



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Transcat-Rochester

35 Vantage Point Drive
Rochester, NY 14624

Fulfills the requirements of

ISO/IEC 17025:2017

and national standards

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

In the field of

CALIBRATION

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

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 07 September 2023

Certificate Number: AC-2489



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)

Transcat - Rochester

35 Vantage Point Drive

Rochester, NY 14624

Kevin O'Grady 585-352-9720

CALIBRATION

Valid to: **September 7, 2023**

Certificate Number: **AC-2489**

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH – Source ¹	4 pH 7 pH 10 pH	0.013 pH 0.013 pH 0.012 pH	Accredited pH Solutions
Conductivity – Source	5 µS 10 µS 100 µS 1 000 µS 10 000 µS 100 000 µS 150 000 µS	0.3 µS 0.3 µS 0.88 µS 4.4 µS 46 µS 420 µS 710 µS	Accredited Conductivity Solutions

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Wave Flatness – Measure ¹	Up to 3 V 10 Hz 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	0.2 % of reading 0.11 % of reading 0.21 % of reading 0.32 % of reading 0.36 % of reading 0.48 % of reading 0.53 % of reading	Thermal Voltage Converter, HP 3458A 8.5 Digit Multimeter
DC Current – Source ¹	(0 to 220) μ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	36 μ A/A + 6 nA 36 μ A/A + 7 nA 35 μ A/A + 40 nA 48 μ A/A + 0.7 μ A 0.02 % of reading + 12 μ A	Fluke 5720A Multiproduct Calibrator
	(2.2 to 11) A	0.04 % of reading + 0.48 mA	Fluke 5720A Multiproduct Calibrator, Fluke 5725 Amplifier
	(11 to 100) A	0.012 % of reading + 5 mA	Fluke 5520A Multiproduct Calibrator, Fluke 52120A Transconductance Amplifier
DC Current – Measure 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 + 0.9 nA 26 μ A/A + 5.8 nA 26 μ A/A + 58 nA 43 μ A/A + 0.58 μ A 0.013 % of reading + 10 μ A	Keysight 3458A 8.5 Digit Multimeter
	(1 to 3) A (3 to 10) A	0.14 % of reading 0.18 % of reading + 0.8 mA	Fluke 8846A 6.5 Digit Multimeter
	(1 to 10) A	0.047 % of reading	L&N 4361 Current Shunt, Keysight 3458A 8.5 Digit Multimeter
	Up to 100 A	0.012 % of reading + 0.58 mA	Ohms Labs CS-100 Precision Shunt, Keysight 3458A 8.5 Digit Multimeter
DC Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	(20 to 150) A (150 to 1 000) A	0.5 % of reading + 0.14 A 0.52 % of reading + 0.5 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/Coil 50-turn Coil

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	(1 000 to 5 000) A	0.58 % of reading	Fluke 52120A Transconductance Amplifier, Fluke 5520A Multiproduct Calibrator, 3 kA or 6 kA Coil
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	0.031 % of reading + 16 nA 0.019 % of reading + 10 nA 0.015 % of reading + 8 nA 0.03 % of reading + 12 nA 0.11 % of reading + 65 nA	Fluke 5720A Multiproduct 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 0.018 % of reading + 35 nA 0.014 % of reading + 35 nA 0.021 % of reading + 0.11 μ A 0.11 % of reading + 0.65 μ A	
	(2.2 to 22) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.039 % of reading + 0.4 μ A 0.019 % of reading + 0.35 μ A 0.014 % of reading + 0.35 μ A 0.021 % of reading + 0.55 μ A 0.11 % of reading + 5 μ A	
	(22 to 220) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.033 % of reading + 4 μ A 0.18 % of reading + 3.5 μ A 0.014 % of reading + 2.5 μ A 0.021 % of reading + 3.5 μ A 0.11 % of reading + 10 μ A	
	(0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.027 % of reading + 35 μ A 0.046 % of reading + 80 μ A 0.7 % of reading + 0.16 mA	
	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.048 % of reading + 0.17 mA 0.096 % of reading + 0.38 mA 0.36 % of reading + 0.75 mA	
			Fluke 5720A Multiproduct Calibrator, Fluke 5725 Amplifier

