



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**E2b Calibration, LLC**  
9325 Progress Parkway, Suite B  
Mentor, OH 44060

Fulfills the requirements of

**ISO/IEC 17025:2017**

and national standard

**ANSI/NCSL Z540-1-1994 (R2002)**

In the field of

**CALIBRATION**

This certificate is valid only when accompanied by a current scope of accreditation document.  
The current scope of accreditation can be verified at [www.anab.org](http://www.anab.org).

A handwritten signature in black ink, appearing to read 'R. Douglas Leonard Jr.', is positioned above a horizontal line.

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 23 February 2023

Certificate Number: AC-1287



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)**

**E2b Calibration, LLC**

9325 Progress Parkway, Suite B

Mentor, OH 44060

Kyle Pillar 440-352-4700

Email: kpillar@e2bcal.com Website: www.e2bcal.com

**CALIBRATION**

Valid to: **February 23, 2023**

Certificate Number: **AC-1287**

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure <sup>1,3</sup>	Up to 100 mV	1.5 $\mu$ V	HP 3458A Opt 002 8.5 Digit Multimeter
	(0.1 to 1) V	13 $\mu$ V	
	(1 to 10) V	45 $\mu$ V	
	(10 to 100) V	1.1 mV	
	(100 to 300) V	8.7 mV	
	(300 to 500) V	13 mV	
	(500 to 700) V (700 to 1 000) V	18 mV 24 mV	
DC Voltage – Measure <sup>1,3</sup>	(1 to 10) kV	1.7 V/kV + 0.1 V	Ross VD15 Voltage Divider, HP 34401A 6.5 Digit Multimeter
	(10 to 60) kV	1.6 V/kV + 0.2 V	Ross VD60 Voltage Divider, HP34401A 6.5 Digit Multimeter
	(60 to 141) kV	1.8 V/kV + 8.8 V	Ross VMP200 Voltage Divider, Fluke 187 Digital Multimeter
DC Voltage – Source <sup>1,3,5</sup>	Up to 330 mV	12 $\mu$ V/V + 1 $\mu$ V	Fluke 5522A Multiproduct Calibrator
	(0.33 to 3.3) V	7 $\mu$ V/V + 2 $\mu$ V	
	(3.3 to 33) V	8 $\mu$ V/V + 15 $\mu$ V	
	(33 to 330) V	12 $\mu$ V/V + 0.12 mV	
	(330 to 1 020) V	11 $\mu$ V/V + 1.3 mV	



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure <sup>1,3</sup>	Up to 100 $\mu$ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	4.3 nA 39 nA 0.39 $\mu$ A 5.6 $\mu$ A 0.15 mA	HP 3458A Opt 002 8.5 Digit Multimeter
DC Current – Measure <sup>1,3</sup>	(1 to 14) A (14 to 30) A	1.5 mA 2.1 mA	HP 3458A Opt 002 8.5 Digit Multimeter, IET DCCS-0.01 and DCCS-0.001 Shunts
DC Current – Source <sup>1,3,5</sup>	Up to 330 $\mu$ A 330 $\mu$ A to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	94 $\mu$ A/A + 20 nA 62 $\mu$ A/A + 50 nA 64 $\mu$ A/A + 0.19 $\mu$ A 64 $\mu$ A/A + 1.9 $\mu$ A 0.13 mA/A + 30 $\mu$ A 0.24 mA/A + 30 $\mu$ A 0.31 mA/A + 0.36 mA 0.7 mA/A – 0.18 mA	Fluke 5522A Multiproduct Calibrator
AC Voltage – Measure <sup>1,3</sup>	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 4) MHz (10 to 100) mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz (2 to 8) MHz (8 to 10) MHz	9.8 $\mu$ V 6.6 $\mu$ V 7.7 $\mu$ V 17 $\mu$ V 62 $\mu$ V 0.47 mV 0.16 mV 0.17 mV 15 $\mu$ V 13 $\mu$ V 21 $\mu$ V 40 $\mu$ V 97 $\mu$ V 0.37 mV 1.2 mV 1.9 mV 4.8 mV 18 mV	HP 3458A Opt 002 8.5 Digit Multimeter

