CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

McHale & Associates, Inc.
4700 Coster Road
Knoxville, TN 37912

Fulfills the requirements of

ISO/IEC 17025:2017

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.

Jason Stine, Vice President

Expiry Date: 17 September 2024

Certificate Number: AC-2909

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

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CALIBRATION

Valid to: **September 17, 2024** Certificate Number: **AC-2909**

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1,2]	Up to 330 mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1 000) V	16 nV/mV + 1.2 µV 21 µV/V + 4.4 µV 9.4 µV/V + 60 µV 14 µV/V + 0.7 mV 14 µV/V + 2.6 mV	Multi-Product Calibrator
DC Voltage - Measure [1,2]	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1 000) V	6 nV/mV + 0.2 µV 2.9 µV/V + 0.3 µV 2.9 µV/V + 0.5 µV 4.3 µV/V + 30 µV 4.6 µV/V + 0.5 mV	Reference Multimeter
DC High Voltage – Measure [1,2]	Up to 10 kV	0.33 mV/V + 70 mV	Precision HV Meter
DC Current – Source [1,2]	Up to 330 µA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA (0.33 to 1.1) A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	0.12 nA/µA + 20 nA 78 nA/mA + 50 nA 78 nA/mA + 0.4 µA 78 nA/mA + 4.1 µA 0.16 mA/A + 50 µA 0.29 mA/A + 0.1 mA 0.39 mA/A + 0.7 mA 0.78 mA/A + 2.4 mA	Multi-Product Calibrator
DC Current – Source [1,2]	(10 to 16.5) A (16.5 to 150) A (150 to 1 025) A	11 mA/A + 2.5 mA 2.5 mA/A + 20 mA 2.6 mA/A + 0.2 A	Multi-Product Calibrator with 50-turn Coil

