading + 0.23 mV 4 % of reading + 0.23 mV 4.9 % of reading + 0.23 mV	Fluke 55xxA/11 Multiproduct Calibrator
Scope Bandwidth/Flatness – Source ¹ into 50 Ω load (50 kHz Reference)	5 mVp-p to 5.5 Vp-p 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz	1.4 % of reading + 78 μ V 1.8 % of reading + 78 μ V 3.2 % of reading + 78 μ V 3.9 % of reading + 78 μ V	Fluke 55xxA/11 Multiproduct Calibrator
Scope Input Impedance – Measure ¹	(40 to 60) Ω (0.5 to 1.5) M Ω	0.082% of reading 0.081 % of reading	Fluke 55xxA/11 Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scope Input Capacitance – Measure ¹	(5 to 50) pF	3.9 % of reading + 0.39 pF	Fluke 55xxA/11 Multiproduct Calibrator
Scope Waveform Generator – Source ¹ Sine, Square, Triangle into 50 Ω load into 1 M Ω load	10 Hz to 10 kHz 1.8 mVp-p to 2.5 Vp-p 1.8 mVp-p to 55 Vp-p	0.23 % of reading + 78 μ V 0.23 % of reading + 78 μ V	Fluke 55xxA/11 Multiproduct Calibrator
LF Phase – Source ¹	(0 to 90) ° (10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.11 ° 0.2 ° 0.39 ° 1.9 ° 3.9 ° 7.8 °	Fluke 5520A/1100 Calibrator
DC Power – Source ¹ 330 μ A to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	11 μ W to 3.4 W 110 mW to 34 W 1.1 mW to 340 W 11 mW to 3.4 kW 36 mW to 3.1 kW 0.99 W to 11 kW 360 mW to 21 kW	0.02 % of reading 0.01 % of reading 0.01 % of reading 0.03 % of reading 0.03 % of reading 0.06 % of reading 0.09 % of reading	Fluke 5520A/1100 Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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	Fluke 5520A/11 Calibrator
(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	
(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	
	100 Hz to 1 kHz 360 mW to 15 kW	0.16 % of reading	
(15 to 20.5) A	(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	

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		Agilent 8496H Programmable Attenuator w/ Type-N
	10 dB	0.6 dB	
	20 dB	0.8 dB	
	30 dB	1.2 dB	
	40 dB	1.6 dB	
	50 dB	2.0 dB	
	60 dB	2.4 dB	
	70 dB	2.8 dB	
	80 dB	3.2 dB	
	90 dB	3.6 dB	
	100 dB	4.0 dB	
	110 dB	4.4 dB	
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	3.8 % of reading	Agilent 8487D RF Power Sensor w/ RF Power Meter
	(40 to 50) GHz (-70 to -30) dBm	5.5 % of reading	
	(18 to 40) GHz (-30 to 20) dBm	4.4 % of reading	Agilent 8487D RF Power Sensor w/ RF Power Meter
	(40 to 50) GHz (-30 to 20) dBm	5.5 % of reading	
	30 MHz to 50 GHz (20 to 30) dBm	4.8 % of reading	Agilent E5532A-550 RF Power Sensor Module w/ RF Power Meter

