CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Transcat-Phoenix
8240 S. Kyrene Road, Suite 107
Tempe, AZ 85284

Fulfills the requirements of

ISO/IEC 17025:2017

and the national standards

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

In the 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-2489.11

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)

Transcat – Phoenix
8240 S. Kyrene Road, Suite 107
Tempe, AZ 85284
Ryan Verdin

CALIBRATION

Valid to: **September 7, 2023** Certificate Number: **AC-2489.11**

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Wave Flatness [1] (into 50 Ω load)	(0.3 to 1) 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	 0.073 % of reading 0.14 % of reading 0.39 % of reading 0.79 % of reading 1.6 % of reading 2.4 % of reading	Agilent 11050A Thermal Convertor
	(1 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	 0.071 % of reading 0.11 % of reading 0.21 % of reading 0.47 % of reading 0.96 % of reading 1.3 % of reading	Agilent 11049A Thermal Convertor
AC Current – Source [1]	Up to 220 µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 to 2.2) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.032 % of reading + 16 nA 0.019 % of reading + 10 nA 0.014 % of reading + 8 nA 0.029 % of reading + 12 nA 0.11 % of reading + 65 nA 0.032 % of reading + 40 nA 0.019 % of reading + 35 nA 0.014 % of reading + 35 nA 0.021 % of reading + 0.11 µA 0.11 % of reading + 0.65 µA	Fluke 5720A Multiproduct Calibrator

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 5720A Multiproduct Calibrator
	(10 to 20) Hz	0.032 % of reading + 0.4 µA	
	(20 to 40) Hz	0.019 % of reading + 0.35 µA	
	40 Hz to 1 kHz	0.015 % of reading + 0.35 µA	
	(1 to 5) kHz	0.022 % of reading + 0.55 µA	
	(5 to 10) kHz	0.11 % of reading + 5 µA	
	(22 to 220) mA		
	(10 to 20) Hz	0.032 % of reading + 4 µA	
	(20 to 40) Hz	0.018 % of reading + 3.5 µA	
	40 Hz to 1 kHz	0.013 % of reading + 2.5 µA	
	(1 to 5) kHz	0.021 % of reading + 3.5 µA	
	(5 to 10) kHz	0.11 % of reading + 10 µA	
	(0.22 to 2.2) A		
	20 Hz to 1 kHz	0.027 % of reading + 35 µA	
	(1 to 5) kHz	0.045 % of reading + 80 µA	
	(5 to 10) kHz	0.7 % of reading + 0.16 mA	
	(2.2 to 11) A		Fluke 5720A Multiproduct Calibrator, 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	
	(2.2 to 30) A		Agilent 34330A Current Shunt, Agilent 3458A opt 002 8.5 Digit Multimeter, AC Current Source
	(50 to 100) Hz	0.065 % of reading + 0.23 mA	
	(100 to 300) Hz	0.065 % of reading + 0.23 mA	
	300 Hz to 1 kHz	0.065 % of reading + 0.23 mA	
	(1 to 3) kHz	0.37 % of reading + 0.23 mA	
	(3 to 4) kHz	0.37 % of reading + 0.23 mA	
	(4 to 5) kHz	0.37 % of reading + 0.23 mA	
AC Current – Source [1] (Extended Frequency Ranges)	(29 to 330) µA		Fluke 5520A Multiproduct Calibrator
	(10 to 30) kHz	1.2 % of reading + 0.31 µA	
	(0.33 to 3.3) mA		
	(10 to 30) kHz	0.78 % of reading + 0.47 µA	
	(3.3 to 33) mA		
	10 kHz to 30 kHz	0.31 % of reading + 3.1 µA	
	(33 to 330) mA		
	(10 to 30) kHz	0.31 % of reading + 0.16 mA	
AC Clamp-on Ammeters [1] (Toroidal Type) Transformer Type Sensor	(20 to 150) A		Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil
	(45 to 65) Hz	0.35 % of reading + 30 mA	
	(65 to 440) Hz	0.94 % of reading + 50 mA	
	(150 to 1 000) A		
	(45 to 65) Hz	0.31 % of reading + 0.13 A	
	(65 to 440) Hz	1.2 % of reading + 0.23 A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Clamp-on Ammeters [1] (Non-Toroidal Type) Hall Effect Sensor	(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	 0.68 % of reading + 0.29 A 1.2 % of reading + 0.29 A 0.66 % of reading + 1 A 1.4 % of reading + 1.1 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil
AC Current – Measure [1]	Up to 100 µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 5 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 0.18 % of reading + 35 nA 0.072 % of reading + 35 nA 0.46 % of reading + 0.23 µA 0.17 % of reading + 0.23 µA 0.071 % of reading + 0.23 µA 0.038 % of reading + 0.23 µA 0.46 % of reading + 2.3 µA 0.17 % of reading + 2.3 µA 0.071 % of reading + 2.3 µA 0.038 % of reading + 2.3 µA 0.46 % of reading + 23 µA 0.17 % of reading + 23 µA 0.07 % of reading + 23 µA 0.037 % of reading + 23 µA 0.46 % of reading + 0.23 mA 0.19 % of reading + 0.23 mA 0.097 % of reading + 0.23 mA 0.12 % of reading + 0.23 mA	Agilent 3458A opt 002 8.5 Digit Multimeter
	(1 to 30) A (50 to 100) Hz (100 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 4) kHz (4 to 5) kHz	 0.065 % of reading + 0.23 mA 0.065 % of reading + 0.23 mA 0.065 % of reading + 0.23 mA 0.37 % of reading + 0.23 mA 0.37 % of reading + 0.23 mA 0.37 % of reading + 0.23 mA	Agilent 34330A Current Shunt, Agilent 3458A opt 002 8.5 Digit Multimeter
DC Current – Source/Measure [1]	Up to 100 µA 100 µA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	26 µA/A + 0.92 nA 26 µA/A + 5.8 nA 26 µA/A + 58 nA 41 µA/A + 0.58 µA 0.13 mA/A + 12 µA	Agilent 3458A opt 002 8.5 Digit Multimeter, Current Source