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source ¹	(11 to 20.5) A (10 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.097 % of reading + 3.9 mA 0.12 % of reading + 3.9 mA 2.3 % of reading + 3.9 mA	Fluke 5520A Multiproduct Calibrator
	(20.5 to 40) A (10 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.14 % of reading + 11 mA 0.17 % of reading + 11 mA 3.3 % of reading + 11 mA	(2) Fluke 5520A Multiproduct Calibrators in Parallel configuration.
	(10 to 65) Hz (20 to 33) A (33 to 40) A (40 to 60) A (60 to 100) A	0.029 % of reading + 24 mA 0.037 % of reading + 36 mA 0.038 % of reading + 36 mA 0.034 % of reading + 36 mA	Fluke 52120A Transconductance Amplifier, Fluke 5520A Multiproduct Calibrator
	(65 to 300) Hz (20 to 33) A (33 to 60) A (60 to 100) A	0.042 % of reading + 36 mA 0.05 % of reading + 45 mA 0.052 % of reading + 45 mA	
	300 Hz to 1 kHz (20 to 33) A (33 to 60) A (60 to 100) A	0.12 % of reading + 0.12 A 0.12 % of reading + 0.12 A 0.12 % of reading + 0.12 A	
AC Current – Source ¹ Extended Frequency Ranges	(10 to 30) kHz (29 to 330) μ A (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA	1.2 % of reading + 0.31 μ A 0.78 % of reading + 0.47 μ A 0.31 % of reading + 3.1 μ A 0.31 % of reading + 0.16 mA	Fluke 5520A 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	0.3 % of reading + 26 mA 0.83 % of reading + 47 mA 0.35 % of reading + 0.12 A 1.1 % of reading + 0.22 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil
AC Clamp-on Ammeters (Non-Toroidal Type) Hall Effect Sensor 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	0.57 % of reading + 0.26 A 1 % of reading + 0.29 A 0.6 % of reading + 0.9 A 1.3 % of reading + 0.92 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Clamp-on Ammeters (Non-Toroidal Type) Hall Effect Sensor ¹	(1 000 to 6 000) A (10 to 300) Hz (300 to 440) Hz	0.77 % of reading 0.77 % of reading	Fluke 52120A Transconductance Amplifier, Fluke 5520A Multiproduct Calibrator, 3 kA or 6 kA Coil
AC Current – Measure ¹	Up to 100 μ A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 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 0.46 % of reading + 0.23 μ A 0.17 % of reading + 0.23 μ A 0.071 % of reading + 0.23 μ A 0.038 % of reading + 0.23 μ A 0.46 % of reading + 2.3 μ A 0.17 % of reading + 2.3 μ A 0.071 % of reading + 2.3 μ A 0.038 % of reading + 2.3 μ A 0.46 % of reading + 23 μ A 0.17 % of reading + 23 μ A 0.07 % of reading + 23 μ A 0.037 % of reading + 23 μ A 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	Keysight 3458A 8.5 Digit Multimeter
	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz (3 to 10) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz	1.3 % of reading + 2 mA 0.41 % of reading + 2 mA 0.18 % of reading + 2 mA 0.41 % of reading + 24 mA 1.1 % of reading + 13 mA 0.41 % of reading + 7 mA 0.18 % of reading + 7 mA 0.42 % of reading + 81 mA	Fluke 8846A 6.5 Digit Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure ¹	Up to 60 Hz Up to 10 A (10 to 20) A (20 to 40) A (40 to 60) A (60 to 100) A	0.019 % of reading + 2.3 mA 0.02 % of reading + 2.3 mA 0.029 % of reading + 2.3 mA 0.03 % of reading + 2.3 mA 0.025 % of reading + 2.3 mA	Ohms Labs CS-100 Current Shunt, Keysight 3458A 8.5 Digit Multimeter
AC Current – Measure ¹	(60 to 100) Hz Up to 5 A (5 to 20) A (20 to 60) A (60 to 100) A 100 Hz to 1 kHz Up to 100 A	0.023 % of reading + 2.3 mA 0.024 % of reading + 2.3 mA 0.032 % of reading + 2.3 mA 0.037 % of reading + 2.3 mA 0.12 % of reading + 2.3 mA	Ohms Labs CS-100 Current Shunt, Keysight 3458A 8.5 Digit Multimeter
Resistance – Source/Measure ¹	(0 to 10) Ω (10 to 100) Ω (0.1 to 1) k Ω (1 to 10) k Ω (10 to 100) k Ω (0.1 to 1) M Ω (1 to 10) M Ω (10 to 100) M Ω (0.1 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 $\mu\Omega/\Omega$ + 0.12 k Ω 0.059 % of reading + 1.2 k Ω 0.58 % of reading + 12 k Ω	Keysight 3458A 8.5 Digit Multimeter, Decade Resistor
Resistance – Source ¹ (Fixed Artifact)	1 m Ω	0.12 $\mu\Omega$	Ohms Labs CS-100 Current Shunt
	10 m Ω 0.1 Ω	1 $\mu\Omega$ 10 $\mu\Omega$	Guideline 9200 Multiple Standard Resistor
Resistance – Source ¹ (Variable Artifact)	1 G Ω 10 G Ω	5.8 M Ω 0.12 G Ω	Biddle Megadek, High Resistance Decade Box
Resistance – Source ¹ Up to 10 kV (Variable Artifact)	(100 to 200) k Ω (300 to 700) k Ω (0.8 to 1) M Ω (1 to 10) M Ω (20 to 100) M Ω (200 to 900) M Ω (1 to 9) G Ω (10 to 90) G Ω (0.1 to 1) T Ω	0.036 % of reading 0.036 % of reading + 100 Ω 0.036 % of reading + 200 Ω 0.035 % of reading + 1.2 $\mu\Omega/V$ 0.12 % of reading + 1.2 $\mu\Omega/V$ 0.3 % of reading + 1.2 $\mu\Omega/V$ 0.58 % of reading + 1.2 $\mu\Omega/V$ 1.2 % of reading + 2.3 $\mu\Omega/V$ 1.2 % of reading + 5.8 $\mu\Omega/V$	IET High Resistance Decade Substituter
Resistance – Source ¹ (Fixed)	(0.5 to 5) kV 1 T Ω	6 G Ω	IET Standard Resistor

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source ¹ (Fixed)	500 V		IET Standard Resistor
	10 TΩ	86 GΩ	
	1 kV	0.15 TΩ	
	10 TΩ	0.1 TΩ	
	2.5 kV	60 GΩ	
DC Voltage – Source ¹	10 TΩ		Fluke 5720A Multiproduct Calibrator
	5 kV		
	10 TΩ		
	Up to 220 mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V	8.5 μV/V + 0.4 μV 5.1 μV/V + 0.7 μV 3.7 μV/V + 2.5 μV 3.8 μV/V + 4 μV 5.1 μV/V + 40 μV	
	(220 to 1 100) V	7 μV/V + 0.4 mV	
DC Voltage – Measure ¹	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 500) V (500 to 800) V (800 to 1 000) V	7.1 μV/V + 0.58 μV 5 μV/V + 0.58 μV 5.1 μV/V + 0.58 μV 7.6 μV/V + 35 μV 11 μV/V + 0.12 mV 16 μV/V + 0.12 mV 21 μV/V + 0.12 mV	Keysight 3458A 8.5 Digit Multimeter
	(1 to 10) kV	0.049 % of reading + 0.62 V	
	(10 to 20) kV (20 to 35) kV	0.08 % of reading + 0.35 V 0.14 % of reading + 1 V	
	(15 to 30) kV (30 to 45) kV (45 to 70) kV	0.065 % of reading + 1 V 0.09 % of reading + 3 V 0.317 % of reading + 1 V	
	(25 to 100) kV	0.11 % of reading + 0.5 V	
DC High Voltage – Measure ¹	(1 to 10) kV	0.049 % of reading + 0.62 V	Vitrek 4700 Digital HV Meter
	(10 to 20) kV (20 to 35) kV	0.08 % of reading + 0.35 V 0.14 % of reading + 1 V	Vitrek 4700 Digital HV Meter, Vitrek HVP-35 High Voltage Probe
	(15 to 30) kV (30 to 45) kV (45 to 70) kV	0.065 % of reading + 1 V 0.09 % of reading + 3 V 0.317 % of reading + 1 V	Vitrek 4700 Digital HV Meter, Vitrek HVL-70 High Voltage Probe
	(25 to 100) kV	0.11 % of reading + 0.5 V	Vitrek 4700 Digital HV Meter, Vitrek HVL-100 High Voltage Probe