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current - Measure [1,2]	Up to 10 µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 30) A	27 fA/µA + 0.4 nA 9.4 fA/µA + 0.4 nA 8.5 nA/mA + 4 nA 40 nA/mA + 40 nA 67 nA/mA + 1 µA 0.26 mA/A + 0.1 mA 0.18 mA/A + 0.4 mA 0.51 mA/A + 4.4 mA	Reference Multimeter
Resistance – Source [1,2] (Simulation)	Up to 11Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.33 to 1.1) kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ (0.33 to 1.1) MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (330 to 1 100) MΩ	32 µΩ/Ω + 0.8 mΩ 24 µΩ/Ω + 1.2 mΩ 22 µΩ/Ω + 1.2 mΩ 22 µΩ/Ω + 1.9 mΩ 22 mΩ/kΩ + 4.6 mΩ 23 mΩ/kΩ + 20 mΩ 22 mΩ/kΩ + 40 mΩ 22 mΩ/kΩ + 0.2 Ω 22 mΩ/kΩ + 0.4 Ω 25 mΩ/kΩ + 2.4 Ω 25 Ω/MΩ + 4.9 Ω 50 Ω/MΩ + 30 Ω 0.1 kΩ/MΩ + 0.1 kΩ 0.19 kΩ/MΩ + 3 kΩ 0.39 kΩ/MΩ + 0.1 MΩ 2.3 kΩ/MΩ + 0.1 MΩ 12 kΩ/MΩ + 0.8 MΩ	Multi-Product Calibrator
AC Voltage – Source [1,2]	(1 to 33) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (33 to 330) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	 0.62 µV/mV + 5.4 µV 0.12 µV/mV + 5.5 µV 0.16 µV/mV + 5 µV 0.78 µV/mV + 5.5 µV 2.7 µV/mV + 10 µV 6.2 µV/mV + 40 µV 0.23 µV/mV + 6.2 µV 0.11 µV/mV + 6.2 µV 0.12 µV/mV + 10 µV 0.27 µV/mV + 10 µV 0.62 µV/mV + 30 µV 1.6 µV/mV + 90 µV	Multi-Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1,2]	(0.33 to 3.3) V		Multi-Product Calibrator
	(10 to 45) Hz	0.23 mV/V + 0.2 mV	
	45 Hz to 10 kHz	0.12 mV/V + 0.2 mV	
	(10 to 20) kHz	0.15 mV/V + 70 µV	
	(20 to 50) kHz	0.23 mV/V + 0.1 mV	
	(50 to 100) kHz	0.54 mV/V + 0.2 mV	
	(100 to 500) kHz	1.9 mV/V + 1 mV	
	(3.3 to 33) V		
	(10 to 45) Hz	0.23 mV/V + 1.8 mV	
	45 Hz to 10 kHz	0.12 mV/V + 2.2 mV	
	(10 to 20) kHz	0.19 mV/V + 0.9 mV	
	(20 to 50) kHz	0.27 mV/V + 1.2 mV	
	(50 to 100) kHz	0.7 mV/V + 1.9 mV	
	(33 to 330) V		
	(10 to 45) Hz	0.15 mV/V + 7.4 mV	
	45 Hz to 10 kHz	0.16 mV/V + 20 mV	
	(10 to 20) kHz	0.19 mV/V + 10 mV	
	(20 to 50) kHz	0.23 mV/V + 20 mV	
	(50 to 100) kHz	1.6 mV/V + 80 mV	
	(330 to 1 020) V		
	45 Hz to 1 kHz	0.23 mV/V + 30 mV	
	(1 to 5) kHz	0.19 mV/V + 30 mV	
	(5 to 10) kHz	0.23 mV/V + 40 mV	
AC Voltage - Measure [1,2]	Up to 10 mV		Reference Multimeter
	1 Hz to 2 kHz	0.28 µV/mV + 1.1 µV	
	(2 to 10) kHz	0.36 µV/mV + 1.1 µV	
	(10 to 30) kHz	0.39 µV/mV + 1.1 µV	
	(30 to 100) kHz	3 µV/mV + 1.1 µV	
	(100 to 300) kHz	10 µV/mV + 4 µV	
	300 kHz to 1 MHz	20 µV/mV + 4 µV	
	(10 to 100) mV		
	1 Hz to 2 kHz	0.075 µV/mV + 0.5 µV	
	(2 to 10) kHz	0.12 µV/mV + 0.5 µV	
	(10 to 30) kHz	0.21 µV/mV + 1 µV	
	(30 to 100) kHz	0.51 µV/mV + 5 µV	
	(100 to 300) kHz	2 µV/mV + 30 µV	
	300 kHz to 1 MHz	10 µV/mV + 0.1 mV	
	(1 to 2) MHz	15 µV/mV + 0.5 mV	
	(2 to 4) MHz	40 µV/mV + 1 mV	
	(4 to 8) MHz	80 µV/mV + 1 mV	
	(8 to 10) MHz	0.15 mV/mV + 1 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure [1,2]	(0.1 to 1) V		Reference Multimeter
	1 Hz to 2 kHz	0.67 mV/V + 5 µV	
	(2 to 10) kHz	0.11 mV/V + 5 µV	
	(10 to 30) kHz	0.21 mV/V + 10 µV	
	(30 to 100) kHz	0.51 mV/V + 50 µV	
	(100 to 300) kHz	2 mV/V + 0.3 mV	
	300 kHz to 1 MHz	10 mV/V + 1 mV	
	(1 to 2) MHz	16 mV/V + 5 mV	
	(2 to 4) MHz	40 mV/V + 10 mV	
	(4 to 8) MHz	81 mV/V + 10 mV	
	(8 to 10) MHz	0.15 V/V + 10 mV	
	(1 to 10) V		
	1 Hz to 2 kHz	66 µV/V + 50 µV	
	(2 to 10) kHz	0.11 mV/V + 50 µV	
	(10 to 30) kHz	0.21 mV/V + 0.1 mV	
	(30 to 100) kHz	0.54 mV/V + 0.5 mV	
	(100 to 300) kHz	2 mV/V + 3 mV	
	300 kHz to 1 MHz	10 mV/V + 10 mV	
	(1 to 2) MHz	15 mV/V + 50 mV	
	(2 to 4) MHz	40 mV/V + 0.1 V	
	(4 to 8) MHz	80 mV/V + 0.1 V	
	(8 to 10) MHz	0.15 V/V + 0.1 V	
	(10 to 100) V		
	1 Hz to 2 kHz	73 µV/V + 0.5 mV	
	(2 to 10) kHz	93 µV/V + 0.5 mV	
	(10 to 30) kHz	0.21 mV/V + 1 mV	
	(30 to 100) kHz	0.51 mV/V + 5 mV	
	(100 to 300) kHz	3.5 mV/V + 50 mV	
	300 kHz to 1 MHz	10 mV/V + 0.5 V	
	(100 to 1 000)V		
	1 Hz to 2 kHz	92 µV/V + 30 mV	
	(2 to 10) kHz	0.1 mV/V + 30 mV	
	(10 to 30) kHz	0.22 mV/V + 30 mV	
	(30 to 100) kHz	0.52 mV/V + 0.1 V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC High Voltage – Measure [1,2]	Up to 10 kV		Precision HV Meter
	(30 to 600) Hz		
	30 Hz to 200 Hz	1.9 mV/V + 0.2 V	
	200 Hz to 450 Hz	4.4 mV/V + 0.2 V	
	450 Hz to 600 Hz	7.7 mV/V + 0.2 V	
	(10 to 150) Hz		
	10 Hz to 65 Hz	1.9 mV/V + 0.2 V	
	65 Hz to 150 Hz	4.3 mV/V + 0.2 V	
	(1 to 75) Hz		
	1 Hz to 35 Hz	1.9 mV/V + 0.2 V	
	35 Hz to 75 Hz	4.3 mV/V + 0.2 V	
	(0.1 to 35) Hz		
	0.1 Hz to 15 Hz	1.9 mV/V + 0.2 V	
	15 Hz to 35 Hz	4.3 mV/V + 0.2 V	
	(0.01 to 2) Hz		
	0.01 Hz to 1 Hz	1.9 mV/V + 0.2 V	
	(1 to 2) Hz	4.3 mV/V + 0.2 V	
AC Current – Source [1,2]	Up to 330 µA		Multi-Product Calibrator
	(10 to 20) Hz	1.6 nA/µA + 80 nA	
	(20 to 45) Hz	1.2 nA/µA + 80 nA	
	45 Hz to 1 kHz	0.97 nA/µA + 0.1 µA	
	(1 to 5) kHz	2.3 nA/µA + 0.2 µA	
	(5 to 10 kHz	6.2 nA/µA + 0.2 µA	
	(10 to 30) kHz	12 nA/µA + 0.3 µA	
	(0.33 to 3.3) mA		
	(10 to 20) Hz	1.6 µA/mA + 0.2 µA	
	(20 to 45) Hz	0.97 µA/mA + 0.2 µA	
	45 Hz to 1 kHz	0.78 µA/mA + 0.2 µA	
	(1 to 5) kHz	1.6 µA/mA + 0.7 µA	
	(5 to 10) kHz	3.9 µA/mA + 0.3 µA	
	(10 to 30) kHz	7.8 µA/mA + 1.1 µA	
	(3.3 to 33) mA		
	(10 to 20) Hz	1.4 µA/mA + 4.5 µA	
	(20 to 45) Hz	0.7 µA/mA + 2.7 µA	
	45 Hz to 1 kHz	0.31 µA/mA + 7 µA	
	(1 to 5) kHz	0.62 µA/mA + 7 µA	
	(5 to 10 kHz	1.6 µA/mA + 3.9 µA	
	(10 to 30) kHz	3.1 µA/mA + 9.1 µA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1,2]	(33 to 330) mA		Multi-Product Calibrator
	(10 to 20) Hz	1.4 µA/mA + 50 µA	
	(20 to 45) Hz	0.7 µA/mA + 30 µA	
	45 Hz to 1 kHz	0.31 µA/mA + 60 µA	
	(1 to 5) kHz	0.78 µA/mA + 70 µA	
	(5 to 10 kHz	1.6 µA/mA + 0.2 mA	
	(10 to 30) kHz	3.1 µA/mA + 0.2 mA	
	(0.33 to 1.1) A		
	(10 to 45) Hz	1.4 mA/A + 0.1 mA	
	45 Hz to 1 kHz	0.39 mA/A + 0.1 mA	
	(1 to 5) kHz	4.7 mA/A + 0.9 mA	