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source/Measure [1]	(1 to 20) A	0.45 mA/A	Agilent 34330A Current Shunt, Agilent 3458A opt 002 8.5 Digit Multimeter, DC Current Source
DC Clamp-on Ammeters [1] (Non-Toroidal Type) Hall Effect Sensor	(20 to 150) A (150 to 1 000) A	0.53 % of reading + 0.17 A 0.52 % of reading + 0.58 A	Fluke 5520A Multiproduct Calibrator, Fluke 5500A/COIL 50-turn Coil
DC Current – Measure [1]	(20 to 100) A	0.046 % of reading	L&N 4361 Current Shunt, Agilent 3458A opt 002 8.5 Digit Multimeter
DC Resistance – Source/Measure [1]	Up to 10 Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ	18 μΩ/Ω + 58 μΩ 15 μΩ/Ω + 0.58 mΩ 13 μΩ/Ω + 0.58 mΩ 12 μΩ/Ω + 5.8 mΩ 13 μΩ/Ω + 58 mΩ 21 μΩ/Ω + 2.3 Ω 62 μΩ/Ω + 0.12 kΩ	Agilent 3458A opt 002 8.5 Digit Multimeter, Decade Resistor
	(10 to 100) MΩ (0.1 to 1) GΩ (1 to 10) GΩ (10 to 100) GΩ (100 to 300) GΩ (300 to 700) GΩ (0.7 to 1) TΩ	0.012 % of reading + 0.28 kΩ 0.012 % of reading + 9.7 kΩ 0.012 % of reading + 0.42 MΩ 0.012 % of reading + 45 MΩ 0.016 % of reading + 45 MΩ 0.016 % of reading + 0.11 GΩ 0.016 % of reading + 0.49 GΩ	Extended Arm Bridge
DC Resistance – Source [1] (Fixed Artifacts)	10 μΩ 100 μΩ 1 mΩ 10 mΩ 100 mΩ	0.4 % of reading 0.046 % of reading 0.046 % of reading 35 μΩ/Ω 67 μΩ/Ω	Standard Resistors
DC Resistance – Source [1] (Simulation)	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ	96 μΩ/Ω 96 μΩ/Ω 24 μΩ/Ω 24 μΩ/Ω 11 μΩ/Ω 11 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω	Fluke 5720A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance – Source [1] (Simulation)	19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	12 μΩ/Ω 11 μΩ/Ω 13 μΩ/Ω 23 μΩ/Ω 21 μΩ/Ω 42 μΩ/Ω 49 μΩ/Ω 0.12 mΩ/Ω	Fluke 5720A Multiproduct Calibrator
AC Voltage – Source [1]	Up to 2.2 mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 o 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (2.2 to 22) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 o 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 o 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.1 % of reading + 4 μV 0.077 % of reading + 4 μV 0.077 % of reading + 4 μV 0.077 % of reading + 4 μV 0.13 % of reading + 5 μV 0.24 % of reading + 10 μV 0.34 % of reading + 20 μV 0.52 % of reading + 20 μV 0.041 % of reading + 4 μV 0.028 % of reading + 4 μV 0.015 % of reading + 4 μV 0.026 % of reading + 4 μV 0.056 % of reading + 5 μV 0.11 % of reading + 10 μV 0.15 % of reading + 20 μV 0.28 % of reading + 20 μV 0.025 % of reading + 12 μV 0.009 6 % of reading + 7 μV 0.008 6 % of reading + 7 μV 0.02 % of reading + 7 μV 0.046 % of reading + 17 μV 0.091 % of reading + 20 μV 0.14 % of reading + 25 μV 0.27 % of reading + 45 μV	Fluke 5720A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	(0.22 to 2.2) V		Fluke 5720A Multiproduct Calibrator
	(10 to 20) Hz	0.024 % of reading + 40 µV	
	(20 to 40) Hz	0.009 % of reading + 15 µV	
	40 Hz to 20 kHz	0.005 % of reading + 8 µV	
	(20 o 50) kHz	0.008 % of reading + 10 µV	
	(50 to 100) kHz	0.011 % of reading + 30 µV	
	(100 to 300) kHz	0.042 % of reading + 80 µV	
	(300 to 500) kHz	0.1 % of reading + 0.2 mV	
	500 kHz to 1 MHz	0.17 % of reading + 0.3 mV	
	(2.2 to 22) V		
	(10 to 20) Hz	0.024 % of reading + 0.4 mV	
	(20 to 40) Hz	0.009 % of reading + 0.15 mV	
	40 Hz to 20 kHz	0.005 % of reading + 50 µV	
	(20 o 50) kHz	0.008 % of reading + 0.1 mV	
	(50 to 100) kHz	0.011 % of reading + 0.2 mV	