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source ¹	(-70 to -10) dBm		Agilent E8257D Analog Signal Generator
	250 kHz to 2 GHz	0.8 dB	
	(2 to 20) GHz	1.1 dB	
	(20 to 40) GHz	1.2 dB	
	(40 to 50) GHz	1.8 dB	
	(-10 to 0) dBm		
	250 kHz to 2 GHz	0.7 dB	
	(2 to 20) GHz	0.9 dB	
	(20 to 40) GHz	1.1 dB	
	(40 to 50) GHz	1.1 dB	
	(0 to 10 dBm)		
	250 kHz to 2 GHz	0.7 dB	
	(2 to 20) GHz	0.9 dB	
	(20 to 40) GHz	1.1 dB	
	(40 to 50) GHz	1.5 dB	
	(10 to 14 dBm)		
	250 kHz to 2 GHz	0.7 dB	
	(2 to 20) GHz	0.9 dB	
	(20 to 40) GHz	1.2 dB	
	(14 to 19 dBm)		
	250 kHz to 2 GHz	0.9 dB	
	(2 to 20) GHz	0.9 dB	
	(20 to 40) GHz	1.2 dB	
RF Relative Power – Measure ¹ (Tuned RF Level)	100 kHz to 50 GHz		Agilent E4448A Spectrum Analyzer
	(-10 to 0) dB	0.02 dB	
	(-20 to -10) dB	0.02 dB	
	(-30 to -20) dB	0.03 dB	
	(-40 to -30) dB	0.04 dB	
	(-50 to -40) dB	0.04 dB	
	(-60 to -50) dB	0.09 dB	
	(-70 to -60) dB	0.10 dB	
	(-80 to -70) dB	0.14 dB	
	(-90 to -80) dB	0.15 dB	
	100 kHz to 45 GHz		
	(-100 to -90) dB	0.16 dB	
	(-110 to -100) dB	0.29 dB	
	100 kHz to 31.15 GHz		
	(-120 to -110) dB	0.29 dB	
	(-130 to -120) dB	0.29 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
S11/S22 Reflection Magnitude – Measure ¹ (Linear)	9 kHz to 10 MHz		Agilent E5071C Network Analyzer (Corrected with Agilent 85032F Calibration Kit)
	(0 to 0.5) lin	0.009	
	(0.5 to 1) lin	0.019	
	10 MHz to 9 GHz		
	(0 to 0.5) lin	0.012	Agilent E5235A Network Analyzer (Corrected with Agilent 85056K Calibration Kit)
	(0.5 to 1) lin	0.022	
S12/S21 Transmission Magnitude – Measure ¹ (dB)	50 MHz to 2 GHz		
	(0 to 0.5) lin	0.015	
	(0.5 to 1) lin	0.023	
	(2 to 40) GHz		
	(0 to 0.5) lin	0.028	Agilent E5071C Network Analyzer (Corrected with Agilent 85032F Calibration Kit)
	(0.5 to 1) lin	0.04	
	9 kHz to 10 MHz		
	(-30 to 0) dB	0.09 dB	
	(-60 to -30) dB	0.45 dB	Agilent E5235A Network Analyzer (Corrected with Agilent 85056K Calibration Kit)
	10 MHz to 9 GHz		
	(-30 to 0) dB	0.09 dB	
	(-60 to -30) dB	0.26 dB	
	(10 to 500) MHz		Agilent E5235A Network Analyzer (Corrected with Agilent 85056K Calibration Kit)
	(-30 to 0) dB	0.07 dB	
	(-60 to -30) dB	1.6 dB	
	500 MHz to 2 GHz		
	(-30 to 0) dB	0.05 dB	
	(-60 to -30) dB	0.18 dB	
	(2 to 50) GHz		
	(-30 to 0) dB	0.14 dB	
	(-60 to -30) dB	0.55 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – AM Depth Measure ¹ Rate: 100 kHz to 20 MHz	50 Hz to 10 kHz (5 to 99) % Depth	0.9 % Depth	Agilent E4448A Spectrum Analyzer
10 MHz to 3 GHz	50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	0.8 % Depth 2.6 % Depth	
(3 to 26.5) GHz	50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	1.6 % Depth 4.5 % Depth	
(26.5 to 31.15) GHz	50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	2.1 % Depth 6.8 % Depth	
(31.15 to 50) GHz	50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	6 % Depth 26 % Depth	
Amplitude Modulation Distortion – Measure ¹ 100 kHz to 10 kHz	20 Hz to 1 kHz > 1 % > 3 %	0.85 % of reading 0.42 % of reading	
10 MHz to 26.5 GHz	20 Hz to 1 kHz > 1 % > 3 %	1 % of reading 0.5 % of reading	
(26.5 to 50) GHz	20 Hz to 1 kHz > 1 % > 3 % > 5 %	6.2 % of reading 2 % of reading 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