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source ¹	Up to 2.2 mV		Fluke 5720A Multiproduct Calibrator
	(10 to 20) Hz	0.16 % of reading + 4 μ V	
	(20 to 40) Hz	0.1 % of reading + 4 μ V	
	40 Hz to 20 kHz	0.077 % of reading + 4 μ V	
	(20 to 50) kHz	0.13 % of reading + 4 μ V	
	(50 to 100) kHz	0.17 % of reading + 5 μ V	
	(100 to 300) kHz	0.33 % of reading + 10 μ V	
	(300 to 500) kHz	0.47 % of reading + 20 μ V	
	500 kHz to 1 MHz	0.58 % of reading + 20 μ V	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.042 % of reading + 4 μ V	
	(20 to 40) Hz	0.03 % of reading + 4 μ V	
	40 Hz to 20 kHz	0.014 % of reading + 4 μ V	
	(20 to 50) kHz	0.03 % of reading + 4 μ V	
	(50 to 100) kHz	0.058 % of reading + 5 μ V	
	(100 to 300) kHz	0.12 % of reading + 10 μ V	
	(300 to 500) kHz	0.16 % of reading + 20 μ V	
	500 kHz to 1 MHz	0.27 % of reading + 20 μ V	
	(22 to 220) mV		
	(10 to 20) Hz	0.028 % of reading + 12 μ V	
	(20 to 40) Hz	0.011 % of reading + 7 μ V	
	40 Hz to 20 kHz	0.008 % of reading + 7 μ V	
	(20 to 50) kHz	0.021 % of reading + 7 μ V	
	(50 to 100) kHz	0.047 % of reading + 17 μ V	
	(100 to 300) kHz	0.091 % of reading + 20 μ V	
	(300 to 500) kHz	0.14 % of reading + 25 μ V	
	500 kHz to 1 MHz	0.28 % of reading + 45 μ V	
	(0.22 to 2.2) V		
	(10 to 20) Hz	0.027 % of reading + 40 μ V	
	(20 to 40) Hz	0.01 % of reading + 15 μ V	
	40 Hz to 20 kHz	0.004 % of reading + 8 μ V	
	(20 to 50) kHz	0.008 % of reading + 10 μ V	
	(50 to 100) kHz	0.012 % of reading + 30 μ V	
	(100 to 300) kHz	0.043 % of reading + 80 μ V	
	(300 to 500) kHz	0.1 % of reading + 0.2 mV	
	500 kHz to 1 MHz	0.18 % of reading + 0.3 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source ¹	(2.2 to 22) V		Fluke 5720A Multiproduct Calibrator
	(10 to 20) Hz	0.028 % of reading + 0.4 mV	
	(20 to 40) Hz	0.01 % of reading + 0.15 mV	
	40 Hz to 20 kHz	0.004 9 % of reading + 50 μ V	
	(20 to 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	0.005 6 % of reading + 0.6 mV	
	(20 to 50) kHz	0.009 3 % of reading + 1 mV	
	(50 to 100) kHz	0.016 % of reading + 2.5 mV	Fluke 5720A Multiproduct Calibrator, Fluke 5725A Amplifier
	(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	
	(220 to 750) V		
	(30 to 50) kHz	0.061 % of reading + 11 mV	
	(50 to 100) kHz	0.23 % of reading + 45 mV	
	(220 to 1 100) V		
	40 Hz to 1 kHz	0.011 % of reading + 4 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
	(20 to 30) kHz	0.061 % of reading + 11 mV	
AC Voltage – Measure ¹	Up to 10 mV		Keysight 3458A 8.5 Digit Multimeter
	(1 to 40) Hz	0.039 % of reading + 3.5 μ V	
	40 Hz to 1 kHz	0.028 % of reading + 1.2 μ V	
	(1 to 20) kHz	0.038 % of reading + 1.2 μ V	
	(20 to 50) kHz	0.15 % of reading + 1.2 μ V	
	(50 to 100) kHz	0.59 % of reading + 1.2 μ V	
	(100 to 300) kHz	4.6 % of reading + 2.3 μ V	
	(10 to 100) mV		
	(1 to 40) Hz	0.013 % of reading + 4.6 μ V	
	40 Hz to 1 kHz	0.009 5 % of reading + 2.3 μ V	
	(1 to 20) kHz	0.017 % of reading + 2.3 μ V	
	(20 to 50) kHz	0.037 % of reading + 2.3 μ V	
	(50 to 100) kHz	0.093 % of reading + 2.3 μ V	
	(100 to 300) kHz	0.36 % of reading + 12 μ V	
	300 kHz to 1 MHz	1.2 % of reading + 12 μ V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure ¹	(0.1 to 1) V		Keysight 3458A 8.5 Digit Multimeter
	(1 to 40) Hz	0.009 8 % of reading + 46 μ V	
	40 Hz to 1 kHz	0.009 5 % of reading + 23 μ V	
	(1 to 20) kHz	0.017 % of reading + 23 μ V	
	(20 to 50) kHz	0.036 % of reading + 23 μ V	
	(50 to 100) kHz	0.093 % of reading + 23 μ V	
	(100 to 300) kHz	0.35 % of reading + 0.12 mV	
	300 kHz to 1 MHz	1.2 % of reading + 0.12 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.009 5 % of reading + 0.46 mV	
	40 Hz to 1 kHz	0.009 5 % 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	0.35 % of reading + 1.2 mV	
	300 kHz to 1 MHz	1.2 % of reading + 1.2 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	0.047 % of reading + 46 mV	
	40 Hz to 1 kHz	0.047 % of reading + 23 mV	
	(1 to 20) kHz	0.071 % of reading + 23 mV	
	(20 to 50) kHz	0.14 % of reading + 23 mV	
	(50 to 100) kHz	0.35 % of reading + 23 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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	2 % of reading + 2.4 μ V 3.8 % of reading + 2.4 μ V 10 % of reading + 2.4 μ V 25 % of reading + 2.4 μ V	Rohde & Schwarz URE3 RMS Voltmeter
	(1 to 3) mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz	1 % of reading + 2 μ V 3.8 % of reading + 2 μ V 11 % of reading + 2 μ V 25 % of reading + 2 μ V	
	(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	0.98 % of reading + 3 μ V 1.9 % of reading + 3 μ V 3.2 % of reading + 3 μ V 7.6 % of reading + 3 μ V 16 % of reading + 3 μ V	
AC High Voltage – Measure ¹	(0.7 to 10) kV 60 Hz	0.17 % of reading + 0.16 V	Vitretek 4700 Digital HV Meter
	(10 to 20) kV 60 Hz	0.17 % of reading + 0.6 V	Vitretek 4700 Digital HV Meter,
	(20 to 35) kV 60 Hz	0.23 % of reading + 3.5 V	Vitretek HVP-35 High Voltage Probe
	(12.5 to 25) kV 60 Hz	0.15 % of reading + 1.4 V	Vitretek 4700 Digital HV Meter, Vitretek HVL-70 High Voltage Probe
	(25 to 37.5) kV 60 Hz	0.16 % of reading + 2.8 V	
	(37.5 to 50) kV 60 Hz	0.2 % of reading + 0.2 V	
	25 kV to 75 kV 60 Hz	0.19 % of reading + 3.5 V	Vitretek 4700 Digital HV Meter, Vitretek HVL-100 High Voltage Probe

