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.
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Jason Stine, Vice President

Expiry Date: 17 September 2028

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

McHale & Associates, Inc.

4700 Coster Road
Knoxville, TN 37912

Graham Vice
Graham.Vice@mchale.com or support@mchale.com

CALIBRATION

ISO/IEC 17025 Accreditation Granted: **16 September 2026**

Certificate Number: **AC-2909** Certificate Expiry Date: **17 September 2028**

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	Comparison to 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	Comparison to Reference Multimeter
DC High Voltage – Measure [1,2]	Up to 10 kV	0.33 mV/V + 67 mV	Comparison to 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 + 16 nA 78 nA/mA + 48 nA 78 nA/mA + 0.4 µA 78 nA/mA + 4.1 µA 0.16 mA/A + 52 µA 0.29 mA/A + 0.1 mA 0.39 mA/A + 0.7 mA 0.78 mA/A + 2.4 mA	Comparison to Multi-Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source [1,2] (Clamp-on Devices)	(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 + 22 mA 2.6 mA/A + 0.2 A	Comparison to Multi-Product Calibrator with 50-turn Coil
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	Comparison to Reference Multimeter
Resistance – Source [1] (Fixed Artifacts)	25 Ω 100 Ω 200 Ω 400 Ω	0.000 27 Ω 0.001 1 Ω 0.002 1 Ω 0.004 3 Ω	Comparison to Standard Resistors
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	Comparison to Multi-Product Calibrator

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance - Measure [1,2]	Up to 1 Ω	11 μΩ/Ω + 4 μΩ	Comparison to 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	
AC Voltage – Source [1,2]	(1 to 33) mV		Comparison to Multi-Product Calibrator
	(10 to 45) Hz	0.62 μV/mV + 5.4 μV	
	45 Hz to 10 kHz	0.12 μV/mV + 5.5 μV	
	(10 to 20) kHz	0.16 μV/mV + 5 μV	
	(20 to 50) kHz	0.78 μV/mV + 5.5 μV	
	(50 to 100) kHz	2.7 μV/mV + 10 μV	
	(100 to 500) kHz	6.2 μV/mV + 42 μV	
	(33 to 330) mV		
	(10 to 45) Hz	0.23 μV/mV + 6.2 μV	
	45 Hz to 10 kHz	0.11 μV/mV + 6.2 μV	
	(10 to 20) kHz	0.12 μV/mV + 10 μV	
	(20 to 50) kHz	0.27 μV/mV + 13 μV	
	(50 to 100) kHz	0.62 μV/mV + 31 μV	
	(100 to 500) kHz	1.6 μV/mV + 84 μV	
	(0.33 to 3.3) V		
	(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 + 74 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	

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1,2]	(33 to 330) V		Comparison to Multi-Product Calibrator
	(10 to 45) Hz	0.15 mV/V + 7.4 mV	
	45 Hz to 10 kHz	0.16 mV/V + 17 mV	
	(10 to 20) kHz	0.19 mV/V + 13 mV	
	(20 to 50) kHz	0.23 mV/V + 23 mV	
	(50 to 100) kHz	1.6 mV/V + 76 mV	
	(330 to 1 020) V		
	45 Hz to 1 kHz	0.23 mV/V + 29 mV	
	(1 to 5) kHz	0.19 mV/V + 34 mV	
	(5 to 10) kHz	0.23 mV/V + 37 mV	
AC Voltage - Measure [1,2]	Up to 10 mV		Comparison to 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	
	(0.1 to 1) V		
	1 Hz to 2 kHz	0.067 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	

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AC Voltage - Measure [1,2]	(1 to 10) V		Comparison to Reference Multimeter
	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 + 25 mV	
	(2 to 10) kHz	0.1 mV/V + 25 mV	
	(10 to 30) kHz	0.22 mV/V + 25 mV	
	(30 to 100) kHz	0.52 mV/V + 0.1 V	
AC High Voltage – Measure [1,2]	Up to 10 kV		Comparison to 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	