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation Deviation – Measure ¹ Rate: 250 kHz to 10 MHz	20 Hz to 10 kHz Dev/Rate > 0.2 Dev/Rate > 1.2	1.5 % Deviation 1 % Deviation	Agilent E4448A Spectrum Analyzer
10 MHz to 6.6 GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 0.45	1.5 % Deviation 1 % Deviation	
(6.6 to 13.2) GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 8	2.5 % Deviation 1 % Deviation	
(13.2 to 31.15) GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 16	3.8 % Deviation 1 % Deviation	
(31.5 to 50) GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 32	8.5 % Deviation 1 % Deviation	
Frequency Modulation Distortion – Measure ¹ 1 MHz to 6.6 GHz	20 Hz to 1 kHz Dev 500 Hz to 2 kHz Dev ≥ 2.0 kHz	0.3 % of reading 0.11 % of reading	Agilent E8257D Analog Signal Generator
(6.6 to 13.2) GHz	20 Hz to 1 kHz Dev > 2.3 kHz Dev ≥ 4.5 kHz	0.3 % of reading 0.11 % of reading	
(13.2 to 31.15) GHz	20 Hz to 1 kHz Dev > 2.7 kHz Dev ≥ 6.0 kHz	0.31 % of reading 0.12 % of reading	
(31.5 to 50) GHz	20 Hz to 1 kHz Dev > 4.0 kHz Dev ≥ 12.0 kHz	0.32 % of reading 0.14 % of reading	
Frequency Modulation – Deviation Source ¹ 250 kHz to 50 GHz	DC to 10 MHz Dev ≤ 128 MHz	3.9 % Deviation	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation Deviation – Measure ¹ Rate: 100 kHz to 6.6 GHz	> 0.7 rad	1.1 % Deviation	Agilent E4448A Spectrum Analyzer
(6.6 to 13.2) GHz	> 0.3 rad	3.2 % Deviation	
(13.2 to 26.5) GHz	> 2.0 rad	1.1 % Deviation	
(26.5 to 31.15) GHz	> 0.6 rad	3.2 % Deviation	
(31.15 to 50) GHz	> 4.0 rad	1.1 % Deviation	
	> 1.2 rad	3.2 % Deviation	
	> 4.0 rad	1.1 % Deviation	
	> 1.3 rad	3.2 % Deviation	
	> 8.0 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	
	≥ 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	
(13.2 to 31.15) GHz	(20 to 500) Hz		
	> 3.5 rad	0.31 % of reading	
	≥ 10.0 rad	0.13 % of reading	
(31.15 to 50) GHz	(20 to 500) Hz		
	> 7.5 rad	0.31 % of reading	
	≥ 19.0 rad	0.13 % of reading	
	500 Hz to 1 kHz		
	> 3.0 rad	0.31 % of reading	
	≥ 8.0 rad	0.13 % of reading	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation Distortion – Source ¹	(250 to 500) MHz (0 to 10) rad 500 MHz to 1 GHz (0 to 20) rad (1 to 2) GHz (0 to 40) rad (2 to 3.2) GHz (0 to 80) rad (3.2 to 10) GHz (0 to 160) rad (10 to 20) GHz (0 to 320) rad (20 to 40) GHz (0 to 640) rad (40 to 50) GHz (0 to 1 280) rad	5.8 % of reading 5.8 % of reading 5.8 % of reading 5.8 % of reading 5.8 % of reading 5.8 % of reading 5.8 % of reading	Agilent E8257D Analog Signal Generator
Single Sideband Phase Noise – Measure ¹ CW Frequency: 3 Hz to 3 GHz (3 to 6.6) GHz (6.6 to 22) GHz (22 to 26.8) GHz (26.8 to 31.15) GHz (31.15 to 50) GHz	Markers: 100 Hz to 1 MHz 100 Hz to 1 MHz 100 Hz to 1 MHz 100 Hz to 1 MHz 100 Hz to 1 MHz 100 Hz to 1 MHz	0.6 dB 1 dB 1.6 dB 1.7 dB 1.1 dB 1.4 dB	Agilent E4448A Spectrum Analyzer
Total Harmonic Distortion – Measure ¹ (-100 to 0) dB	10 Hz to 100 kHz 20 Hz to 20 kHz (20 to 100) kHz	8.4 % of reading 1.1 dB 2 dB	Agilent U8903A Audio Analyzer
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
Angles	< 90 °	4.1 "	Sine Bar w/ Surface Plate
	≥ 90 °	1.4 "	Master Square w/ Surface Plate
Micrometers and Calipers– Outside, Inside, Depth ^{1, 2}	(0 to 0.4) in (0.4 to 1) in (1 to 4) in (4 to 15) in (15 to 40) in	13 μin (13 + 1L) μin (10 + 3.7L) μin (12 + 4L) μin (16 + 4L) μin	Comparison to Gage Blocks
Anvil Flatness ¹	Up to 1 in Diameter	6.5 μin	Optical Flats
Anvil Parallelism ¹	Up to 1 in	5.9 μin	Optical Parallels
Linear Displacement ²	Up to 12 ft	(1 + 2.1L) μin	Laser Interferometer
Dial Indicators ^{1, 2}	Up to 0.1 in (0.1 to 6) in	4.5 μin (4 + 4L) in	Comparison to Gage Blocks
Single Axis Length – Inside ²	(0.06 to 4.7) in	(3 + 4L) in	Horizontal Comparator
Single Axis Length – Outside ²	(0.06 to 4.7) in	(3 + 4L) in	Horizontal Comparator
	Up to 1 in (1 to 10) in	(15 to 0.5L) in (12 + 4L) in	Super Micrometer
Height Measuring Equipment ²	Up to 8 in (8 to 26) in	(6 + 4L) μin (12 + 4L) μin	Gage Blocks w/ Surface Plate
Measuring Tapes and Rulers ²	Up to 6 ft (6 to 12) ft (12 to 100) ft	(400 + 2L) μin (400 + 7L) μin (400 + 6L) μin	Accu-Gage
Threaded Plug ² Pitch Diameter		83 μin	Super Micrometer w/ Thread Wires Super Micrometer
Major Diameter	Up to 1 in (1 to 6) in	(15 + 0.5L) μin (12 + 4L) μin	
Threaded Ring Inner Pitch Diameter	Up to 6 in	150 μin	Comparison to Set Plugs