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source ^{1,2} (Simulation)	220 pF to 399.99 pF 0.4 nF to 1.0999 nF 1.1 nF to 3.2999 nF 3.3 nF to 10.9999 nF 11 nF to 32.9999 nF 33 nF to 109.99 nF 110 nF to 329.999 nF 0.33 μF to 1.0999 μF 1.1 μF to 3.2999 μF 3.3 μF to 10.9999 μF 11 μF to 32.9999 μF 33 μF to 109.999 μF 110 μF to 329.999 μF 0.33 mF to 1.099999 mF 1.1 mF to 3.29999 mF 3.3 mF to 10.9999 mF 11 mF to 32.9999 mF 33 mF to 110 mF	0.4 % of reading + 7.8 pF 0.4 % of reading + 7.8 pF 0.4 % of reading + 0.0078 nF 0.21 % of reading + 0.0078 nF 0.2 % of reading + 0.078 nF 0.21 % of reading + 0.078 nF 0.2 % of reading + 0.23 nF 0.21 % of reading + 0.78 nF 0.21 % of reading + 2.3 nF 0.2 % of reading + 7.8 nF 0.32 % of reading + 23 nF 0.37 % of reading + 0.078 μF 0.38 % of reading + 0.23 μF 0.35 % of reading + 0.78 μF 0.35 % of reading + 2.3 μF 0.35 % of reading + 7.8 μF 0.58 % of reading + 23 μF 0.85 % of reading + 78 μF	Fluke 5522A Multifunction Calibrator
Capacitance – Source ^{1,2} (Fixed Artifacts)	100 Hz to 1 kHz (0.1 to 0.7) nF (0.7 to 600) nF 600 nF to 1.4 μF	0.1 % of reading + 0.53 pF 0.15 % of reading + 0.2 pF 0.045 % of reading + 0.5 nF	Arco SS32 Precision Standard Capacitor Set
Capacitance – Source ^{1,2} (Variable Artifact)	1 kHz 100 pF to 1 nF (1.1 to 10.1) nF (10.1 to 100.1) nF 100.1 nF to 1.1111 μF	0.61 fF/pF + 1.3 fF 0.17 pF/nF + 12 pF 0.57 pF/nF + 4.6 pF 0.61 pF/nF + 2.1 pF	GenRad 1423A Decade Capacitor
Capacitance – Measure ²	0.1 pF 100 kHz 1 MHz 1 pF 10 kHz 100 kHz 1 MHz 10 pF 1 kHz 10 kHz 100 kHz 1 MHz	1.4 % of reading 1.8 % of reading 1.4 % of reading 0.37 % of reading 0.44 % of reading 1.4 % of reading 0.28 % of reading 0.28 % of reading 0.3 % of reading	Agilent E4980AL LCR Meter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure ²	100 pF		Agilent E4980AL LCR Meter
	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	
	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	
	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	
	100 nF		
	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	
	1 μF		
	20 Hz	0.15 % of reading	
	100 Hz	0.1 % of reading	
	1 kHz	0.1 % 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	0.01 % of reading	
	1 kHz	0.16 % of reading	
	10 kHz	0.28 % of reading	
	100 kHz	0.73 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure ²	100 μ F		Agilent E4980AL LCR Meter
	20 Hz	0.16 % of reading	
	100 Hz	0.17 % of reading	
	1 kHz	0.29 % of reading	
	10 kHz	0.8 % of reading	
Impedance – Measure ^{1,2}	0.1 Ω		Agilent E4980AL LCR Meter
	1 kHz	2 % of reading	
	10 kHz	1.2 % of reading	
	100 kHz	1.1 % of reading	
	1 MHz	1.2 % of reading	
	1 Ω		
	20 Hz	0.67 % of reading	
	100 Hz	0.45 % of reading	
	1 kHz	0.36 % of reading	
	10 kHz	0.33 % of reading	
	100 kHz	0.31 % of reading	
	1 MHz	0.38 % of reading	
	10 Ω		
	20 Hz	0.29 % of reading	
	100 Hz	0.2 % of reading	
	1 kHz	0.17 % of reading	
	10 kHz	0.18 % of reading	
	100 kHz	0.18 % of reading	
	1 MHz	0.31 % of reading	
	100 Ω		
	20 Hz	0.16 % of reading	
	100 Hz	0.1 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.12 % of reading	
	100 kHz	0.12 % of reading	
	1 MHz	0.2 % of reading	
	1 k Ω		
	20 Hz	0.15 % of reading	
	100 Hz	0.1 % 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	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Impedance – Measure ^{1,2}	10 k Ω		Agilent E4980AL LCR Meter
	20 Hz	0.15 % of reading	
	100 Hz	0.1 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.1 % of reading	
	100 kHz	0.1 % of reading	
	1 MHz	0.29 % of reading	
	100 k Ω		
	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}	100 mH 1 kHz	0.14 mH	Standard Inductor
Inductance – Measure ²	1 μ H		Agilent E4980AL LCR Meter
	10 kHz	1.6 % of reading	
	100 kHz	0.36 % of reading	
	1 MHz	0.27 % of reading	
	10 μ H		
	10 kHz	0.37 % of reading	
	100 kHz	0.2 % of reading	
	1 MHz	0.2 % of reading	
	100 μ H		
	1 kHz	0.41 % of reading	
	10 kHz	0.2 % of reading	
	100 kHz	0.12 % of reading	
	1 MHz	0.14 % of reading	
	1 mH		
	100 Hz	0.56 % of reading	
	1 kHz	0.19 % of reading	
	10 kHz	0.12 % of reading	
	100 kHz	0.1 % of reading	
	1 MHz	0.23 % of reading	
	10 mH		
	20 Hz	0.86 % of reading	
	100 Hz	0.22 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.1 % of reading	
	100 kHz	0.11 % of reading	
	1 MHz	0.35 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure ²	100 mH		Agilent E4980AL LCR Meter
	20 Hz	0.28 % of reading	
	100 Hz	0.11 % of reading	
	1 kHz	0.1 % of reading	
	10 kHz	0.1 % of reading	
	100 kHz	0.21 % of reading	
	1 MHz	0.88 % of reading	
	10 H		
	20 Hz	0.15 % of reading	
	100 Hz	0.1 % 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	0.11 % of reading	
	1 kHz	0.15 % of reading	
	10 kHz	0.62 % of reading	
Current Harmonics – Source ^{1,3}	Carrier Range to 0.25 A Harmonic: Up to 75 mA (16 to 850) Hz	61 μ A/A + 21 μ A	Fluke 6105A Electrical Power Quality Calibrator
	850 Hz to 6.5 kHz	0.46 mA/A + 22 μ A	
	Carrier Range to 0.5 A Harmonic: Up to 0.15 A (16 to 850) Hz	70 μ A/A + 21 μ A	
	850 Hz to 6.5 kHz	0.46 mA/A + 23 μ A	
	Carrier Range to 1 A Harmonic: Up to 0.3 A (16 to 850) Hz	70 μ A/A + 29 μ A	
	850 Hz to 6.5 kHz	0.46 mA/A + 29 μ A	
	Carrier Range to 2 A Harmonic: Up to 0.6 A (16 to 850) Hz	70 μ A/A + 0.1 mA	
	850 Hz to 6.5 kHz	0.46 mA/A + 0.1 mA	
	Carrier Range to 5 A Harmonic: Up to 1.5 A (16 to 850) Hz	70 μ A/A + 0.1 mA	
	850 Hz to 6.5 kHz	0.46 A/A + 0.1 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Current Harmonics – Source ^{1,3}	Carrier Range to 10 A Harmonic: Up to 3 A (16 to 850) Hz 850 Hz to 6.5 kHz	74 μ A/A + 0.29 mA 0.46 mA/A + 0.29 mA	Fluke 6105A Electrical Power Quality Calibrator
	Carrier Range to 20 A Harmonic: Up to 6 A (16 to 850) Hz 850 Hz to 6.5 kHz	75 μ A/A + 451 μ A 0.46 mA/A + 0.45 mA	
Voltage Harmonics – Source ^{1,3}	Carrier Range to 23 V Harmonic: Up to 6.9 V (16 to 850) Hz 850 Hz to 6.5 kHz	58 μ V/V + 1 mV 0.52 mV/V + 1 mV	Fluke 6105A Electrical Power Quality Calibrator
	Carrier Range to 45 V Harmonic: Up to 13.5 V (16 to 850) Hz 850 Hz to 6.5 kHz	67 μ V/V + 2 mV 0.52 mV/V + 2 mV	
	Carrier Range to 90 V Harmonic: Up to 27 V (16 to 850) Hz 850 Hz to 6.5 kHz	69 μ V/V + 2 mV 0.52 mV/V + 2 mV	
	Carrier Range to 180 V Harmonic: Up to 54 V (16 to 850) Hz 850 Hz to 6.5 kHz	69 μ V/V + 6 mV 0.52 mV/V + 6 mV	
	Carrier Range to 360 V Harmonic: Up to 108 V (16 to 850) Hz 850 Hz to 6.5 kHz	69 μ V/V + 13 mV 0.52 V/V + 13 mV	
	Carrier Range to 650 V Harmonic: Up to 195 V (16 to 850) Hz 850 Hz to 6.5 kHz	70 μ V/V + 22 mV 0.52 mV/V + 22 mV	
	Carrier Range to 1 008 V Harmonic: Up to 302 V (16 to 850) Hz 850 Hz to 6.5 kHz	70 μ V/V + 33 mV 0.52 mV/V + 33 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Power – Source ¹ (0.33 to 330) mA	11 μ W to 1.1 mW 1.1 mW to 0.11 W (0.11 to 110) W (110 to 330) W	0.024 % of reading 0.027 % of reading 0.024 % of reading 0.018 % of reading	Fluke 5520A Multiproduct Calibrator
(0.33 to 3) A	11 μ W to 110 mW (0.11 to 990) W (0.99 to 3) kW	0.044 % of reading 0.053 % of reading 0.009 6 % of reading	
(3 to 20.5) A	99 mW to 0.99 W 0.99 W to 6.8 kW (6.8 to 20.5) kW	0.088 % of reading 0.07 % of reading 0.04 % of reading	
AC Power – Source ^{1,4} PF = 1			Fluke 5520A Multiproduct Calibrator
(3.3 to 9) mA	(10 to 65) Hz (0.11 mW to 3) mW 3 mW to 9 W	0.13 % of reading 0.077 % of reading	
(9 to 33) mA	(10 to 65) W (0.3 to 10) mW 10 mW to 33 W	0.089 % of reading 0.077 % of reading	
(33 to 90) mA	(10 to 65) Hz (1 to 30) mW 30 mW to 90 W	0.071 % of reading 0.057 % of reading	
(90 to 330) mA	(10 to 65) Hz (3 to 100) mW 100 mW to 300 W	0.089 % of reading 0.078 % of reading	
(0.33 to 0.9) A	(10 to 65) Hz (11 to 300) mW (0.3 to 900) W	0.071 % of reading 0.081 % of reading	
(0.9 to 2.2) A	(10 to 65) Hz (30 to 720) mW 0.72 W to 2 kW	0.089 % of reading 0.079 % of reading	
(2.2 to 4.5) A	(10 to 65) Hz 80 mW to 1.4 W 1.4 W to 4.5 kW	0.088 % of reading 0.18 % of reading	
(4.5 to 20.5) A	(10 to 65) Hz 150 mW to 20kW	0.17 % of reading	
AC Power – Source ^{1,4} PF = 1			Fluke 6105A Electrical Power Quality Calibrator
(0.5 to 20) A	(16 to 850) Hz 23 W to 13 kW	0.024 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 Multiproduct Calibrator
Distortion – Measure ¹ Carrier: 5 Hz to 600 kHz Input Voltage: < 30 V Level: (0.3 to 100) %THD	10 Hz to 1 MHz (1 to 3) MHz	3.5 % of reading 6.9 % of reading	HP 334A Distortion Analyzer
Distortion – Measure ¹ Carrier: 5 Hz to 600 kHz Input Voltage: < 30 V Level: 0.1 %THD	(10 to 20) Hz (20 to 30) Hz 30 Hz to 300 kHz (300 to 500) kHz 500 kHz to 1.2 MHz	14 % of reading 6.9 % of reading 3.5 % of reading 6.9 % of reading 14 % of reading	HP 334A Distortion Analyzer
Distortion – Measure ¹ Carrier: 5 Hz to 600 kHz Input Voltage: > 30 V Level: (0.3 to 100) %THD	10 Hz to 300 kHz (300 to 500) kHz 500 kHz to 3 MHz	3.5 % of reading 6.9 % of reading 14 % of reading	
Distortion – Measure ¹ Carrier: 5 Hz to 600 kHz Input Voltage: > 30 V Level: 0.1 %THD	(20 to 30) Hz 30 Hz to 300 kHz (300 to 500) kHz 500 kHz to 1.2 MHz	14 % of reading 3.5 % of reading 6.9 % of reading 14 % of reading	
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	1.2 °C 0.9 °C 0.71 °C 0.55 °C 0.45 °C 0.35 °C 0.21 °C 0.17 °C 0.19 °C 0.22 °C 0.24 °C 0.30 °C 0.33 °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 E		Ectron 1140A Thermocouple Calibrator/Simulator
	(-270 to -245) °C	1.6 °C	
	(-245 to -195) °C	0.24 °C	
	(-195 to -155) °C	0.12 °C	
	(-155 to -90) °C	0.095 °C	
	(-90 to 0) °C	0.08 °C	
	(0 to 15) °C	0.076 °C	
	(15 to 890) °C	0.064 °C	
	(890 to 1 000) °C	0.074 °C	
	Type J		
	(-210 to -180) °C	0.15 °C	
	(-180 to -120) °C	0.12 °C	
	(-120 to -50) °C	0.093 °C	
	(-50 to 990) °C	0.08 °C	
	(990 to 1 200) °C	0.094 °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	0.087 °C	
	(1 000 to 1 372) °C	0.096 °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	