	(5 to 10) kHz	19 mA/A + 4 mA	
	(1.1 to 3) A		
	(10 to 45) Hz	1.4 mA/A + 0.2 mA	
	45 Hz to 1 kHz	0.47 mA/A + 0.2 mA	
	(1 to 5) kHz	4.7 mA/A + 1.1 mA	
	(5 to 10) kHz	19 mA/A + 4.3 mA	
AC Current – Source [1,2]	(3 to 11) A		Multi-Product Calibrator
	(45 to 100) Hz	0.47 mA/A + 1.9 mA	
	100 Hz to 1 kHz	0.78 mA/A + 2.1 mA	
	(1 to 5) kHz	23 mA/A + 7.3 mA	
	(11 to 20.5) A		
	(45 to 100) Hz	0.93 mA/A + 4.7 mA	
	100 Hz to 1 kHz	1.2 mA/A + 5.2 mA	
	(1 to 5) kHz	23 mA/A + 20 mA	
AC Current – Source [1,2]	(10 to 16.5) A		Multi-Product Calibrator with 50-turn Coil
	(45 to 65) Hz	2.8 mA/A + 3.3 mA	
	(65 to 440) Hz	2.8 mA/A + 25 mA	
	(16.5 to 150) A		
	(45 to 65) Hz	2.8 mA/A + 90 mA	
	(65 to 440) Hz	7.9 mA/A + 6.4 mA	
	(150 to 1 025) A		
	(45 to 65) Hz	8 mA/A + 0.2 A	
	(65 to 440) Hz	8 mA/A + 0.3 A	
AC Current - Measure [1,2]	Up to 10 µA		Reference Multimeter
	1 Hz to 30 kHz	2 nA/µA + 2.5 nA	
	(10 to 100) µA		
	1 Hz to 2 kHz	0.27 nA/µA + 5 nA	
	(2 to 10) kHz	0.51 nA/µA + 5 nA	
	(10 to 30) kHz	0.73 nA/µA + 5 nA	
	(30 to 100) kHz	4 nA/µA + 10 nA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Measure [1,2]	(0.1 to 1) mA		Reference Multimeter
	1 Hz to 2 kHz	0.27 µA/mA + 50 nA	
	(2 to 10) kHz	0.51 µA/mA + 50 nA	
	(10 to 30) kHz	0.72 µA/mA + 50 nA	
	(30 to 100) kHz	4 µA/mA + 0.1 µA	
	(1 to 10) mA		
	1 Hz to 2 kHz	0.27 µA/mA + 0.5 µA	
	(2 to 10) kHz	0.51 µA/mA + 0.5 µA	
	(10 to 30) kHz	0.72 µA/mA + 0.5 µA	
	(30 to 100) kHz	4 µA/mA + 1 µA	
	(10 to 100) mA		
	1 Hz to 2 kHz	0.27 µA/mA + 5 µA	
	(2 to 10) kHz	0.5 µA/mA + 5 µA	
	(10 to 30) kHz	0.7 µA/mA + 5 µA	
	(0.1 to 1) A		
	1 Hz to 2 kHz	0.27 mA/A + 0.1 mA	
	(2 to 10) kHz	0.51 mA/A + 0.1 mA	
	(10 to 30) kHz	0.73 mA/A + 0.1 mA	
	(1 to 10) A		
	10 Hz to 10 kHz	0.8 mA/A + 0.5 mA	
	(10 to 30) A		
	10 Hz to 2 kHz	0.8 mA/A + 12 mA	
	(2 to 10) kHz	1.2 mA/A + 12 mA	
Resistance - Measure [1,2]	Up to 1 Ω	11 µΩ/Ω + 4 µΩ	Reference Multimeter
	(1 to 10) Ω	8.2 µΩ/Ω + 10 µΩ	
	(10 to 100) Ω	7.4 µΩ/Ω + 50 µΩ	
	(0.1 to 1) kΩ	7.2 mΩ/kΩ + 0.5 mΩ	
	(1 to 10) kΩ	7.7 mΩ/kΩ + 5 mΩ	
	(10 to 100) kΩ	7.5 mΩ/kΩ + 50 mΩ	
	(0.1 to 1) MΩ	9.3 Ω/MΩ + 1 Ω	
	(1 to 10) MΩ	12 Ω/MΩ + 0.1 kΩ	
	(10 to 100) MΩ	44 Ω/MΩ + 10 kΩ	
	(0.1 to 1) GΩ	0.51 MΩ/GΩ + 1 MΩ	
Capacitance – Source [1,2]	(0.19 to 0.4) nF	4.6 pF/nF + 8.4 pF	Multi-Product Calibrator
	(0.4 to 1.1) nF	4 pF/nF + 8.4 pF	
	(1.1 to 3.3) nF	3.9 pF/nF + 8.1 pF	
	(3.3 to 11) nF	1.9 pF/nF + 10 pF	
	(11 to 33) nF	1.9 pF/nF + 7.9 pF	
	(33 to 110) nF	1.9 pF/nF + 70 pF	
	(110 to 330) nF	1.9 pF/nF + 0.2 nF	
	330 nF to 1.1 µF	1.9 nF/µF + 10 nF	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source [1,2]	(1.1 to 3.3) µF (3.3 to 11) µF (11 to 33) µF (33 to 110) µF (110 to 330) µF 330 µF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11to 33) mF (33 to 110) mF	1.9 nF/µF + 30 nF 1.9 nF/µF + 10 nF 3.1 nF/µF + 30 nF 3.5 nF/µF + 0.2 µF 3.5 nF/µF + 0.3 µF 3.5 µF/mF + 0.9 µF 3.5 µF/mF + 2.5 µF 3.5 µF/mF + 8.4 µF 5.8 µF/mF + 30 µF 8.5 µF/mF + 90 µF	Multi-Product Calibrator
Capacitance - Measure [1,2]	Up to 1 nF (1 to 10) nF (10 to 100) nF (0.1 to 1) µF (1 to 10) µF (10 to 100) µF (0.1 to 1) mF (1 to 10) mF (10 to 100) mF	1.1 pF/nF + 1 pF 0.64 pF/nF + 2 pF 0.42 pF/nF + 10 pF 0.41 nF/µF + 0.1 nF 0.42 nF/µF + 1 nF 0.61 nF/µF + 10 nF 0.61 µF/mF + 0.1 µF 0.71 µF/mF + 1 µF 0.71 µF/mF + 10 µF	Reference Multimeter
Electrical Simulation of Thermocouple Indicating Instruments – Source [1]	Type B (600 to 800) °C (800 to 1 000) °C (1 000 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 316) °C Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1 000) °C	 0.35 °C 0.27 °C 0.24 °C 0.26 °C 0.24 °C 0.21 °C 0.25 °C 0.39 °C 0.65 °C 0.39 °C 0.14 °C 0.13 °C 0.14 °C 0.18 °C	Multi-Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Instruments – Source [1]	Type J		Multi-Product Calibrator
	(-210 to -100) °C	0.22 °C	
	(-100 to -30) °C	0.14 °C	
	(-30 to 150) °C	0.12 °C	
	(150 to 760) °C	0.15 °C	
	(760 to 1 200) °C	0.19 °C	
	Type K		
	(-200 to -100) °C	0.26 °C	
	(-100 to -25) °C	0.15 °C	
	(-25 to 120) °C	0.14 °C	
	(120 to 1 000) °C	0.21 °C	
	(1 000 to 1 372) °C	0.32 °C	
	Type L		
	(-200 to -100) °C	0.29 °C	
	(-100 to 800) °C	0.21 °C	
	(800 to 900) °C	0.15 °C	
	Type N		
	(-200 to -100) °C	0.32 °C	
	(-100 to -25) °C	0.18 °C	
	(-25 to 120) °C	0.16 °C	
	(120 to 410) °C	0.15 °C	
	(410 to 1 300) °C	0.22 °C	
	Type R		
	(0 to 250) °C	0.45 °C	
	(250 to 400) °C	0.28 °C	
	(400 to 1 000) °C	0.26 °C	
	(1 000 to 1 767) °C	0.32 °C	
	Type S		
	(0 to 200) °C	0.37 °C	
	(250 to 1 400) °C	0.29 °C	
	(1 400 to 1 767) °C	0.36 °C	
	Type T		
	(-250 to -150) °C	0.49 °C	
	(-150 to 0) °C	0.2 °C	
	(0 to 120) °C	0.14 °C	
	(120 to 400) °C	0.13 °C	
	Type U		
	(-200 to 0) °C	0.44 °C	
	(0 to 600) °C	0.22 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Instruments – Source [1]	Pt 385, 100 Ω		Multi-Product Calibrator
	(-200 to 0) °C	0.039 °C	
	(0 to 100) °C	0.054 °C	
	(100 to 300) °C	0.07 °C	
	(300 to 400) °C	0.078 °C	
	(400 to 630) °C	0.093 °C	
	(630 to 800) °C	0.18 °C	
	Pt 3926, 100 Ω		
	(-200 to 0) °C	0.039 °C	
	(0 to 100) °C	0.054 °C	
	(100 to 300) °C	0.07 °C	
	(300 to 400) °C	0.078 °C	
	(400 to 630) °C	0.093 °C	
	Pt 3916, 100 Ω		
	(-200 to -190) °C	0.19 °C	
	(-190 to -80) °C	0.031 °C	
	(-80 to 0) °C	0.039 °C	
	(0 to 100) °C	0.047 °C	
	(100 to 260) °C	0.054 °C	
	(260 to 300) °C	0.062 °C	
	Pt 3916, 300 Ω		
	(0 to 400) °C	0.07 °C	
	Pt 3916, 400 Ω		
	(0 to 600) °C	0.078 °C	
	Pt 3916, 600 Ω		
	(600 to 630) °C	0.18 °C	
	Pt 385, 200 Ω		
	(-200 to 100) °C	0.031 °C	
	(100 to 260) °C	0.39 °C	
	(260 to 300) °C	0.93 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 600) °C	0.11 °C	
	(600 to 630) °C	0.12 °C	