	(100 to 300) kHz	0.028 % of reading + 0.6 mV	
	(300 to 500) kHz	0.1 % of reading + 2 mV	
	500 kHz to 1 MHz	0.15 % of reading + 3.2 mV	
	(22 to 220) V		
	(10 to 20) Hz	0.024 % of reading + 4 mV	
	(20 to 40) Hz	0.009 % of reading + 1.5 mV	
	40 Hz to 20 kHz	0.006 % of reading + 0.6 mV	
	(20 o 50) kHz	0.008 % of reading + 1 mV	
	(50 to 100) kHz	0.016 % of reading + 2.5 mV	
	(100 to 300) kHz	0.09 % of reading + 16 mV	
	(300 to 500) kHz	0.44 % of reading + 40 mV	
	500 kHz to 1 MHz	0.8 % of reading + 80 mV	
	(220 to 750) V		Fluke 5720A Multiproduct Calibrator, Fluke 5725A Amplifier
	(30 to 50) kHz	0.061 % of reading + 11 mV	
	(50 to 100) kHz	0.23 % of reading + 45 mV	
	(220 to 1 100) V		
	40 Hz to 1 kHz	0.011 % of reading + 4 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
	(20 to 30) kHz	0.06 % of reading + 11 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	Up to 10 mV		Agilent 3458A opt 002 8.5 Digit Multimeter
	(1 to 40) Hz	0.039 % of reading + 3.5 µV	
	40 Hz to 1 kHz	0.028 % of reading + 1.3 µV	
	(1 to 20) kHz	0.038 % of reading + 1.3 µV	
	(20 to 50) kHz	0.12 % of reading + 1.3 µV	
	(50 to 100) kHz	0.59 % of reading + 1.3 µV	
	(100 to 300) kHz	4.6 % of reading + 2.3 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.013 % of reading + 4.6 µV	
	40 Hz to 1 kHz	0.009 % of reading + 2.3 µV	
	(1 to 20) kHz	0.017 % of reading + 2.3 µV	
	(20 to 50) kHz	0.035 % of reading + 2.3 µV	
	(50 to 100) kHz	0.093 % of reading + 2.3 µV	
	(100 to 300) kHz	0.36 % of reading + 12 µV	
	300 kHz to 1 MHz	1.2 % of reading + 12 µV	
	(1 to 2) MHz	1.8 % of reading + 12 µV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.01 % of reading + 46 µV	
	40 Hz to 1 kHz	0.009 % of reading + 23 µV	
	(1 to 20) kHz	0.017 % of reading + 23 µV	
	(20 to 50) kHz	0.036 % of reading + 23 µV	
	(50 to 100) kHz	0.093 % of reading + 23 µV	
	(100 to 300) kHz	0.35 % of reading + 0.12 mV	
	300 kHz to 1 MHz	1.2 % of reading + 0.12 mV	
	(1 to 2) MHz	1.8% of reading + 0.12 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.01 % of reading + 0.46 mV	
	40 Hz to 1 kHz	0.009 % 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	
	(1 to 2) MHz	1.7 % of reading + 1.2 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(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	 0.024 % of reading + 4.6 mV 0.024 % of reading + 2.3 mV 0.024 % of reading + 2.3 mV 0.041 % of reading + 2.3 mV 0.14 % of reading + 2.3 mV 0.47 % of reading + 12 mV 1.7 % of reading + 12 mV 0.047 % of reading + 46 mV 0.047 % of reading + 23 mV 0.071 % of reading + 23 mV 0.14 % of reading + 23 mV 0.35 % of reading + 23 mV	Agilent 3458A opt 002 8.5 Digit Multimeter
AC Voltage – Measure [1]	Up to 1 mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (1 to 3) mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (3 to 100) mV 100 kHz to 1 MHz (1 to 3) MHz (3 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 1.8 % of reading + 2.4 µV 3.5 % of reading + 2.4 µV 9.3 % of reading + 2.4 µV 23 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV 1.8 % of reading + 2.4 µV	Rohde & Schwarz URE3 RMS Voltmeter
AC High Voltage – Measure [1]	(0.7 to 5) kV 10 mHz to 10 Hz (10 to 30) Hz (30 to 200) Hz (200 to 450) Hz (450 to 600) Hz	 0.15 % of reading + 0.17 V 0.13 % of reading + 0.29 V 0.11 % of reading + 0.37 V 0.48 % of reading + 0.17 V 0.88 % of reading + 0.17 V	Vitrek 4700 Digital HV Meter, Vitrek HVL Series Probes