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1,2]	Up to 330 µA		Comparison to Multi-Product Calibrator
	(10 to 20) Hz	1.6 nA/µA + 81 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	
	(33 to 330) mA		
	(10 to 20) Hz	1.4 µA/mA + 45 µA	
	(20 to 45) Hz	0.7 µA/mA + 28 µA	
	45 Hz to 1 kHz	0.31 µA/mA + 63 µA	
	(1 to 5) kHz	0.78 µA/mA + 75 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	

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1,2]	(3 to 11) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.47 mA/A + 1.9 mA 0.78 mA/A + 2.1 mA 23 mA/A + 7.3 mA 0.93 mA/A + 4.7 mA 1.2 mA/A + 5.2 mA 23 mA/A + 16 mA	Comparison to Multi-Product Calibrator
AC Current – Source [1,2] (Clamp-on Devices)	(10 to 16.5) A (45 to 65) Hz (65 to 440) Hz (16.5 to 150) A (45 to 65) Hz (65 to 440) Hz (150 to 1 025) A (45 to 65) Hz (65 to 440) Hz	 2.8 mA/A + 3.3 mA 2.8 mA/A + 25 mA 2.8 mA/A + 91 mA 7.9 mA/A + 6.4 mA 8 mA/A + 0.2 A 8 mA/A + 0.3 A	Comparison to Multi-Product Calibrator with 50-turn Coil
AC Current - Measure [1,2]	Up to 10 µA 1 Hz to 30 kHz (10 to 100) µA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (0.1 to 1) mA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (1 to 10) mA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (10 to 100) mA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz	 2 nA/µA + 2.5 nA 0.27 nA/µA + 5 nA 0.51 nA/µA + 5 nA 0.73 nA/µA + 5 nA 4 nA/µA + 10 nA 0.27 µA/mA + 50 nA 0.51 µA/mA + 50 nA 0.72 µA/mA + 50 nA 4 µA/mA + 0.1 µA 0.27 µA/mA + 0.5 µA 0.51 µA/mA + 0.5 µA 0.72 µA/mA + 0.5 µA 4 µA/mA + 1 µA 0.27 µA/mA + 5 µA 0.5 µA/mA + 5 µA 0.7 µA/mA + 5 µA	Comparison to Reference Multimeter

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AC Current - Measure [1,2]	(0.1 to 1) A 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (1 to 10) A 10 Hz to 10 kHz (10 to 30) A 10 Hz to 2 kHz (2 to 10) kHz	 0.27 mA/A + 0.1 mA 0.51 mA/A + 0.1 mA 0.73 mA/A + 0.1 mA 0.8 mA/A + 0.5 mA 0.8 mA/A + 12 mA 1.2 mA/A + 12 mA	Comparison to Reference Multimeter
Capacitance – Source [1,2]	(0.19 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF 330 nF to 1.1 µF	4.6 pF/nF + 8.4 pF 4 pF/nF + 8.4 pF 3.9 pF/nF + 8.1 pF 1.9 pF/nF + 11 pF 1.9 pF/nF + 7.9 pF 1.9 pF/nF + 74 pF 1.9 pF/nF + 0.2 nF 1.9 nF/µF + 10 nF	Comparison to Multi-Product Calibrator
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 + 3.1 nF 1.9 nF/µF + 10.8 nF 3.1 nF/µF + 32 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 + 25 µF 8.5 µF/mF + 858 µF	Comparison to 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	Comparison to Reference Multimeter