	Pt 385, 500 Ω		
	(-200 to -80) °C	0.032 °C	
	(-80 to 100) °C	0.039 °C	
	(100 to 260) °C	0.047 °C	
	(260 to 400) °C	0.062 °C	
	(400 to 600) °C	0.07 °C	
	(600 to 630) °C	0.086 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Instruments – Source [1]	Pt 385, 1 000 Ω (-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C PtNi 385, 120 Ω (-80 to 100) °C (100 to 260) °C Cu 427, 10 Ω (-100 to 260) °C	 0.026 °C 0.033 °C 0.04 °C 0.048 °C 0.056 °C 0.18 °C 0.062 °C 0.11 °C 0.23 °C	Multi-Product Calibrator
AC Voltage Harmonics– Source [1,2]	10 mV to 5 V (10 to 45) Hz (45 to 65) kHz (0.1 to 5) V (65 to 500) kHz 500 Hz to 5 kHz (5 to 10) kHz (0.1 to 3.3) V (10 to 30) kHz	 0.78 mV/V + 1 mV 0.7 mV/V + 0.9 mV 0.7 mV/V + 0.9 mV 1.6 mV/V + 2.5 mV 3.1 mV/V + 3.2 mV 39 mV/V + 4.3 mV	Multi-Product Calibrator
AC Current Harmonics – Source [1,2]	(33 to 330) mA (5 to 10) kHz (10 to 30) kHz 3.3 mA to 3 A (10 to 45) Hz 3.3 mA to 20.5 A (45 to 65) Hz 33 mA to 20.5 A (65 to 500) Hz 500 Hz to 5 kHz	 1.6 µA/mA + 0.2 mA 3.1 µA/mA + 0.3 mA 1.4 mA/A + 0.3 mA 0.93 mA/A + 8.2 mA 1.2 mA/A + 8.2 mA 23 mA/A + 20 mA	Multi-product Calibrator
DC Power Source [1,2]	33 mV to 1 020 V (0.33 to 330) mA 330 mA to 3 A (3 to 20.5) A	 14 µW/W + 60 mW 0.29 mW/W + 0.6 W 0.78 mW/W + 5.8 W	Multi-Product Calibrator
AC Power- Source [1,2]	(33 to 330) mV (3.3 to 33) mA (33 to 330) mA (330 to 900) mA 900 mA to 2.2 A (2.2 to 4.5) A (4.5 to 20.5) A	 0.33 µW/W + 6.5 µW 0.33 µW/W + 20 µW 0.39 mW/W + 0.1 mW 0.47 mW/W + 0.1 mW 0.47 mW/W + 2 mW 0.93 mW/W + 5 mW	Multi-Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power- Source [1,2]	330 mV to 1 020 V		Multi-Product Calibrator
	(3.3 to 9) mA	0.23 mW/W + 7.8 mW	
	(9 to 90) mA	0.23 mW/W + 9.7 mW	
	(90 to 330) mA	0.23 mW/W + 60 mW	
	(330 to 900) mA	0.45 mW/W + 60 mW	
	900 mA to 4.5 A	0.52 mW/W + 0.6 W	
	(4.5 to 20.5) A	0.96 W/W + 5.8 W	
Phase – Source [1,2]	(0 to 360)°		Multi-Product Calibrator
	(10 to 65) Hz	0.083°	
	(65 to 500) Hz	0.19°	
	(0.5 to 1) kHz	0.39°	
	(1 to 5) kHz	1.9°	
	(5 to 10) kHz	3.9°	
	(10 to 30) kHz	7.8°	
Oscilloscopes [1,2]			Multi-Product Calibrator
DC Voltage			
into 50 Ω load	(1 to 109.99) mV	1.9 µV/mV + 30 µV	
	(0.11 to 2.199 9) V	2 mV/V + 0.1 mV	
	(2.2 to 6.6) V	2 mV/V + 2.1 mV	
into 1 MΩ load	(1 to 24.999) mV	0.46 µV/mV + 30 µV	
	(25 to 109.99) mV	0.39 µV/V + 30 µV	
	(0.11 to 2.199 9) V	0.39 mV/V + 0.1 mV	
	(2.2 to 10.999) V	0.39 mV/V + 0.9 mV	
	(11 to 130) V	0.39 mV/V + 7.6 mV	
AC Voltage			
into 50 Ω load	(1 to 109.99) mV	1.9 µV/mV + 50 µV	
	(0.11 to 2.1999) V	2.2 mV/mV + 0.8 mV	
	(2.2 to 6.6) V	2 mV/V + 1.4 mV	
1 MΩ load	(1 to 24.999) mV	0.81 µV/mV + 50 µV	
	(25 to 109.99) mV	0.78 µV/V + 0.4 mV	
	(0.11 to 2.199 9) V	0.82 mV/V + 1.4 mV	
	(2.2 to 10.999) V	0.78 mV/V + 10 mV	
	(11 to 130) V	0.79 mV/V + 0.2 V	
Leveled Sine Wave – Voltage	5.5 mVp-p to 5.5 Vp-p		
	Up to 50 kHz	19 mV/V + 20 mV	
	50 kHz to 100 MHz	28 mV/V + 20 mV	
	(100 to 300) MHz	31 mV/V + 10 mV	
	(300 to 600) MHz	47 mV/V + 40 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1,2]			
Leveled Sine Wave – Voltage	5.5 mVp-p to 3.5 Vp-p		
	600 MHz to 1.1 GHz	54 mV/V + 40 mV	
Time Markers	(1 to 5) ns		
	10 ns	1.9 fs/ns + 0.6 ps	
	(20 to 50) ns	1.9 fs/ns + 0.6 ps	
	(0.1 to 20) ms	1.9 fs/ns + 5.8 ps	
	50 ms to 5 s	25 ns/ms + 5.8 µs	
		11 ms/s + 20 ms	
Wave Generator			
into 50 Ω load	1.8 mVp-p to 2.5 Vp-p		
		24 mV/V + 1 mV	Multi-Product Calibrator
into 1 MΩ load	1.8 mVp-p to 55 Vp-p		
		23 mV/V + 80 µV	
Pulse Generator – Width	(4 to 45) ns		
	(45 to 500) ns	39 ps/ns + 1.6 ns	
		39 ps/ns + 2.2 ns	
Pulse Generator – Period	200 ns to 20 ms		
		25 ns/ms + 0.6 µs	
Input Impedance Measure	(40 to 60) Ω		
	(0.5 to 1.5) MΩ	0.78 mΩ/Ω + 300 Ω	
		0.78 kΩ/MΩ + 0.8 kΩ	
Input Capacitance Measure	(5 to 50) pF		
		39 fF/pF + 0.6 pF	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Source [1] Relative to +16 dBm	(0 to 55) dBm	0.02 dB	Fluke 9640 RF Reference Source
	(55 to 64) dBm	0.03 dB	
	(64 to 74) dBm	0.05 dB	
	(74 to 100) dBm	0.07 dB	
	(100 to 116) dBm	0.15 dB	
Attenuation – Source [1] Relative to +10 dBm	(0 to 33) dBm	0.04 dB	Fluke 9640 RF Reference Source
	(33 to 64) dBm	0.05 dB	
	(64 to 100) dBm	0.15 dB	
	(100 to 110) dBm	0.3 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Modulation [1,2]	150 kHz to 10 MHz 10 MHz to 1.30 GHz	46 mrad/rad + 0.5 rad 35 mrad/rad + 0.5 rad	Keysight 8902 Measuring Receiver
AM Modulation [1,2]	150 kHz to 10 MHz Rate: 50 Hz to 10 kHz 10 MHz to 1.3 GHz Rate: 50 Hz to 50 kHz 150 kHz to 1.3 GHz Rate: 20 Hz to 100 kHz	23 Hz/kHz + 12 Hz 12 Hz/kHz + 12 Hz 35 Hz/kHz + 12 Hz	Keysight 8902 Measuring Receiver
AM Modulation Flatness [1,2]	10 MHz to 1.3 GHz Rate: 90 Hz to 10 kHz	3.5 Hz/kHz + 12 Hz	Keysight 8902 Measuring Receiver
FM Modulation [1,2]	250 kHz-10 MHz Rate: 20 Hz to 10 kHz 10MHz-1.3GHz Rate: 50Hz to 100kHz 10 MHz to 1.3 GHz Rate: 20 Hz to 200 kHz	23 Hz/kHz + 1.2 Hz 12 kHz/MHz + 1.2 Hz 58 kHz/MHz + 1.2 Hz	Keysight 8902 Measuring Receiver
Pulse Generation [1]	DC to 350 MHz 2.8 ns to 1 000 sec	0.4 ns	Agilent 53220A Counter
Harmonic Distortion	100 kHz to 1.5 GHz	7.1 dB	ESA-L1500A Spectrum Analyzer
RF Power Measure [1,2]	(-20 to -+30) dBm 0.1MHz to 2.5GHz	1.2 % reading + 0.05 dB	Keysight 8902 Measuring Receiver HP 11722A Sensor Module Keysight 11581A Attenuator Set
RF Power Source [1]	(+20 to +24) dBm 10 Hz to 100 kHz 100 kHz 100 kHz to 10 MHz (10 to 128) MHz	 0.03 dB 0.03 dB 0.05 dB 0.05 dB	Fluke 9640 RF Reference Source
RF Power Source [1]	(+14 to +20) dBm 10 Hz to 100 kHz 100 kHz 100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz	 0.03 dB 0.03 dB 0.05 dB 0.05 dB 0.07 dB 0.2 dB	Fluke 9640 RF Reference Source