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC High Voltage – Measure [1]	(5 to 30) kV 10 mHz to 10 Hz (10 to 30) Hz (30 to 200) Hz (200 to 450) Hz (450 to 600) Hz (30 to 50) kV 10 mHz to 10 Hz (10 to 30) Hz (30 to 70) Hz (70 to 200) Hz (200 to 450) Hz (50 to 70) kV 10 mHz to 10 Hz (10 to 30) Hz (30 to 70) Hz (70 to 200) Hz (200 to 450) Hz	 0.2 % of reading + 2.4 V 0.15 % of reading + 2.4 V 0.12 % of reading + 2.4 V 0.71 % of reading + 2.4 V 1.4 % of reading + 2.4 V 0.25 % of reading + 2.5 V 0.19 % of reading + 2.5 V 0.14 % of reading + 2.5 V 0.7 % of reading + 2.5 V 2.9 % of reading + 2.5 V 0.37 % of reading + 2.6 V 0.27 % of reading + 2.6 V 0.18 % of reading + 2.6 V 1.2 % of reading + 2.6 V 1.7 % of reading + 2.6 V	Vitrek 4700 Digital HV Meter, Vitrek HVL Series Probes
DC Voltage – Source [1]	Up to 220 mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V	9.6 µV/V + 0.4 µV 5.6 µV/V + 0.7 µV 4.1 µV/V + 2.5 µV 4.1 µV/V + 4 µV 5.9 µV/V + 40 µV	Fluke 5720A Multiproduct Calibrator
	(220 to 1 100) V	7.6 µV/V + 0.4 mV	Fluke 5720A Multiproduct Calibrator, Fluke 5725A Amplifier
DC Voltage – Measure [1]	Up to 100 mV (0.1 to 10) V (10 to 100) V (100 to 500) V (500 to 700) V (700 to 1 000) V	8.3 µV/V + 0.35 µV 5.3 µV/V + 0.35 µV 7.6 µV/V + 35 µV 11 µV/V + 0.12 mV 14 µV/V + 0.12 mV 21 µV/V + 0.12 mV	Agilent 3458A opt 002 8.5 Digit Multimeter
DC High Voltage – Measure [1]	(1 to 10) kV (10 to 35) kV (35 to 50) kV (50 to 70) kV (70 to 100) kV	0.042 % of reading + 92 mV 0.047 % of reading + 2.4 V 0.056 % of reading + 2.4 V 0.088 % of reading + 2.4 V 0.17 % of reading + 2.5 V	Vitrek 4700 Digital HV Meter, Vitrek HVL Series Probes