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure <sup>1,3</sup>	(0.1 to 1) V		HP 3458A Opt 002 8.5 Digit Multimeter
	(1 to 40) Hz	0.15 mV	
	40 Hz to 1 kHz	0.12 mV	
	(1 to 20) kHz	0.21 mV	
	(20 to 50) kHz	0.39 mV	
	(50 to 100) kHz	0.97 mV	
	(100 to 300) kHz	3.7 mV	
	300 kHz to 1 MHz	12 mV	
	(1 to 2) MHz	19 mV	
	(2 to 8) MHz	48 mV	
	(8 to 10) MHz	0.18 V	
	(1 to 10) V		
	(1 to 40) Hz	2.5 mV	
	40 Hz to 1 kHz	1.2 mV	
	(1 to 20) kHz	2.1 mV	
	(20 to 50) kHz	3.9 mV	
	(50 to 100) kHz	9.7 mV	
	(100 to 300) kHz	37 mV	
300 kHz to 1 MHz	0.12 V		
(1 to 2) MHz	0.18 V		
(2 to 8) MHz	0.48 V		
(8 to 10) MHz	1.8 V		
(10 to 100) V			
40 Hz to 20 kHz	28 mV		
(20 to 50) kHz	45 mV		
(50 to 100) kHz	0.15 V		
(100 to 1 000) V			
40 Hz to 1 kHz	0.46 mV/V + 39 mV		
(1 to 20) kHz	0.73 mV/V + 0.75 mV		
AC Voltage – Measure <sup>1</sup>	(1 to 10) kV 60 Hz	7.2 V/kV + 2.9 V	Ross VD15 Voltage Divider, HP 34401A 6.5 Digit Multimeter
	(10 to 42) kV 60 Hz	6.2 V/kV + 7.9 V	Ross VD60 Voltage Divider, HP 34401A 6.5 Digit Multimeter
	(42 to 106) kV 60 Hz	16 V/kV + 6 V	Ross VMP200 Voltage Divider, Fluke 187 Digital Multimeter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1,3,5</sup>	Up to 33 mV		Fluke 5522A Multiproduct Calibrator
	(10 to 45) Hz	0.46 mV/V + 5 μV	
	45 Hz to 10 kHz	94 μV/V + 5 μV	
	(10 to 20) kHz	0.13 mV/V + 5 μV	
	(20 to 50) kHz	0.65 mV/V + 5 μV	
	(50 to 100) kHz	2.4 mV/V + 10 μV	
	(100 to 500) kHz	4.9 mV/V + 40 μV	
	(33 to 330) mV		
	(10 to 45) Hz	0.2 mV/V + 7 μV	
	45 Hz to 10 kHz	0.11 mV/V + 7 μV	
	(10 to 20) kHz	0.12 mV/V + 8 μV	
	(20 to 50) kHz	0.23 mV/V + 8 μV	
	(50 to 100) kHz	0.47 mV/V + 25 μV	
	(100 to 500) kHz	1.3 mV/V + 55 μV	
	330 mV to 3.3 V		
	(10 to 45) Hz	0.2 mV/V + 45 μV	
	45 Hz to 10 kHz	0.11 mV/V + 47 μV	
	(10 to 20) kHz	0.13 mV/V + 46 μV	
	(20 to 50) kHz	0.2 mV/V + 45 μV	
	(50 to 100) kHz	0.43 mV/V + 0.11 mV	
	(100 to 500) kHz	1.6 mV/V + 0.48 mV	
	(3.3 to 33) V		
	(10 to 45) Hz	0.2 mV/V + 0.55 mV	
	45 Hz to 10 kHz	0.1 mV/V + 0.47 mV	
(10 to 20) kHz	0.17 mV/V + 0.53 mV		
(20 to 50) kHz	0.24 mV/V + 0.51 mV		
(50 to 100) kHz	0.6 mV/V + 1.3 mV		
(33 to 330) V			
45 Hz to 1 kHz	0.12 mV/V + 1.6 mV		
(1 to 10) kHz	0.13 mV/V + 4.7 mV		
(10 to 20) kHz	0.17 mV/V + 5.3 mV		
(20 to 50) kHz	0.19 mV/V + 4.7 mV		
(50 to 100) kHz	1.3 mV/V + 39 mV		
330 V to 1.02 kV			
45 Hz to 1 kHz	0.21 mV/V + 4 mV		
(1 to 5) kHz	0.17 mV/V + 5 mV		
(5 to 10) kHz	0.21 mV/V + 4 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source <sup>1,3,5</sup>	(29 to 330) $\mu$ A		Fluke 5522A Multiproduct Calibrator
	(10 to 20) Hz	0.13 % of reading + 0.09 $\mu$ A	
	(20 to 45) Hz	0.13 % of reading + 0.08 $\mu$ A	
	45 Hz to 1 kHz	0.08 % of reading + 0.09 $\mu$ A	
	(1 to 5) kHz	0.13 % of reading + 0.08 $\mu$ A	
	(5 to 10) kHz	0.47 % of reading + 0.16 $\mu$ A	
	(10 to 30) kHz	0.94 % of reading + 0.31 $\mu$ A	
	(0.33 to 3.3) mA		
	(10 to 20) Hz	0.13 % of reading + 0.12 $\mu$ A	
	(20 to 45) Hz	0.08 % of reading + 0.11 $\mu$ A	
	45 Hz to 1 kHz	0.07 % of reading + 0.12 $\mu$ A	
	(1 to 5) kHz	0.13 % of reading + 0.15 $\mu$ A	
	(5 to 10) kHz	0.33 % of reading + 0.19 $\mu$ A	
	(10 to 30) kHz	0.63 % of reading + 0.49 $\mu$ A	
	(3.3 to 33) mA		
	(10 to 20) Hz	0.12 % of reading + 1.6 $\mu$ A	
	(20 to 45) Hz	0.06 % of reading + 1.6 $\mu$ A	
	45 Hz to 1 kHz	0.03 % of reading + 1.6 $\mu$ A	
	(1 to 5) kHz	0.054 % of reading + 1.5 $\mu$ A	
	(5 to 10) kHz	0.13 % of reading + 2.3 $\mu$ A	
	(10 to 30) kHz	0.25 % of reading + 3.7 $\mu$ A	
	(33 to 330) mA		
	(10 to 20) Hz	0.12 % of reading + 16 $\mu$ A	
	(20 to 45) Hz	0.06 % of reading + 16 $\mu$ A	
	45 Hz to 1 kHz	0.03 % of reading + 16 $\mu$ A	
	(1 to 5) kHz	0.065 % of reading + 39 $\mu$ A	
	(5 to 10) kHz	0.13 % of reading + 78 $\mu$ A	
	(10 to 30) kHz	0.25 % of reading + 0.16 mA	
(0.33 to 1.1) A			
(10 to 45) Hz	0.13 % of reading + 70 $\mu$ A		
45 Hz to 1 kHz	0.028 % of reading + 90 $\mu$ A		
(1 to 5) kHz	0.4 % of reading + 0.76 mA		
(5 to 10) kHz	1.6 % of reading + 4 mA		
(1.1 to 3) A			
(10 to 45) Hz	0.12 % of reading + 0.1 mA		
45 Hz to 1 kHz	0.042 % of reading + 50 $\mu$ A		
(1 to 5) kHz	0.42 % of reading + 0.5 mA		
(5 to 10) kHz	1.6 % of reading + 4.4 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 <sup>1,3,5</sup>	(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	0.04 % of reading + 1.6 mA 0.062 % of reading + 1.6 mA 2 % of reading  0.071 % + 5.6 mA 0.11 % + 3.3 mA 2 % of reading	Fluke 5522A Multiproduct Calibrator
AC Current – Measure <sup>1,3</sup>	Up to 100 µA (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 (0.1 to 1) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.5 µA 0.21 µA 0.11 µA  4.9 µA 1.8 µA 0.74 µA 0.41 µA  49 µA 18 µA 7.4 µA 4.1 µA  0.49 mA 0.18 mA 73 µA 40 µA  4.9 mA 1.9 mA 1 mA 1.3 mA	HP 3458A Opt 002 8.5 Digit Multimeter
AC Current – Measure <sup>1,3</sup>	(1 to 3) A 60 Hz 400 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	0.8 mA 1.2 mA 1.4 mA 1.1 mA 1.4 mA 7.2 mA 8.2 mA	HP 3458A Opt 002 8.5 Digit Multimeter, Precision Measurements 9810 Current Shunt