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Source [1]	(-17 to +14) dBm 10 Hz to 100 kHz 100 kHz 100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz (3 to 4) GHz	 0.03 dB 0.03 dB 0.05 dB 0.05 dB 0.07 dB 0.2 dB 0.3 dB 0.5 dB	Fluke 9640 RF Reference Source
RF Power Source [1]	(-48 to -17) dBm 10 Hz to 100 kHz 100 kHz 100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz (3 to 4) GHz	 0.03 dB 0.03 dB 0.05 dB 0.05 dB 0.07 dB 0.2 dB 0.3 dB 0.5 dB	Fluke 9640 RF Reference Source
RF Power Source [1]	(-74 to -48) dBm 100 kHz 100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz (3 to 4) GHz	 0.2 dB 0.2 dB 0.1 dB 0.1 dB 0.4 dB 0.5 dB 0.5 dB	Fluke 9640 RF Reference Source
RF Power Source [1]	(-84 to -74) dBm 100 kHz 100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz (3 to 4) GHz	 0.5 dB 0.5 dB 0.1 dB 0.3 dB 0.5 dB 1 dB 1 dB	Fluke 9640 RF Reference Source
RF Power Source [1]	(-94 to -84) dBm 100 kHz 100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz	 0.5 dB 0.5 dB 0.3 dB 0.5 dB 1 dB 1 dB	Fluke 9640 RF Reference Source