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source [1]	10 Hz to 10 kHz (0.19 to < 1.1) nF 10 Hz to 3 kHz (1.1 to < 3.3) nF 10 Hz to 1 kHz (3.3 to < 11) nF (11 to < 110) nF (110 to < 330) nF (10 to 600) Hz (0.33 to < 1.1) µF (10 to 300) Hz (1.1 to < 3.3) µF (10 to 150) Hz (3.3 to < 11) µF (10 to 120) Hz (11 to < 33) µF (10 to 80) Hz (33 to < 110) µF DC to 50 Hz (110 to < 330) µF DC to 20 Hz (0.33 to < 1.1) mF DC to 6 Hz (1.1 to < 3.3) mF DC to 2 Hz (3.3 to < 11) mF DC to 0.6 Hz (11 to < 33) mF DC to 0.2 Hz (33 to < 110) mF	0.39 % of reading + 7.8 pF 0.39 % of reading + 7.8 pF 0.21 % of reading + 7.8 pF 0.21 % of reading + 78 pF 0.21 % of reading + 0.23 nF 0.21 % of reading + 0.78 nF 0.21 % of reading + 2.3 nF 0.21 % of reading + 7.8 nF 0.32 % of reading + 23 nF 0.36 % of reading + 78 nF 0.36 % 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 5520A Multiproduct Calibrator
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	 1.2 °C 0.9 °C 0.71 °C 0.55 °C 0.45 °C 0.35 °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 C		Ectron 1140A Thermocouple Calibrator/Simulator
	(0 to 250) °C	0.24 °C	
	(250 to 1 000) °C	0.19 °C	
	(1 000 to 1 500) °C	0.21 °C	
	(1 500 to 1 800) °C	0.24 °C	
	(1 800 to 2 000) °C	0.27 °C	
	(2 000 to 2 250) °C	0.33 °C	
	(2 250 to 2 315) °C	0.37 °C	
	Type E		
	(-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	