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure <sup>1,3</sup>	(3 to 10) A		HP 3458A Opt 002 8.5 Digit Multimeter, Precision Measurements 9810 Current Shunt
	60 Hz	5.5 mA	
	400 Hz	6.3 mA	
	1 kHz	6.7 mA	
	10 kHz	9.4 mA	
	20 kHz	9.7 mA	
	50 kHz	29 mA	
	100 kHz	48 mA	
	(10 to 30) A		
	60 Hz	7.5 mA	
	400 Hz	12 mA	
	1 kHz	14 mA	
	10 kHz	11 mA	
	20 kHz	14 mA	
50 kHz	72 mA		
100 kHz	82 mA		
AC Current – Measure <sup>1,3</sup>	(30 to 50) A		HP 3458A Opt 002 8.5 Digit Multimeter, Precision Measurements 9830 Current Shunt
	60 Hz	18 mA	
	400 Hz	19 mA	
	1 kHz	20 mA	
	10 kHz	28 mA	
	20 kHz	31 mA	
	50 kHz	0.13 A	
	100 kHz	0.17 A	
Inductance – Source <sup>1</sup>	50 $\mu$ H	0.32 $\mu$ H	GenRad Fixed Inductors
	1 mH	2 $\mu$ H	
	5 H	0.014 H	
Inductance – Measure <sup>1</sup>	100 $\mu$ H to 1 mH	0.2 nH	GenRad 1689 RLC Bridge
	(1 to 10) mH	2.4 $\mu$ H	
	(10 to 100) mH	2.4 $\mu$ H	
	100 mH to 1 H	0.24 mH	
	(1 to 10) H	2.4 mH	
Capacitance – Measure <sup>1</sup>	Up to 1 nF	0.2 pF	GenRad 1689 RLC Bridge
	(1 to 10) nF	2.4 pF	
	(10 to 100) nF	24 pF	
	(0.1 to 1) $\mu$ F	0.24 nF	
	(1 to 1.111) $\mu$ F	0.29 nF	