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Source [1]	(-130 to -94) dBm (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz	 0.7 dB 1.5 dB 1.5 dB 1.5 dB	Fluke 9640 RF Reference Source
RF Power Sensors [1,2]	(-27 to 20) dBm 3.16 µW @ 10 MHz 10 µW @ 10 MHz 31.6 µW @ 10 MHz 100 µW @ 10 MHz 316 µW @ 10 MHz 1 mW @ 10 MHz 1.156 mW @ 10 MHz 10.02 mW @ 10 MHz 31.79 mW @ 10 MHz 101.4 mW @ 10 MHz	 2.4 % reading + 8.1 nW 1.6 % reading + 0.026 µW 1.4 % reading + 0.079 µW 1.4 % reading + 0.26 µW 1.4 % reading + 0.79 µW 1.4 % reading + 2.6 µW 1.4 % reading + 7.9 µW 1.4 % reading + 0.026 mW 1.4 % reading + 0.079 mW 1.4 % reading + 0.26 mW	Agilent E4418B EPM Series Power Meter & 8482A Power Sensor

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers [1]	Up to 8 in (8 to 24) in (24 to 40) in	74 µin 450 µin 510 µin	Gage Blocks, Long Gage Blocks
Depth Micrometer [1]	Up to 8 in (8 to 12) in (12 to 24) in (24 to 40) in	77 µin 100 µin 450 µin 870 µin	Gage Blocks, Surface Plate
Height Gage [1]	Up to 24 in (24 to 40) in	190 µin 310 µin	Gage Blocks, Surface Plate
Indicators [1] (Dial, Digital)	Up to 6 in	63 µin	Gage Blocks, Surface Plate
Micrometer, OD [1]	Up to 1 in (1 to 6) in (6 to 12) in (12 to 24) in (24 to 40) in	42 µin 62 µin 98 µin 200 µin 310 µin	Gage Blocks, Long Gage Blocks
Optical Comparators [1] Linearity Magnification	 Up to 12 in 10x to 200x	 140 µin 590 µin	Glass Scale, Reticle