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 R (-50 to -30) °C (-30 to 45) °C (45 to 160) °C (160 to 380) °C (380 to 775) °C (775 to 1 768) °C 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 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	 0.8 °C 0.69 °C 0.49 °C 0.35 °C 0.3 °C 0.26 °C 0.76 °C 0.68 °C 0.49 °C 0.41 °C 0.35 °C 0.31 °C 1.9 °C 0.6 °C 0.36 °C 0.22 °C 0.15 °C 0.095 °C 0.08 °C	Ectron 1140A Thermocouple Calibrator/Simulator
DC Power – Source [1] (0.33 to 330) mA (0.33 to 3) A (3 to 20.5) A	 11 µW to 1.1 mW 1.1 mW to 0.11 W (0.11 to 110) W (110 to 330) W 11 µW to 110 mW (0.11 to 990) W (0.99 to 3) kW 99 mW to 0.99 W 0.99 W to 6.8 kW (6.8 to 20.5) kW	 0.024 % of reading 0.027 % of reading 0.024 % of reading 0.018 % of reading 0.044 % of reading 0.053 % of reading 0.009 6 % of reading 0.088 % of reading 0.07 % of reading 0.04 % of reading	Fluke 5520A Multiproduct Calibrator
AC Power – Source [1,2] PF = 1 (3.3 to 9) mA (9 to 33) mA	(10 to 65) Hz (0.11 mW to 3) mW 3 mW to 9 W (10 to 65) W (0.3 to 10) mW 10 mW to 33 W	 0.13 % of reading 0.077 % of reading 0.089 % of reading 0.077 % of reading	Fluke 5520A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Source [1,2]			Fluke 5520A Multiproduct Calibrator
PF = 1			
(33 to 90) mA	(10 to 65) Hz		
	(1 to 30) mW	0.071 % of reading	
	30 mW to 90 W	0.057 % of reading	
(90 to 330) mA	(10 to 65) Hz		
	(3 to 100) mW	0.089 % of reading	
	100 mW to 300 W	0.078 % of reading	
(0.33 to 0.9) A	(10 to 65) Hz		
	(11 to 300) mW	0.071 % of reading	
	(0.3 to 900) W	0.081 % of reading	
(0.9 to 2.2) A	(10 to 65) Hz		
	(30 to 720) mW	0.089 % of reading	
	0.72 W to 2 kW	0.079 % of reading	
(2.2 to 4.5) A	(10 to 65) Hz		
	80 mW to 1.4 W	0.088 % of reading	
	1.4 W to 4.5 kW	0.18 % of reading	
(4.5 to 20.5) A	(10 to 65) Hz		
	150 mW to 230 kW	0.17 % of reading	
LF Phase – Source [1]	(0 to 90) °		Fluke 5520A Multiproduct Calibrator
	(10 to 65) Hz	0.11 °	
	(65 to 500) Hz	0.2 °	
	500 Hz to 1 kHz	0.4 °	
	(1 to 5) kHz	1.9 °	
	(5 to 10) kHz	3.9 °	
	(10 to 30) kHz	7.8 °	
Oscilloscopes [1]			Fluke 5520A/11 Multiproduct Calibrator
Amplitude DC – Source			
into 50 Ω load	(-6 to 6) V	0.2 % of reading + 31 µV	
into 1 MΩ load	(-130 to 130) V	0.04 % of reading + 31 µV	
Square Wave – Source			
into 50 Ω load	10 Hz to 100 kHz		
	1 mV p-p to 6.6 Vp-p	0.19 % of reading + 31 µV	
into 1 MΩ load	10 Hz to 1 kHz		
	1 mV p-p to 6.6 Vp-p	0.08 % of reading + 31 µV	
	(1 kHz to 10) kHz		
	1 mV p-p to 6.6 Vp-p	0.19 % of reading + 31 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1,3]			
Time Markers – Source			
into 50 Ω load	1 ns to 20 ms	0.000 2 % of reading	
	50 ms	2.3 µs	
	0.1 s	7.6 µs	
	0.2 s	28 µs	
	0.5 s	0.16 ms	
	1 s	0.62 ms	
	2 s	2.4 ms	
	5 s	15 ms	
Rise Time – Source [1]			
into 50 Ω load	5 mVp-p to 2.5 Vp-p		
Rate: 1 kHz to 2 MHz	250 ps (nominal)	50 ps	
Rate: 2 MHz to 10 MHz	250 ps (nominal)	50 ps	
Leveled Sine Wave – Source			
into 50 Ω load	5 mVp-p to 5 Vp-p		
	50 kHz	1.8 % of reading + 0.23 mV	Fluke 5520A/11 Multiproduct Calibrator
	50 kHz to 100 MHz	2.8 % of reading + 0.23 mV	
	(100 to 300) MHz	3.2 % of reading + 0.23 mV	
	(300 to 600) MHz	4 % of reading + 0.23 mV	
	5 mVp-p to 3.5 Vp-p		
	600 MHz to 1.1 GHz	4.9 % of reading + 0.23 mV	
Bandwidth/Flatness – Source (50 kHz Reference)			
into 50 Ω load	5 mVp-p to 5.5 Vp-p		
	50 kHz to 100 MHz	1.4 % of reading + 78 µV	
	(100 to 300) MHz	1.8 % of reading + 78 µV	
	(300 to 600) MHz	3.2 % of reading + 78 µV	
	5 mVp-p to 3.5 Vp-p		
	600 MHz to 1.1 GHz	3.9 % of reading + 78 µV	
Input Impedance – Measure	(40 to 60) Ω	0.082 % of reading	
	(0.5 to 1.5) MΩ	0.081 % of reading	
Input Capacitance – Measure	(5 to 50) pF	3.9 % of reading + 0.39 pF	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1] Waveform Generator – Source Amplitude (Sine, Square, Triangle) into 50 Ω load into 1 MΩ load Frequency (Sine, Square, Triangle)	10 Hz to 10 kHz 1.8 mVp-p to 2.5 Vp-p 1.8 mVp-p to 55 Vp-p 10 Hz to 10 kHz	 2.3 % of reading + 78 µV 2.3 % of reading + 78 µV 0.001 9 % of reading + 12 mHz	Fluke 5520A/11 Multiproduct Calibrator
Total Harmonic Distortion	20 Hz to 100 kHz	0.7 dB	HP 8903B Audio Analyzer
	100 kHz to 2.9 GHz	1.7 dB	HP 8563E Spectrum Analyzer