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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source <sup>1,3,5</sup> 10 Hz to 10 kHz 10 Hz to 3 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz (10 to 120) Hz (10 to 80) Hz (10 to 50) Hz (10 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	220 pF to 1.1 nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (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 (11 to 33) mF (33 to 110) mF	0.32 % of reading + 8 pF 0.32 % of reading + 8 pF 0.15 % of reading + 9 pF 0.15 % of reading + 79 pF 0.15 % of reading + 0.24 pF 0.15 % of reading + 0.81 nF 0.15 % of reading + 2.4 nF 0.15 % of reading + 9 nF 0.23 % of reading + 25 nF 0.27 % of reading + 81 nF 0.27 % of reading + 0.24 μF 0.27 % of reading + 0.81 μF 0.27 % of reading + 2.4 μF 0.27 % of reading + 8.1 μF 0.58 % of reading + 20 μF 0.97 % of reading + 44 μF	Fluke 5522A Multiproduct Calibrator
DC Resistance – Source <sup>1,3,5</sup>	Up to 11 Ω (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 (0.33 to 1.1) GΩ	29 μΩ/Ω + 0.8 mΩ 19 μΩ/Ω + 1.2 mΩ 17 μΩ/Ω + 1.2 mΩ 17 μΩ/Ω + 1.6 mΩ 18 μΩ/Ω + 1.4 mΩ 18 μΩ/Ω + 16 mΩ 18 μΩ/Ω + 14 mΩ 18 μΩ/Ω + 0.16 Ω 18 μΩ/Ω + 0.14 Ω 20 μΩ/Ω + 1.6 Ω 20 μΩ/Ω + 1.6 Ω 33 μΩ/Ω + 22 Ω 86 μΩ/Ω + 40 Ω 0.16 mΩ/Ω + 2 kΩ 0.32 mΩ/Ω + 2.3 kΩ 2 mΩ/Ω + 76 kΩ 9.8 mΩ/Ω + 0.3 MΩ	Fluke 5522A Multiproduct Calibrator