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Instruments – Source	Type B		Comparison to Multi-Product Calibrator
	(600 to 800) °C	0.35 °C	
	(800 to 1 000) °C	0.27 °C	
	(1 000 to 1 550) °C	0.24 °C	
	(1 550 to 1 820) °C	0.26 °C	
	Type C		
	(0 to 150) °C	0.24 °C	
	(150 to 650) °C	0.21 °C	
	(650 to 1 000) °C	0.25 °C	
	(1 000 to 1 800) °C	0.39 °C	
	(1 800 to 2 316) °C	0.65 °C	
	Type E		
	(-250 to -100) °C	0.39 °C	
	(-100 to -25) °C	0.14 °C	
	(-25 to 350) °C	0.13 °C	
	(350 to 650) °C	0.14 °C	
	(650 to 1 000) °C	0.18 °C	
	Type J		
	(-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	

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Instruments – Source	Type R (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (1 000 to 1 767) °C Type S (0 to 200) °C (250 to 1 400) °C (1 400 to 1 767) °C Type T (-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.45 °C 0.28 °C 0.26 °C 0.32 °C 0.37 °C 0.29 °C 0.36 °C 0.49 °C 0.2 °C 0.14 °C 0.13 °C 0.44 °C 0.22 °C	Comparison to Multi-Product Calibrator
Electrical Simulation of RTD Indicating Instruments – Source [1]	Pt 385, 100 Ω (-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C Pt 3926, 100 Ω (-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C Pt 3916, 100 Ω (-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C	 0.039 °C 0.054 °C 0.07 °C 0.078 °C 0.093 °C 0.18 °C 0.039 °C 0.054 °C 0.07 °C 0.078 °C 0.093 °C 0.19 °C 0.031 °C 0.039 °C 0.047 °C 0.054 °C 0.062 °C	Comparison to Multi-Product Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Instruments – Source [1]	Pt 3916, 300 Ω		Comparison to Multi-Product Calibrator
	(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	
	Pt 385, 1 000 Ω		
	(-200 to 0) °C	0.026 °C	
	(0 to 100) °C	0.033 °C	
	(100 to 260) °C	0.04 °C	
	(260 to 300) °C	0.048 °C	
	(300 to 600) °C	0.056 °C	
	(600 to 630) °C	0.18 °C	
	PtNi 385, 120 Ω		
	(-80 to 100) °C	0.062 °C	
	(100 to 260) °C	0.11 °C	
	Cu 427, 10 Ω		
	(-100 to 260) °C	0.23 °C	

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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	 1.7 µA/mA + 0.2 mA 3.1 µA/mA + 0.31 mA 0.7 mA/A + 3.2 µA 0.31 mA/A + 3.2 µA 0.31 mA/A + 3.1 µmA 0.62 mA/A + 3.1 µmA	Comparison to 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 + 58 mW 0.29 mW/W + 0.6 W 0.78 mW/W + 5.8 W	Comparison to 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 + 21 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	Comparison to Multi-Product Calibrator
AC Power- Source [1,2]	330 mV to 1 020 V (3.3 to 9) mA (9 to 90) mA (90 to 330) mA (330 to 900) mA 900 mA to 4.5 A (4.5 to 20.5) A	 0.23 mW/W + 7.8 mW 0.23 mW/W + 9.7 mW 0.23 mW/W + 60 mW 0.45 mW/W + 60 mW 0.52 mW/W + 0.6 W 0.96 W/W + 5.8 W	Comparison to Multi-Product Calibrator
Phase – Source [1,2]	(0 to 360)° (10 to 65) Hz (65 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	 0.083° 0.19° 0.39° 1.9° 3.9° 7.8°	Comparison to Multi-Product Calibrator

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1,2]			Comparison to Multi-Product Calibrator
DC Voltage			
into 50 Ω load	(1 to 109.99) mV	1.9 µV/mV + 32 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 + 32 µV	
	(25 to 109.99) mV	0.39 µV/V + 35 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	
into 1 MΩ load	(1 to 24.999) mV	0.81 µV/mV + 47 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 + 14 mV	
	(11 to 130) V	0.79 mV/V + 0.2 V	