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers, Calipers [1,4] Length – Outside/Inside/Depth/Step Anvil Flatness	 (0.05 to 1) in (1 to 9) in (9 to 15) in (15 to 40) in Up to 1 in Diameter	 13 µin (9 + 4*L*) µin (11 + 4*L*) µin (16 + 4*L*) µin 4.4 µin	 Gage Blocks, Long Gage Blocks Optical Flats
Dial Indicators [1,4]	(0.01 to 0.4) in (0.45 to 3) in	7 µin (17 + 5.3*L*) µin	Gage Blocks, Surface Plate
Height Measuring Equipment [4]	(0.01 to 8) in (8 to 40) in	(17 + 3.4*L*) µin (15 + 4.3*L*) µin	Gage Blocks, Long Gage Blocks, Surface Plate
Height – Measure [4]	(0.01 to 6) in (6 to 12) in	(24 + 2.6*L*) µin (14 + 4.4*L*) µin	Gage Blocks, Long Gage Blocks, Surface Plate
Pin Gages – Outside Diameter	(0.004 to 1) in	32 µin	Non-contact Method using Laser Micrometer.

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Measuring Equipment (Tension and Compression)	(1 to 50) lbf (50 to 250) lbf 1 gf to 4 kgf	0.013 % of reading 0.004 4 % of reading + 0.006 5 lbf 0.013 % of reading	Deadweights
Torque Devices [1] (Measure)	20 ozf·in to 600 lbf·ft	1 % of reading	Torque Calibrator
Balances [1,5] Avoirdupois SI (metric)	 (0.07 to 0.18) oz (0.18 to 1.8) oz 1.8 oz to 58 lb (2 to 5) g (5 to 50) g 50 g to 26 kg	 0.13 mg 0.001 7 % of reading 0.000 6 % of reading 0.13 mg 0.001 7 % of reading 0.000 6 % of reading	Class S Weights and internal calibration procedure utilized in the calibration of the weighing device.
Balances [1,5] Avoirdupois SI (metric)	 Up to 0.018 oz (0.018 to 0.2) oz (0.2 to 0.4) oz (0.4 to 0.7) oz 0.7 oz to 13 lb Up to 500 mg 500 mg to 5 g (5 to 10) g (10 to 20) g 20 g to 6 kg	 0.012 mg 0.04 mg 0.06 mg 0.09 mg 0.000 3% of reading 0.012 mg 0.04 mg 0.06 mg 0.09 mg 0.000 3% of reading	ASTM E617 Class 1 Weights and internal calibration procedure utilized in the calibration of the weighing device.
Scales [1,5] Avoirdupois SI (metric)	 (50 to 600) lb (22 to 272) kg	 0.012 % of reading 0.012 % of reading	NIST Class F Weights and internal calibration procedure utilized in the calibration of the weighing device.
Absolute Pressure – Source (Pneumatic)	Up to 25 psia (25 to 500) psia	0.001 9 psi 0.006 % of reading + 0.001 psi	Ruska 7250xi Pressure Controller/Calibrator
Gauge Pressure – Source (Pneumatic)	(-15 to 25) psig (25 to 500) psig	0.001 7 psi 0.006 % of reading	Ruska 7250xi Pressure Controller/Calibrator
Gauge Pressure – Source (Hydraulic)	Up to 1 500 psig (1 500 to 15 000) psig	0.36 psi 0.023 % of reading	Fluke RPM4-E-DWT Electronic Deadweight Tester