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance – Measure <sup>1,3</sup>	Up to 10 Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ	0.36 mΩ 2.7 mΩ 19 mΩ 0.19 Ω 2 Ω 30 Ω 0.85 kΩ 64 kΩ	HP 3458A Opt 002 8.5 Digit Multimeter
AC Resistance – Measure <sup>1,3</sup>	60 Hz 8 mΩ 23 mΩ	1.7 μΩ 4.2 μΩ	Precision Measurements 9810/9830 Shunts
Oscilloscopes <sup>1,2,3</sup> Amplitude – DC into 50 Ω load into 1 MΩ load  Amplitude – Square Wave into 50 Ω load into 1 MΩ load  Leveled Sine Wave Amplitude (relative to 50 kHz)  Flatness  Time Marker  Rise Time	(-6.6 to 6.6) V (-130 to 130) V  1 mVp-p to 6.6 Vp-p 1 mVp-p to 130 Vp-p  5 mVp-p to 5.5 Vp-p 50 kHz 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 600 MHz to 1.1 GHz  50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 600 MHz to 1.1 GHz  2 ns to 20 ms 50 ms to 5 s  ≤ 300 ps	6.5 mV/V + 40 μV 6 mV/V + 40 μV  6.5 mV/V + 40 μV 6.1 mV/V + 40 μV  20 mV/V + 0.3 mV 35 mV/V + 0.3 mV 40 mV/V + 0.3 mV 60 mV/V + 0.3 mV 70 mV/V + 0.3 mV  16 mV/V + 0.1 mV 21 mV/V + 0.1 mV 40 mV/V + 0.1 mV 50 mV/V + 0.1 mV  2.5 μs/s (2 500 + 1 000t) μs  +0/-100 ps	Fluke 5522A/SC1100 Multiproduct Calibrator



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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 Devices – Source/Measure <sup>1,3,5</sup>	Type B		Fluke 5522A Multiproduct Calibrator
	(600 to 800) °C	0.33 °C	
	(800 to 1 000) °C	0.27 °C	
	(1 000 to 1 550) °C	0.24 °C	
	(1 550 to 1 820) °C	0.18 °C	
	Type C		
	(0 to 150) °C	0.18 °C	
	(150 to 650) °C	0.15 °C	
	(650 to 1 000) °C	0.18 °C	
	(1 000 to 1 800) °C	0.3 °C	
	(1 800 to 2 316) °C	0.49 °C	
	Type E		
	(-250 to -100) °C	0.3 °C	
	(-100 to -25) °C	0.1 °C	
	(-25 to 350) °C	0.08 °C	
	(350 to 650) °C	0.1 °C	
	(650 to 1 000) °C	0.13 °C	
	Type J		
	(-210 to -100) °C	0.16 °C	
	(-100 to -30) °C	0.1 °C	
	(-30 to 150) °C	0.08 °C	
	(150 to 760) °C	0.11 °C	
	(760 to 1 200) °C	0.14 °C	
	Type K		
(-200 to -100) °C	0.2 °C		
(-100 to -25) °C	0.11 °C		
(-25 to 120) °C	0.1 °C		
(120 to 1 000) °C	0.15 °C		
(1 000 to 1 372) °C	0.24 °C		
Type L			
(-200 to -100) °C	0.29 °C		
(-100 to 800) °C	0.21 °C		
(800 to 900) °C	0.14 °C		
Type N			
(-200 to -100) °C	0.24 °C		
(-100 to -25) °C	0.14 °C		
(-25 to 120) °C	0.12 °C		
(120 to 410) °C	0.11 °C		
(410 to 1 300) °C	0.17 °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 Devices – Source/Measure <sup>1,3,5</sup>	Type R (0 to 250) °C	0.38 °C	Fluke 5522A Multiproduct Calibrator
	(250 to 400) °C	0.22 °C	
	(400 to 1 000) °C	0.21 °C	
	(1 000 to 1 767) °C	0.24 °C	
	Type S (0 to 250) °C	0.37 °C	
	(250 to 1 000) °C	0.24 °C	
	(1 000 to 1 400) °C	0.22 °C	
	(1 400 to 1 767) °C	0.27 °C	
	Type T (-250 to -150) °C	0.38 °C	
	(-150 to 0) °C	0.14 °C	
	(0 to 120) °C	0.1 °C	
	(120 to 400) °C	0.08 °C	
Type U (-200 to 0) °C	0.44 °C		
(0 to 600) °C	0.21 °C		
Phase Angle – Source <sup>1,3,5</sup>	Up to 360°		Fluke 5522A Multiproduct Calibrator
	(10 to 65) Hz	0.08°	
	(65 to 500) Hz	0.2°	
	500 Hz to 1 kHz	0.39°	
	(1 to 5) kHz	2°	
	(5 to 10) kHz	3.9°	
(10 to 30) kHz	7.8°		