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 S (-50 to -30) °C (-30 to 45) °C (45 to 105) °C (105 to 310) °C (310 to 615) °C (615 to 1 768) °C	0.76 °C 0.68 °C 0.49 °C 0.41 °C 0.35 °C 0.31 °C	Ectron 1140A Thermocouple Calibrator/Simulator
	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 0.095 °C 0.08 °C	
Oscilloscopes ^{1,8}			
Amplitude – DC into 50 Ω load	(-5 to 5) V	0.023 % of reading + 19 μV	Fluke 9500B Oscilloscope Calibrator, Fluke 9500B/3200 Oscilloscope Calibrator, Fluke 9530 3.2 GHz Active Head
into 1 MΩ load	(-200 to 200) V	0.023 % of reading + 19 μV	
Amplitude – Square Wave Rate: 10 Hz to 10 kHz into 50 Ω load	40 μVp-p to 1 mVp-p 1 mVp-p to 5 Vp-p	0.78 % of reading + 7.8 μV 0.078 % of reading + 7.8 μV	
into 1 MΩ load	40 μVp-p to 1 mVp-p 1 mVp-p to 200 Vp-p	0.78 % of reading + 7.8 μV 0.078 % of reading + 7.8 μV	
Time Markers 100 mVp-p to 1 Vp-p into 50 Ω load			
Square Wave	9.009 1 ns to 83 μs 83 μs to 55s	0.19 μs/s 2.3 μs/s	
Sine Wave	450.5 ps to 9.009 ns	0.19 μs/s	
Pulse	900.91 ns to 83 μs 83 μs to 55s	0.19 μs/s 2.3 μs/s	
Triangle Wave	900.91 ns to 83 μs 83 μs to 55s	0.19 μs/s 2.3 μs/	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes ^{1,8} Rise Time into 50 Ω load Rate: 10 Hz to 2 MHz	5 mVp-p to 3 Vp-p 500 ps (nominal) 150 ps (nominal)	290 ps 35 ps	Fluke 9500B Oscilloscope Calibrator, Fluke 9500B/3200 Oscilloscope Calibrator, Fluke 9530 3.2 GHz Active Head, Fluke 9550 Active Head w/ 25 ps Capability
Rate: 10 Hz to 1 MHz	425 mVp-p to 575 mVp-p 25 ps (nominal)	6.7 ps	
Leveled Sine Wave 50 kHz Reference into 50 Ω load	50 kHz to 10 MHz	1.2 % of reading	
Input Impedance Measure	(10 to 40) Ω (40 to 90) Ω (90 to 150) Ω (50 to 800) k Ω (0.8 to 1.2) M Ω (1.2 to 12) M Ω	0.39 % of reading 0.083 % of reading 0.39 % of reading 0.39 % of reading 0.083 % of reading 0.39 % of reading	
Input Capacitance Measure	(1 to 35) pF (35 to 95) pF	1.6 % of reading + 0.19 pF 2.3 % of reading + 0.19 pF	
Rise Time – Measure ¹	≥ 350 ps	28 ps	Agilent DSO6102 Oscilloscope
Bandwidth Flatness Measure ¹ into VSWR (1.2:1) (wrt Reference Frequency)	5 mVp-p to 5 Vp-p 100 Hz to 300 MHz (300 to 550) MHz 5 mVp-p to 3 Vp-p 550 MHz to 1.1 GHz (1.1 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 3.1 % of reading	Fluke 9500B/3200 Oscilloscope Calibrator, Fluke 9530 3.2 GHz Active Head