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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1,2]			Comparison to Multi-Product Calibrator
Leveled Sine Wave – Voltage	5.5 mVp-p to 5.5 Vp-p		
	Up to 50 kHz	19 mV/V + 0.62 mV	
	50 kHz to 100 MHz	28 mV/V + 0.62 mV	
	(100 to 300) MHz	31 mV/V + 0.62 mV	
	(300 to 600) MHz	47 mV/V + 0.62 mV	
	5.5 mVp-p to 3.5 Vp-p		
	600 MHz to 1.1 GHz	54 mV/V + 0.64 mV	
Time Markers	(1 to 5) ns	1.9 fs/ns + 0.6 ps	
	10 ns	1.9 fs/ns + 0.6 ps	
	(20 to 50) ns	1.9 fs/ns + 5.8 ps	
	(0.1 to 20) ms	25 ns/ms + 5.8 µs	
	50 ms to 5 s	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	
into 1 MΩ load	1.8 mVp-p to 55 Vp-p	23 mV/V + 80 µV	
Pulse Generator – Width	(4 to 45) ns	39 ps/ns + 1.6 ns	
	(45 to 500) 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	0.78 mΩ/Ω + 6 mΩ	
	(0.5 to 1.5) MΩ	0.78 kΩ/MΩ + 60 Ω	
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]	(0 to 33) dBm	0.04 dB	Comparison to RF Reference Source
Relative to +16 dBm	(33 to 64) dBm	0.04 dB	
100 kHz to 128 MHz	(64 to 100) dBm	0.1 dB	
	(100 to 116) dBm	0.2 dB	

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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Level Sine Spurious Signal Content	(2.1 to 3.6) GHz (3.8 to 4) GHz	0.6 dB 1 dB	Comparison to Fluke 9640 RF Reference Source
Level Sine Harmonic Distortion 24 dBm Power Reference	20 kHz to 125 MHz	0.6 dB	Comparison to Fluke 9640 RF Reference Source
Level Sine Harmonic Distortion 20 dBm Power Reference	250 MHz to 1.4 GHz	0.6 dB	Comparison to Fluke 9640 RF Reference Source
Level Sine Harmonic Distortion 14 dBm Power Reference	(1.45 to 2.7) GHz 4.024 GHz	0.6 dB 1 dB	Comparison to Fluke 9640 RF Reference Source
AM Modulation Rate Accuracy 30 MHz Carrier Signal Modulation Depth: 50%	Modulation Rate: 20 kHz Modulation Rate: 100 kHz	0.05 Hz/kHz + 58 mHz 0.1 Hz/kHz + 58 mHz	Comparison to Fluke 9640 RF Reference Source
AM Depth Accuracy 125 MHz Carrier Signal	1 kHz Modulation Rate	10 Hz/kHz + 7.5 Hz	Comparison to Fluke 9640 RF Reference Source
AM Depth Accuracy 125 MHz Carrier Signal	100 kHz Modulation Rate	15 Hz/kHz + 750 Hz	Comparison to Fluke 9640 RF Reference Source
AM Depth Accuracy 1 GHz Carrier Signal	1 kHz Modulation Rate	10 Hz/kHz + 7.5 Hz	Comparison to Fluke 9640 RF Reference Source
AM Depth Accuracy 1 GHz Carrier Signal	20 kHz Modulation Rate	15 Hz/kHz + 150 Hz	Comparison to Fluke 9640 RF Reference Source
AM Distortion	Modulation Depth (10 to 80) %	0.06 dB	Comparison to Fluke 9640 RF Reference Source
FM Modulation Rate Accuracy	Modulation Rate 400 Hz 10 kHz 100 kHz 300 kHz	0.28 mHz/Hz + 0.059 Hz 0.1 Hz/kHz + 1 Hz 0.1 Hz/kHz + 10 Hz 0.03 Hz/kHz + 10 Hz	Comparison to Fluke 9640 RF Reference Source
FM Deviation Accuracy	Modulation Rate 400 Hz to 300 kHz	10 Hz/kHz + 0.2 Hz	Comparison to Fluke 9640 RF Reference Source
FM Distortion	Modulation Rate 400 Hz to 300 kHz	0.02 dB	Comparison to Fluke 9640 RF Reference Source
Level Sine Phase Noise	Offset Frequency 1 kHz to 10 MHz	2.1 dB	Comparison to Fluke 9640 RF Reference Source