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	Class F Weights
	(0 to 500) lbf	0.035 lbf	Load Cells
	(500 to 2 000) lbf	0.12 lbf	
	(2 000 to 10 000) lbf	1.4 lbf	
	(10 000 to 25 000) lbf	5.1 lbf	
	(25 000 to 100 000) lbf	28 lbf	
Mass Determination Metric	30 kg	13 mg	Echelon II
	25 kg	12 mg	
	20 kg	10 mg	
	10 kg	3.5 mg	
	5 kg	1.6 mg	
	3 kg	1.2 mg	
	2 kg	0.66 mg	
	1 kg	0.32 mg	
	500 g	0.15 mg	
	300 g	0.1 mg	
	200 g	67 µg	
	100 g	36 µg	
	50 g	16 µg	
	30 g	12 µg	
	20 g	11 µg	
	10 g	8.2 µg	
	5 g	4.7 µg	
	3 g	4.7 µg	
	2 g	4.7 µg	
	1 g	4.7 µg	
	500 mg	2 µg	
	300 mg	2 µg	
	200 mg	2 µg	
	100 mg	2 µg	
	50 mg	2 µg	
	30 mg	2 µg	
	20 mg	2 µg	
	10 mg	2 µg	
	5 mg	2 µg	
	3 mg	2 µg	
	2 mg	2 µg	
	1 mg	2 µg	

Mass and Mass Related

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

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
	(5 to 250) lbf·in	1 % of reading	
	(1 to 250) lbf·ft	1 % of reading	
	(500 to 10 000) lbf·ft	1 % of reading	Futek Sensor with Display
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 + 0.6R lbf·in 0.06 % of reading + 0.6R lbf·in 0.04 % of reading + 0.6R lbf·in 0.12 % of reading + 0.6R lbf·in	Torque Wheels w/ Weights