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Amplitude – Measure (dBc) into VSWR $\leq 1.3:1$	(-80 to 0) dB 9 kHz to 3 GHz (3 to 6.8) GHz (6.8 to 13.2) GHz	0.02 dB/dB + 1.1 dB 0.02 dB/dB + 3.1 dB 0.02 dB/dB + 3.7 dB	Agilent E4405B Opt. 1DS, 1DR, 1D5 Spectrum Analyzer
Frequency Response to RF Source	100 kHz to 4.2 GHz (-30 to -20) dB (-20 to -10) dB (-10 to 0) dB (0 to 10) dB (10 to 20) dB	1.9 % of reading 1.9 % of reading 1.9 % of reading 1.9 % of reading 1.9 % of reading	Agilent 438A Power Meter, Agilent 8482A Power Sensor

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle Measuring Equipment	Up to 90° 90°	4.4" 1.1"	Angle Blocks, Granite Square
Micrometers, Calipers ^{1,5} (Outside, Inside, Depth)	Up to 1 in (1 to 9) in (9 to 15) in (15 to 40) in	(13 + 4L) μ in (9 + 4L) μ in (10 + 4L) μ in (13 + 4L) μ in	Gage Blocks
Anvil Flatness ¹	Up to 1 in	4.2 μ in	Optical Flats
Anvil Parallelism ¹	Up to 1 in	7.2 μ in	Optical Parallels
Bore Gages ⁵	(0.125 to 1) in (1 to 6) in	33 μ in (26 + 7L) μ in	Characterized Cylindrical Rings
Indicators ^{1,5} (Dial, Digital, Test)	Up to 1 in (1 to 6) in	(10 + 2L) μ in (5 + 5L) μ in	Gage Blocks, Surface Plates
Test Indicators	Up to 0.025 in	5.6 μ in	Universal Length Measuring Machine
Single Axis Length – Outside ⁵	Up to 1 in (1 to 7) in (7 to 12) in (12 to 24) in (24 to 60) in	(6 + 1L) μ in (4 + 3.5L) μ in (4L) μ in (53 + 3L) μ in (5 + 1.67L) μ in	Universal Length Measuring Machine P&W U304393 Digital & Laser Measuring Machine
Single Axis Length – Inside ⁵	(0.04 to 1) in (1 to 2.5) in (2.5 to 10) in (10 to 12) in	(9 + 1L) μ in (9 + 3L) μ in (14 + 3L) μ in (25 + 3L) μ in	Universal Length Measuring Machine

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Height Gages ^{1,5}	Up to 4 in (4 to 24) in	(26 + 0.5L) μ in (16 + 3L) μ in	Gage Blocks
Height – Measure ⁵	Up to 12 in	(28 + 3.2L) μ in	Gage Amplifier, Probe, Grade AA Surface Plate
Squareness	(0 to 18) in	9 μ in/in	Master Square, Gage Amplifier, Probe, Grade AA Surface Plate
Parallelism	Up to (3 x 12) in (3 x 12) in to (3 x 18) in (6 x 18) in to (6 x 30) in	33 μ in 40 μ in 45 μ in	Gage Amplifier, Probe, Grade AA Surface Plate
Straightness	Up to 12 in (12 to 18) in (18 to 30) in	35 μ in 42 μ in 46 μ in	Gage Amplifier, Probe, Grade AA Surface Plate
Flatness	Up to 4 in Diameter	4.4 μ in	Optical Flat
	Up to (3 x 12) in (3 x 12) in to (3 x 18) in (6 x 18) in to (6 x 30) in	35 μ in 42 μ in 46 μ in	Gage Amplifier, Probe, Grade AA Surface Plate
	Up to (3 x 12) in	138 μ in	Vision System w/ Probe
Optical Comparator ^{1,5}			
Length	(0 to 6) in	(100 + 14L) μ in	Calibration Grids
Squareness	(0.04 to 1) in	(120 + 1.5L) μ in	Calibration Grids
Magnification	10X to 50X	(240 + 21L) μ in	Magnification Checker
Length Measuring Equipment ⁵			Laser Interferometer
Linear Displacement	Up to 12 ft	(1 + 2.1L) μ in	
Optical Reference Plane	Up to 6 in (6 to 12) in	51 μ in 75 μ in	Glass Scale, Calibration Grid
Thread Wires	(2 to 120) TPI (0.008 33 to 0.5) in	12 μ in	Universal Length Measuring Machine
Cylindrical Plug Gages ⁵			
Outside Diameter	Up to 1 in (1 to 7) in	12 μ in (9 + 3L) μ in	Universal Length Measuring Machine
Pin Gages			
Outside Diameter	(0.003 to 1) in	30 μ in	Laser Micrometer