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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 (1.30 to 2) GHz (2 to 6) GHz (6 to 10) GHz (10 to 14) GHz (14 to 18) GHz (18 to 22) GHz (22 to 26.5) GHz	46 mrad/rad + 0.5 rad 35 mrad/rad + 0.5 rad 44 mrad/rad + 0.5 rad 45 mrad/rad + 0.5 rad 48 mrad/rad + 0.5 rad 52 mrad/rad + 0.5 rad 54 mrad/rad + 0.5 rad 55 mrad/rad + 0.5 rad 58 mrad/rad + 0.5 rad	Comparison to Keysight 8902 Measuring Receiver, Keysight 11793A Microwave Converter, HP 11729A Sensor Module, HP 8340B Sweeper
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 (1.3 to 26.5) GHz Rate: DC to 100 kHz	23 Hz/kHz + 12 Hz 12 Hz/kHz + 12 Hz 35 Hz/kHz + 12 Hz 64 Hz/kHz	Comparison to Keysight 8902 Measuring Receiver, Keysight 11793A Microwave Converter, HP 11729A Sensor Module, HP 8340B Sweeper
AM Modulation Flatness [1,2]	10 MHz to 26.5 GHz Rate: 90 Hz to 10 kHz 1.3 GHz to 14 GHz Rate: 90 Hz to 10 kHz 14 GHz to 26.5 GHz Rate: 90 Hz to 10 kHz	3.5 Hz/kHz + 12 Hz 27 Hz/kHz 38 Hz/kHz	Comparison to Keysight 8902 Measuring Receiver, Keysight 11793A Microwave Converter, HP 11729A Sensor Module, HP 8340B Sweeper
FM Modulation [1,2]	250 kHz-10 MHz Rate: 20 Hz to 10 kHz 10 MHz-1.3 GHz Rate: 50 Hz to 100 kHz 10 MHz to 26.5 GHz Rate: 20 Hz to 200 kHz	23 Hz/kHz + 1.2 Hz 12 kHz/MHz + 1.2 Hz 100 kHz/MHz	Comparison to Keysight 8902 Measuring Receiver, Keysight 11793A Microwave Converter, HP 11729A Sensor Module, HP 8340B Sweeper
Pulse Generation [1]	DC to 350 MHz 2.8 ns to 1 000 sec	0.4 ns	Comparison to Agilent 53220A Counter

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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1,2]	(-20 to 30) dBm 0.1 MHz to 2.5 GHz 2.5 MHz to 14 GHz 14 MHz to 26.5 GHz	 1.2 Hz/kHz + 0.05 dB 27 Hz/kHz + 0.05 dB 38 Hz/kHz + 0.05 dB	Comparison to Keysight 8902 Measuring Receiver, HP 11722A Sensor Module, Keysight 11581A Attenuator Set, Keysight 11581A Attenuator Set, Keysight 11793A Microwave Converter, HP 11729A Sensor Module
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper

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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper
RF Power Amplitude [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	Comparison to Fluke 9640 RF Reference Source, HP 8340B Sweeper
RF Power Source [1]	(-110 to 20) dBm 10 MHz to 26.5 GHz	 0.9 dB	Comparison to HP 8340B Sweeper
RF Power Sensors [1,2]	(-60 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 + 26 µW 1.4 % reading + 79 µW 1.4 % reading + 0.26 mW	Comparison to Agilent E4418B EPM Series Power Meter & 8482A, HP 8485A Power Sensor
Harmonic Distortion	100 kHz to 1.5 GHz	1.4 dB	Comparison to ESA-L1500A Spectrum Analyzer