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure <sup>1,3,4</sup> Up to 26.5 GHz	(-70 to -30) dBm		Agilent 4418B with 8485D Sensor
	50 MHz to 8 GHz	0.15 dB	
	(8 to 20) GHz	0.2 dB	
	(20 to 26.5) GHz	0.22 dB	Agilent 4418B with 8482A/8485A Sensors
	(-30 to +10) dBm		
	100 kHz to 2.5 GHz	0.04 dB	
	(2.5 to 4.2) GHz	0.09 dB	
	(4.2 to 13) GHz	0.12 dB	
	(13 to 18) GHz	0.14 dB	
	(18 to 26.5) GHz	0.16 dB	

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure <sup>1,3,4</sup>	(10 to 20) dBm 100 kHz to 2.5 GHz (2.5 to 4.2) GHz (4.2 to 13) GHz (13 to 18) GHz (18 to 26.5) GHz	0.16 dB 0.16 dB 0.18 dB 0.19 dB 0.21 dB	Agilent 4418B with 8482A/8485A Sensors
Amplitude Modulation – Measure <sup>1</sup>	(5 to 99) % Depth 150 kHz to 10 MHz 10 MHz to 1.3 GHz	2.4 % Depth 1.2 % Depth	HP 8902A Measuring Receiver
Frequency Modulation – Measure <sup>1</sup>	(5 to 99) % Deviation 150 kHz to 10 MHz 10 MHz to 1.3 GHz	2.4 % of reading 1.2 % of reading	HP 8902A Measuring Receiver
Phase Modulation – Measure <sup>1</sup>	(5 to 99) % Deviation 150 kHz to 10 MHz 10 MHz to 1.3 GHz	3.6 % of reading 3.6 % of reading	
Tuned RF Level Attenuation – Measure <sup>1,4</sup>	2.5 MHz to 1.3 GHz (-10 to 0) dBm (-20 to -10) dBm (-30 to -20) dBm (-40 to -30) dBm (-50 to -40) dBm (-60 to -50) dBm (-70 to -60) dBm (-80 to -70) dBm (-90 to -80) dBm (-100 to -90) dBm (-120 to -100) dBm	0.04 dB 0.05 dB 0.07 dB 0.08 dB 0.1 dB 0.11 dB 0.13 dB 0.15 dB 0.16 dB 0.18 dB 0.19 dB	HP 8902A Measuring Receiver with HP 11722A Power Sensor
Harmonics – Measure <sup>1</sup>	DC Coupled (-80 to 0) dB 30 Hz to 6.5GHz	2.1 dB	HP 8561E Spectrum Analyzer
	AC Coupled (-80 to 0) dB 100 kHz to 6.5 GHz	2.4 dB	
AM Distortion – Measure <sup>1</sup>	(-80 to 0) dB 20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	HP 8903B Audio Analyzer
FM Distortion – Measure <sup>1</sup>	(-80 to 0) dB 20Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	

### Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers <sup>1,2</sup> (OD, ID, Depth, Step)	Up to 6 in (6 to 60) in	(123 + 4.9L) μin (457 + 9.6L) μin	Gage Blocks
Inside Micrometers <sup>1,2</sup>	Up to 4 in (5 to 20) in (24 to 40) in (44 to 48) in	(53 + 1.9L) μin (53 + 3.4L) μin (59 + 4.2L) μin (66 + 4.5L) μin	Gage Blocks, Gage Block Accessory Set (ID)
Outside Micrometers <sup>1,2</sup>	Up to 4 in (4 to 20) in (20 to 40) in	(55 + 1.8L) μin (53 + 3.4L) μin (59 + 4.2L) μin	Gage Blocks
Depth Gages <sup>1,2</sup> (Micrometer/Indicator)	Up to 4 in (5 to 20) in (24 to 40) in (44 to 48) in	(73 + 4L) μin (87 + 5.5L) μin (69 + 4.1L) μin (94 + 4L) μin	Gage Blocks, Surface Plate
Dial Indicators <sup>1,2</sup> Resolution: 0.000 05 in 0.001 in	Up to 1 in Up to 4 in	(66 + 41.7L) μin (84 + 1357L) μin	Gage Blocks
Height Gages <sup>1,2</sup>	Up to 20 in (20 to 40) in (40 to 48) in	(70 + 3.6L) μin (66 + 4.8L) μin (76 + 5L) μin	Gage Blocks, Surface Plate
Laser Micrometers <sup>1</sup>	0.25 in 0.5 in 0.75 in 1 in	25 μin 25 μin 25 μin 30 μin	XX Master Pin Gages
Universal Length Measuring Machines <sup>2</sup>	Up to 100 mm	(0.063 + 0.002 7L) μm	Grade 0 Metric Gage Block Set
Length Standards	Up to 4 in (4 to 10) in (10 to 20) in	(9.6 + 2.4L) μin (29 + 3.2L) μin (29 + 3.1L) μin	Universal Length Measuring Machine, Grade 0 Gage Block Set