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Cylindrical Rings ⁵ Inside Diameter	(0.04 to 0.5) in (0.50 to 4) in (4 to 8.5) in (8.5 to 14) in	7.2 μ in (7.2 + 3L) μ in (4 + 3.6L) μ in (11 + 3.6L) μ in	Universal Length Measuring Machine, Master Ring Gages (Non-commercial Cal)
Cylindrical Rings ⁵ Inside Diameter	(0.04 to 1) in (1 to 2.5) in (2.5 to 10) in (10 to 12) in	(9 + 1L) μ in (9 + 3L) μ in (14 + 3L) μ in (25 + 3L) μ in	Universal Length Measuring Machine, Working Reference Rings
Laser Micrometers ^{1,5}	Up to 0.1 in (0.1 to 0.4) in (0.4 to 1) in	13 μ in 8 μ in (11 + 5 L) μ in	Characterized Master Pin Gages
Measuring Tapes, Rulers ⁵	Up to 1 ft (1 to 3) ft (3 to 1 000) ft	(463 + 2L) μ in (410 + 6L) μ in (18L) μ in	Vision System
Surface Plates ^{1,4} Overall Flatness	(17 to 168) inDL	(24 + $\sqrt{DL}$) μ in	In accordance with ASME B89.3.7 using Electronic Level System
Local Area Flatness (Repeat Readings)	Up to 0.001 in	31 μ in	Repeat-o-Meter w/ Supramess
Thread Plug Gages ⁵ Pitch Diameter 60° Thread	Up to 1 in (1 to 4) in (4 to 7) in	79 μ in 80 μ in 83 μ in	Universal Length Measuring Machine, Master Thread Wires
Major Diameter	Up to 1 in (1 to 7) in	13 μ in (10 + 3L) μ in	
Step Height	Up to 1 in	32 μ in	Gage Amplifier, Probe, Gage Blocks
Tapered Thread Plug Pitch Diameter	Up to 3 in	90 μ in	Universal Length Measuring Machine, Master Thread Wires
Standoff	Up to 1 in	31 μ in	Gage Amplifier, Probe
Tapered Thread Ring Gage	Up to 3 in	90 μ in	Comparison to Master Plug

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Ring Gage Inner Pitch Diameter	Up to 1 in (1 to 4) in (4 to 7) in	79 μ in 80 μ in 83 μ in	Comparison to Master Plug
Two Dimensional Gages/Fixtures X-Y Axis	(0.000 05 to 1) in (1 to 2) in (2 to 3) in (3 to 4) in (4 to 5) in (5 to 6) in (6 to 9) in (9 to 12) in	84 μ in 90 μ in 96 μ in 100 μ in 110 μ in 120 μ in 140 μ in 160 μ in	Vision System
Z Axis	(0.1 to 2) in (2 to 4) in (4 to 5) in	150 μ in 160 μ in 170 μ in	
Angle	Up to 360° Up to 5 in (5 to 10) in (10 to 12) in	0.006° 0.008° 0.009°	
Wire Crimpers/Dies ¹ Die Diameter	(0.011 to 0.625) in	53 μ in	Pin Gage Set
Crimp Height	(0.001 to 0.8) in	180 μ in	Crimp Height Micrometer

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Air Velocity	(0.2 to 2) m/s (2 to 60) m/s	0.87 % of reading 0.61 % of reading	Laser Doppler Velocimeter
	(0.2 to 2) m/s (2 to 60) m/s	0.06 m/s 1.3 % of reading + 0.01 m/s	Westenberg Westi-box Wind Tunnel System

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Balances and Scales ^{1,6} (SI)	Up to 500 mg (0.5 to 5) g (5 to 20) g 20 g to 1 kg (1 to 5) kg (5 to 10) kg (10 to 25) kg (25 to 36) kg	6 µg 20 µg 50 µg 0.000 19 % of reading 0.000 26 % of reading 0.000 16 % of reading 0.000 14 % of reading 0.000 12 % of reading	Characterized with ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system.
Balances and Scales ^{1,6} (SI)	Up to 500 mg (0.5 to 5) g (5 to 20) g 20 g to 10 kg (10 to 25) kg (25 to 35) kg	12 µg 40 µg 89 µg 0.000 31 % of reading 0.000 3 % of reading 0.000 25 % of reading	ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system.
Balances and Scales ^{1,6} (SI)	Up to 3 mg (3 to 10) mg (10 to 50) mg (50 to 100) mg (100 to 300) mg	30 µg 40 µg 50 µg 60 µg 70 µg	ASTM E617 Class 3 weights and internal calibration procedure utilized for the calibration of the weighing system.
Balances and Scales ^{1,6} (SI)	(300 to 500) mg (0.5 to 3) g (3 to 5) g (5 to 10) g (10 to 30) g (30 to 50) g (50 to 100) g	0.1 mg 0.15 mg 0.2 mg 0.3 mg 0.5 mg 0.7 mg 1.2 mg	ASTM E617 Class 3 weights and internal calibration procedure utilized for the calibration of the weighing system.
Balances and Scales ^{1,6} (Avoirdupois)	Up to 0.5 lb (0.5 to 2) lb (2 to 10) lb (10 to 1 150) lb	0.024 % of reading 0.018 % of reading 0.013 % of reading 0.012 % of reading	NIST Class F weights and internal calibration procedure utilized for the calibration of the weighing system.
Mass Determination	Up to 1.2 kg	0.002 8 mg/g + 6.8 mg	Mettler Toledo XS1203S Precision Balance
Force (Tension and Compression)	Up to 400 lbf	0.012 % of reading	Deadweight
Pneumatic Absolute Pressure Devices	Up to 14.7 psia (14.7 to 39.7) psia (39.7 to 514.7) psia	0.002 5 psi 0.000 7 % of reading + 0.002 3 psi 0.006 5 % of reading	Ruska 7250xi Pressure Controller/Calibrator
	Up to 30 psia (30 to 1 000) psia	0.002 4 psi 0.007 % of reading + 0.000 48 psi	DHI PPC4 Pressure Controller