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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	Comparison to 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	Comparison to Gage Blocks, Surface Plate
Height Gage [1]	Up to 24 in (24 to 40) in	190 µin 310 µin	Comparison to Gage Blocks, Surface Plate
Indicators [1] (Dial, Digital)	Up to 1 in (1 to 6) in	42 µin 63 µin	Comparison to 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	Comparison to Gage Blocks, Long Gage Blocks
Optical Comparators [1] Linearity Magnification	 Up to 12 in 10x to 200x	 141 µin 588 µin	Comparison to Glass Scale, Magnification Reticle, Magnification Checker

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	Comparison to Deadweight Tester
	(0.1 to 30) psia (30 to 1 000) psia	0.011 % of reading 0.008 3 % of reading	Comparison to Pressure Controller
	(9.5 to 500) psig (150 to 5 000) psig	0.016 % of reading 0.015 % of reading	Comparison to Deadweight Tester
	(-30 to 30) inH_2O (-13.5 to 35) psig	0.044 inH_2O 0.013 psi	Comparison to Pressure Calibrator
	(-13.5 to 300) psig (-12.5 to 1 000) psig	0.057 psi 0.23 psi	Comparison to Pressure Calibrator
Air Velocity Measuring Instruments	(500 to 4 500) fpm	0.33 % of reading + 0.04 fpm	Comparison to Precision Manometer, Wind Tunnel

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Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	(-200 to -40) °C (-40 to 0) °C (0 to 420) °C (420 to 660) °C	0.01 °C 0.007 2 °C 0.026 °C 0.033 °C	Comparison to SPRT, Temperature Indicator
Temperature – Source [1] (Temperature Indicating Probes)	(-40 to 95) °C	0.014 °C	Comparison to SPRT, 8.5 Digit Multimeter, Temperature Indicator, Liquid Bath
Temperature – Source [1] (Temperature Indicating Probes)	(50 to 660) °C	0.018 °C	Comparison to SPRT, 8.5 Digit Multimeter, Temperature Indicator, Dry Well Calibrator
Temperature Uniformity Surveys [1]	(-34.4 to 93) °C	0.24 °C	Comparison to RTD, Data Logging System
Temperature Uniformity Surveys [1]	(50 to 660) °C	0.81 °C	Comparison to Thermocouples, Data Logging System

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source [1]	10 mHz to 100 kHz 120 Hz to 2 MHz	87 nHz/Hz + 30 nHz 1.9 Hz/MHz + 0.1 kHz	Comparison to Multi-Product Calibrator, GPS Receiver, Reference Multimeter
Level Sine Wave Frequency – Source	10 kHz 1 MHz to 1.006 GHz (2 to 4.024) GHz	0.002×10^{-6} of reading + 0.6 mHz 0.002×10^{-6} of reading + 0.2 mHz 0.01×10^{-6} of reading + 5.8 mHz	Comparison to Fluke 9640 RF Reference Source
Frequency – Source [1] (Reference)	10 MHz	1 pHz	Comparison to GPS Receiver
Frequency – Source [1] (Oscilloscopes)	600 MHz 1.1 GHz	1.9 Hz/MHz + 5.8 kHz 1.9 Hz/MHz + 60 kHz	Comparison to Multi-Product Calibrator, GPS Receiver

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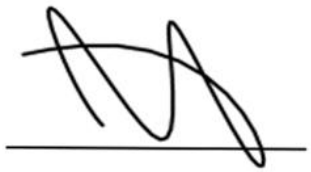
Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure [1]	10 Hz to 6 GHz	87 nHz/Hz + 30 nHz	Comparison to Reference Multimeter, Keysight 53220A Universal Counter, 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.



Jason Stine, Vice President

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