### Mass and Mass-Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure Gages, Transducers <sup>1,3</sup>	(0.2 to 50) psia (0.2 to 50) psig	0.001 2 % of reading	Ruska 2465A Piston Gauge
	(29 to 300) psia	0.14 % of reading	Druck DPI-145 Pressure indicator
Pressure Gages, Transducers <sup>1,3</sup>	(50 to 1 300) psig (1 300 to 13 000) psig	0.035 % of reading + 0.000 07 psi 0.035 % of reading + 0.02 psi	TD-4000N Deadweight Tester

### Mass and Mass-Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Vacuum <sup>1,3</sup>	(-15 to 50) psi	0.001 2 % of reading	Ruska 2465A Piston Gauge
Mass Flow <sup>1</sup>	(5 to 500) sccm (500 to 50 000) sccm	0.3 % of reading 0.3 % of reading	ML-800-10 Flow Cell ML-800-45 Flow Cell
Mass Flow <sup>1</sup>	(0.7 to 7) scfm (7 to 35) scfm (35 to 90) scfm	0.61 % of reading 0.65 % of reading 0.67 % of reading	Cox 16-064 Sonic Nozzle Cox 16-121 Sonic Nozzle Cox 16-228 Sonic Nozzle
Pipettes <sup>3</sup>	Up to 20 µl (20 to 50) µl (50 to 100) µl (100 to 200) µl (200 to 500) µl (500 to 1 000) µl	65 nl 66 nl 69 nl 80 nl 0.14 µl 0.24 µl	A&D 4212B-101 Balance and Software
Torque Transducers <sup>1,3</sup>	(0.5 to 10) lbf·in	0.03 % of reading + 0.000 1 lbf·in	NIST Class F Weights, 4 in Torque Wheel
	(10 to 1 920) lbf·in	0.018 % of reading + 0.000 1 lbf·in	NIST Class F Weights, 10 in Torque Wheel
Torque Transducers <sup>1,3</sup>	(160 to 1 000) lbf·ft	0.24 % of reading + 0.01 lbf·ft	NIST Class F Weights, 4 ft Torque Arm
Torque Tools <sup>1</sup>	(10 to 96) ozf·in	0.6 % of reading	AIMCO UET-0100 Torque Tester
	(6 to 96) lbf·in	0.6 lbf·in	HIOS HP-100 Torque Tester
Torque Tools <sup>1</sup>	(8 to 295) lbf·ft	0.6 % of reading + 0.03 lbf·ft	Norbar Pro Test 400 (43219)
	(295 to 1 100) lbf·ft	1.2 % of reading	Norbar Pro Test 1500ER (43189)
Force <sup>1,3</sup> (Compression & Tension)	Up to 50 lbf	0.006 lbf	NIST Class F Weights
	(50 to 1 000) lbf	0.31 lbf	1 000 lbf Interface Load Cell
	(1 000 to 10 000) lbf	2.5 lbf	10 000 lbf Interface Load Cell
	(10 000 to 50 000) lbf	13 lbf	50 000 lbf Interface Load Cell