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Hydraulic Absolute Pressure Devices	(500 to 16 000) psia	0.019 % of reading	Fluke P3125-3 Deadweight Tester, Barometer
Pneumatic Pressure Devices ¹	(0 to 25) psig (25 to 500) psig (500 to 1 000) psig	0.001 4% of reading + 0.001 3 psi 0.006 7 % of reading 0.006 6 % of reading + 0.001 psi	Ruska 7250xi Pressure Controller/Calibrator
Pneumatic Vacuum Devices ¹	(-14.7 to 0) psiv	0.000 64 % of reading + 0.001 3 psi	Ruska 7250xi Pressure Controller/Calibrator
	(-36 to -22) inH ₂ O	0.009 % of reading + 0.000 15 inH ₂ O	DHI PPC4 Pressure Controller
	(-22 to 22) inH ₂ O	0.002 inH ₂ O	
	(22 to 60) inH ₂ O	0.009 % of reading + 0.000 15 inH ₂ O	
	(60 to 72) inH ₂ O	0.006 5 inH ₂ O	
	(72 to 804) inH ₂ O	0.009 % of reading + 0.000 15 inH ₂ O	
Hydraulic Pressure Devices ¹	(500 to 16 000) psi	0.01 % of reading	Fluke P3125-3 Deadweight Tester
Torque Tools ¹	(1 to 10) lbf·in 9 lbf·in to 800 lbf·ft	0.37 % of reading + 0.028 lbf·in 1 % of reading	Torque Calibrator
Pneumatic Torque Tools	0.2 lbf·in to 18 lbf·in 18 lbf·in to 70 lbf·in 8 lbf·in to 130 lbf·in	0.55 lbf·in 1.1 lbf·in 0.89 lbf·in	Imada Torque Tester
Torque Transducers	Up to 12.5 lbf·in (12 to 150) lbf·in (12.5 to 250) lbf·ft (250 to 1000) lbf·ft (1000 to 2000) lbf·ft	0.00 23 lbf·in 1.8 % + 0.0018 lbf·in 0.76 % + 0.064 lbf·ft 0.54% + 0.068 lbf·ft 0.06 lbf·ft	Master Weights, Butterfly Wheels, 40 in Torque Arm

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Source	(-10 to 15) °C		Thunder Scientific 2500 Humidity Generator
	(10 to 75) %RH	0.5 %RH	
	(75 to 95) %RH	0.65 %RH	
	(15 to 35) °C		
	(10 to 95) %RH	0.5 %RH	
	(35 to 70) °C		
	(10 to 50) %RH	0.5 %RH	
	(50 to 70) %RH	0.7 %RH	
	(70 to 95) %RH	0.85 %RH	

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Measure ¹	(-20 to 15) °C Up to 95 %RH (15 to 25) °C (10 to 90) %RH (90 to 95) %RH (25 to 40) °C Up to 95 %RH	0.008 4 % of reading + 1.2 %RH 1.3 %RH 1.9 %RH 0.008 4 % of reading + 1.2 %RH	Vaisala MI70/HMP76B Temperature/Humidity Indicator/Probe
Dew/Frost Point – Source ¹	(-85 to -80) °C (-80 to -70) °C (-70 to -60) °C (-60 to -50) °C (-50 to -40) °C (-40 to -10) °C (-10 to 20) °C (20 to 30) °C (30 to 40) °C (40 to 65) °C	1.2 °C 0.61 °C 0.4 °C 0.36 °C 0.25 °C 0.15 °C 0.13 °C 0.15 °C 0.16 °C 0.17 °C	Thunder Scientific 3900 Humidity Generator
Temperature – Source ¹	(-75 to -70) °C (-70 to 100) °C (100 to 200) °C (200 to 400) °C (400 to 600) °C	0.086 °C 0.033 °C 0.051 °C 0.074 °C 0.092 °C	AccuMac AM1760 SPRT, Black Stack, Hart Bath or Metrology Well
	(600 to 800) °C (800 to 1 000) °C (1 000 to 1 200) °C	1.2 °C 1.5 °C 3.6 °C	Fluke 5649 Type R Thermocouple Probe, HP 3458 8.5 Digit Multimeter, Furnace
Temperature – Measure ¹	(-195 to 0) °C (0 to 420) °C (420 to 660) °C	0.015 °C 0.022 °C 0.039 °C	AccuMac AM1760 SPRT, Black Stack
Temperature – Measure ¹	(600 to 800) °C (800 to 1 000) °C (1 000 to 1 450) °C	0.55 °C 0.76 °C 2.9 °C	Fluke 5649 Type R Thermocouple Probe, HP 3458 8.5 Digit Multimeter

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Infrared Temperature – Source	(-15 to 0) °C (0 to 50) °C (50 to 100) °C (100 to 120) °C (120 to 200) °C (200 to 350) °C (350 to 500) °C (500 to 1 000) °C	0.8 °C 0.65 °C 0.7 °C 0.76 °C 0.94 °C 1.6 °C 2.1 °C 0.22 % of reading + 2.6 °C	Blackbody Source (Flat Plate) $\lambda = (8 \text{ to } 14) \mu\text{m}$, $\epsilon = (0.9 \text{ to } 1)$
Infrared Temperature – Measure ⁷	-15 °C 0 °C 30 °C 100 °C 200 °C 300 °C 400 °C 500 °C 600 °C 800 °C 1000 °C	0.29 °C 0.17 °C 0.17 °C 0.22 °C 0.32 °C 0.4 °C 0.5 °C 0.61 °C 2.7 °C 3.2 °C 4.2 °C	Heitronics KT19-82 Infrared Radiation Thermometer $\lambda = (8 \text{ to } 14) \mu\text{m}$, $\epsilon = (0.1 \text{ to } 1)$
Surface Probe Measuring Equipment	(20 to 100) °C	0.68 °C	Fluke 3125 Surface Probe Calibrator
	(100 to 300) °C	1.2 °C	Comparison to Pyromation RAT185 RTD, Fluke 1502 Thermometer Readout

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source	10 MHz	3.8 pHz/Hz	Fluke 910R GPS Frequency Standard
Frequency – Measure ¹	10 MHz	2.1 $\mu\text{Hz/Hz}$	HP 53131A Universal Counter
Stopwatches/Timers	Up to 599 s/mon	59 ms/d	Vibrograf 4500 Timometer

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Duty Cycle – Source ¹ Square Wave: < 3.3 Vp-p Freq: 0.1 Hz to 100 kHz	(1 to 10) % Duty Cycle 10 μ s to 100 s (10 to 49) % Duty Cycle 10 μ s to 100 s 50 % Duty Cycle 10 μ s to 100 s (51 to 90) % Duty Cycle 10 μ s to 100 s (90 to 99) % Duty Cycle 10 μ s 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

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.
- As frequency deviates 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.
- Carrier range is the output amplitude capability of the fundamental wave. Up to 10 harmonics can be placed on the fundamental wave up to the amplitude of the value shown as the harmonic range. The uncertainties shown are for both the fundamental and harmonic amplitudes within the frequency range shown.
- 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.
- " = arc-second; L = length in inches; DL = diagonal length in inches.
- The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The CMC presented here does not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
- Uncertainties are for cardinal point temperatures, measurement between cardinal temperate points are available with greater uncertainties.
- 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.
- This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.



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