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Volume – Pipettes [1]	(0.1 to 10) µL (> 10 to 20) µL (> 20 to 30) µL (> 30 to 50) µL (> 50 to 100) µL (> 100 to 200) µL (> 200 to 500) µL (> 500 to 1 000) µL (> 1 000 to 1 500) µL (> 1 500 to 2 000) µL (> 2 000 to 2 500) µL (> 2 500 to 3 000) µL (> 3 000 to 5 000) µL (> 5 000 to 10 000) µL	0.026 µL 0.031 µL 0.051 µL 0.099 µL 0.15 µL 0.19 µL 0.22 µL 0.25 µL 0.35 µL 0.46 µL 0.52 µL 0.63 µL 0.99 µL 2 µL	Gravimetric Method using Electronic Balances and Master Weights.
Gas Flow	(0.001 to 10) slpm (10 to 680) slpm	0.23 % of reading 0.15 % of reading	Bell Prover
Liquid Flow	(0.001 to 60) gpm (0.004 to 230) lpm (0.4 to 23 000) pph	0.1 % of reading 0.1 % of reading 0.1 % of reading	Liquid Ballistic Prover

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source [1]	(0 to 100) °C	0.038 °C	Drywell, Hart 5628A PRT, Digital Readout
Temperature – Measure [1]	(-195 to 0) °C (0 to 420) °C (420 to 600) °C	0.012 °C 0.026 °C 0.036 °C	Hart 5628A PRT, Digital Readout
Infrared Temperature Measuring Equipment	(-15 to 0) °C (0 to 50) °C (50 to 100) °C	0.79 °C 0.54 °C 0.67 °C	Blackbody Source (flat plate) ε = (0.9 to 1.0), λ = (8 to 14) µm
Infrared Temperature Measuring Equipment	(100 to 120) °C (120 to 200) °C (200 to 350) °C (350 to 500) °C	0.75 °C 0.97 °C 1.7 °C 2.2 °C	Blackbody Source (flat plate) ε = (0.9 to 1.0), λ = (8 to 14) µm

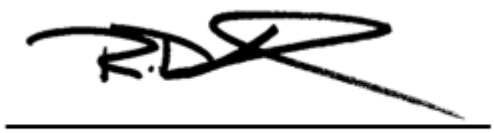
Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Duty Cycle – Source Square Wave: < 3.3 Vp-p Freq: 0.01 Hz to 100 kHz	(1 to 10) % Duty Cycle 10 µS to 100 s (10 to 49) % Duty Cycle 10 µS to 100 s 50 % Duty Cycle 10 µS to 100 s (51 to 90) % Duty Cycle 10 µS to 100 s (90 to 99) % Duty Cycle 10 µS to 100 s	0.62 % of reading + 78 ns 0.4 % of reading + 78 ns 0.02 % of reading + 78 ns 0.04 % of reading + 78 ns 0.62 % of reading + 78 ns	Fluke 5522A Multiproduct Calibrator
Frequency – Source/Measure [1]	10 MHz	38 nHz/Hz	Comparison to Agilent 8648C Synthesized RF Signal Generator
Frequency – Source/Measure	10 MHz	5.8 nHz/Hz	Comparison to SRS FS725 Rubidium Frequency Standard
Rise Time – Measure (Transient Response)	≤ 100 µs/div	20 ns	Tektronix TDS 754D Digital Oscilloscope
Stopwatch/Timers	Up to 599 s/mon	58 ms/day	Helmut Klein TM-4500 Timometer

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

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. The 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 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.
3. The stated uncertainty is the laboratory's ability to source a fast rise pulse that is approximately 250 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.
4. L = length in inches.
5. 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.
6. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.11.



R. Douglas Leonard Jr., VP, PILR SBU