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Balances ¹ Metric	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 500 mg 200 mg 100 mg	3.7 mg 1.4 mg 0.72 mg 0.38 mg 0.21 mg 0.14 mg 0.08 mg 42 µg 24 µg 20 µg 14 µg 8.3 µg 7.8 µg 7.7 µg 7.7 µg 2.4 µg 2.4 µg 2.4 µg	ASTM Class I Weights
Balances ¹ Metric	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	ASTM Class I Weights
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	Class F Weights
Absolute Pressure – Source/Measure ¹	(0 to 760) mmHg	0.005 mmHg	Meriam Manometer
	(1 to 30) psia (1 to 100) psia	0.000 5 psi 0.001 6 psi	Mensor 2101 Digital Pressure Gauge

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Absolute Pressure – Source ¹	(0 to 25) psia (25 to 500) psia	0.001 9 psi 0.006 % of reading + 0.001 psi	Fluke/Ruska 7250xi Pressure Controller/Calibrator
Pressure – Source Pneumatic ¹	(-14.7 to -0.5) psig (0.5 to 3) psig (3 to 500) psig	0.007 % of reading 0.007 % of reading 0.007 % of reading	Druck/Pressurements T3500 Deadweight Tester
Pressure – Source ⁶	(1 to 100) psig	0.019 psi	Ametek MK 750B Deadweight Tester
	(5 to 6 000) psig	0.75 psi	Ametek 10-10 Deadweight Tester
	(5 to 10 000) psig	1.4 psi	Ametek 10-10525 Deadweight Tester
	(5 to 10 000) psig	2.7 psi	Ametek DM-TQ-100 Deadweight Tester
	(60 to 11 000) psig	1.6 psi	Ametek TQ 100 Deadweight Tester
	Up to 5.8 psig	0.000 13 psi	DHI 23111 Low Pressure Controller
	(1 to 60) psig (60 to 1 000) psig	0.017 psi 0.096 psi	Fluke/DHI 5201 Deadweight Tester
	(200 to 10 000) psig	1.4 psi	Fluke/DHI 5203 Deadweight Tester
	(1 000 to 20 000) psig	2 psi	Fluke/DHI 5304 Deadweight Tester
	(1 000 to 50 000) psig	17 psi	Fluke/DHI 5305-02S Deadweight Tester
	Up to 2 000 psig	0.15 psi	Mensor CPG2500 Digital Pressure Indicator
	Up to 6000 psig	0.56 psi	Mensor 2101 Digital Pressure Indicator
	Up to 10 000 psig	1.1 psi	
	(60 to 40 000) psig	9 psi	Fluke/Ruska 2450 Hydraulic Deadweight Tester
Pressure – Source Pneumatic	(-60 to -22) inH ₂ O (-22 to 22) inH ₂ O (22 to 60) inH ₂ O (60 to 72) inH ₂ O (72 to 804) inH ₂ O	0.009 % of reading + 0.000 15 inH ₂ O 0.002 inH ₂ O 0.009 % of reading + 0.000 15 inH ₂ O 0.006 inH ₂ O 0.009 % of reading + 0.000 15 inH ₂ O	Fluke/DHI PPC4-ui Pressure Measurement System

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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

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 70) °C	(10 to 95) % RH	0.5 % 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 °C 0.003 % of reading + 0.017 °C 0.003 % of reading + 0.025 °C 0.003 % of reading + 0.035 °C	Hart 5628 PRT w/ Black Stack and Fluke 7381, 7321, and 6331 Baths
	(300 to 425) °C (425 to 660) °C	0.003 % of reading + 0.043 °C 0.003 % of reading + 0.06 °C	Hart 5628 PRT w/ Black Stack and Fluke 9173 Dry Well
	(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	3.7×10^{-12} Hz/Hz	Fluke 910R GPS Frequency Secondary Standard
Frequency – Measure and Measuring Equipment ¹	10 MHz	6.6×10^{-9} Hz/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

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:

- 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
- L = Length in inches
- 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.
- The stated uncertainty is the laboratory's ability to source a fast rise pulse that is approximately 500 ps, 125 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.
- 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.
- 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.
- This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.08.



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