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure Measuring Instruments [1]	(0.025 to 64) inH_2O	0.02 % of reading	Deadweight Tester
	(0.1 to 30) psia (30 to 1 000) psia	0.008 7 % of reading 0.008 3 % of reading	Pressure Controller
	(9.5 to 500) psig (150 to 5 000) psig	0.016 % of reading 0.015 % of reading	Deadweight Tester
	(-30 to 30) inH_2O (-13.5 to 35) psig	0.044 inH_2O 0.013 psi	Pressure Calibrator
	(-13.5 to 300) psig (-12.5 to 1 000) psig	0.057 psi 0.23 psi	Pressure Calibrator

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	(-40 to 0) °C (0 to 420) °C (420 to 660) °C	0.009 7 °C 0.026 °C 0.033 °C	SPRT, Temperature Indicator
Temperature – Source (Temperature Indicating Probes)	(-34.4 to 93) °C	0.017 °C	SPRT, 8.5 Digit Multimeter, Temperature Indicator, Liquid Bath
Temperature – Source (Temperature Indicating Probes)	(50 to 660) °C	0.066 °C	SPRT, 8.5 Digit Multimeter, Temperature Indicator, Dry Well Calibrator
Thermocouple Probes	(-34.4 to 93) °C	0.47 °C	SPRT, 8.5 Digit Multimeter, Temperature Indicator, Liquid Bath
Thermocouple Probes	(50 to 660) °C	0.47 °C	SPRT, 8.5 Digit Multimeter, Temperature Indicator, Dry Well Calibrator
Temperature Uniformity Surveys [1]	(-34.4 to 93) °C	0.24 °C	RTD, Data Logging System