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**Mass and Mass-Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force <sup>1,3</sup> (Compression & Tension)	Up to 20 lb (20 to 50) lb (50 to 100) lb (100 to 200) lb (200 to 400) lb (400 to 600) lb	1.5 g 3.8 g 7.5 g 15 g 30 g 45 g	NIST Class F Weights
Laboratory Balances <sup>1,6</sup>	Up to 2 mg (2 to 10) mg (10 to 20) mg (20 to 100) mg (100 to 200) mg (200 to 500) mg 500 mg to 1 g	29 µg 35 µg 41 µg 58 µg 70 µg 93 µg 0.12 mg	ASTM E617 Class 3 Weights and NIST HB 44 utilized in the calibration of the weighing system.
Laboratory Balances <sup>1,6</sup>	(1 to 5) g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g	22 µg 30 µg 44 µg 83 µg 0.16 mg 0.3 mg 0.72 mg	Ultra-Class Weights and NIST HB 44 utilized in the calibration of the weighing system.
Scales <sup>1,6</sup>	500 g to 1 kg (1 to 2) kg (2 to 5) kg (5 to 10) kg (10 to 25) kg (25 to 40) kg	2.9 mg 3.1 mg 15 mg 33 mg 74 mg 82 mg	ASTM E617 Class 1 Weights and NIST HB 44 utilized in the calibration of the weighing system.
Scales <sup>1,6</sup>	Up to 20 lb (20 to 50) lb (50 to 100) lb (100 to 200) lb (200 to 400) lb (400 to 600) lb	1.1 g 2.7 g 5.4 g 11 g 22 g 32 g	NIST Class F Weights and NIST HB 44 utilized in the calibration of the weighing system.

**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Measure <sup>1</sup>	Up to 90 %RH (90 to 100) %RH	1.3 %RH 2.2 %RH	Vaisala HMP-363 Transmitter





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### Thermodynamic

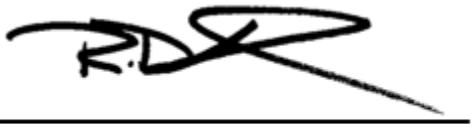
Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Source <sup>1</sup>	11.3 %RH 32.9 %RH 75.4 %RH 96.7 %RH	1.3 %RH 1.3 %RH 1.3 %RH 2.2 %RH	Vaisala HMP-363 Transmitter, Saturated Salt Solutions
Temperature – Measure <sup>1</sup>	(-200 to 0) °C (0 to 420) °C	35 mK 0.04 mK/°C + 29 mK	Fluke 5628 SPRT, HP 3458A Opt 002 8.5 Digit Multimeter
Temperature – Source <sup>1</sup>	(0 to 125) °C	36 mK	Ametek ETC-125 Drywell, Fluke 5628 SPRT, HP 3457A 8.5 Digit Multimeter

### Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source <sup>1,3</sup>	1 μHz to 250 kHz	70 pHz/Hz + 0.58 μHz	Agilent 33220A Signal Generator Locked to Datum LPRO Rubidium Freq Std
Frequency – Source <sup>1,3</sup>	250 kHz to 3 GHz	70 pHz/Hz + 5.8 mHz	HP ESG-D3000A Signal Generator locked to Datum LPRO Rubidium Freq Std
Frequency – Measure <sup>1,3</sup>	100 mHz to 225 MHz	76 pHz/Hz	Agilent 53131A Counter locked to Datum LPRO Rubidium Freq Standard
Frequency – Measure <sup>1,3</sup>	225 MHz to 26.5 GHz	128 pHz/Hz	HP 5348A Counter locked to Datum LPRO Rubidium Freq Standard
Stopwatches/Timers	Up to 24 h	48 ms	NIST 960-12 Totalized Method utilizing Agilent 53131A Counter locked to Datum LPRO Rubidium Freq Standard

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.  $L$  = length in inches,  $t$  = time in seconds.
  3. Uncertainties do not include contributors from a “best available” unit under test.
  4. The uncertainty does not include the mismatch uncertainty. This will be determined and reported at time of calibration. The reported uncertainty will be higher than listed.
  5. These scope uncertainties are based on the 90-day specifications of the Fluke 5522A Multiproduct Calibrator which are not always available. If lower uncertainties based on these 90-day specifications rather than the 1-year specification is required, contact the laboratory for scheduling availability.
  6. The uncertainties for scales and balances are highly dependent upon the resolution of the unit under test. The uncertainties presented here do not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
  7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1287.



R. Douglas Leonard Jr., VP, PILR SBU