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Uniformity Surveys [1]	(50 to 660) °C	0.81 °C	Thermocouples, Data Logging System

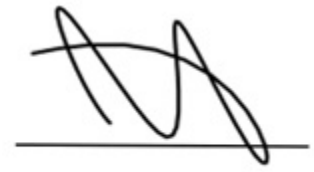
Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source [1]	120 Hz 1.2 kHz 12 kHz 120 kHz 1 200 kHz 2 MHz 100 MHz (Scope Out)	89 nHz/Hz + 3.9 µHz 87 µHz/kHz + 3.9 µHz 87 µHz/kHz + 3.9 µHz 0.56 mHz/kHz + 3.9 µHz 0.52 mHz/kHz + 3.9 µHz 3 Hz/MHz + 3.9 µHz 1.9 Hz/MHz + 0.1 kHz	Multi-Product Calibrator, GPS Receiver, Reference Multimeter
Frequency – Source [1] (Reference)	10 MHz	100 pHz	GPS Receiver
Frequency – Source [1]	600 MHz (Scope Out) 1.1 GHz (Scope Out)	1.9 Hz/MHz + 5.8 kHz 1.9 Hz/MHz + 60 kHz	Multi-Product Calibrator, GPS Receiver
Frequency – Measure [1]	10 Hz to 100 MHz	87 nHz/Hz + 30 nHz	Reference Multimeter, GPS Receiver

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. Uncertainties reported with both a relative and an absolute uncertainty in the format of "mV/V + mV" or "% reading + uW" are computed as the square root of the sum of the squares of the two uncertainty components.
3. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2909.



Jason Stine, Vice President