SCOPE OF ACCREDITATION TO ISO 17025:2017
& ANSI/NCSL Z540-1-1994

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CALIBRATION

Valid To: April 30, 2022 Certificate Number: 2073.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations[1, 7]:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Resistance – Measure, Fixed Points	100 Ω 10 kΩ	0.41 μΩ/Ω 0.41 μΩ/Ω	esi 123 system w/IET (esi) SR104
DC Resistance – Measure	(0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ	0.52 μΩ/Ω 0.42 μΩ/Ω 0.33 μΩ/Ω 0.24 μΩ/Ω 0.16 μΩ/Ω	MIL 6010C system w/ SR-104
	(10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	0.46 μΩ/Ω 0.62 μΩ/Ω 1.0 μΩ/Ω 4.2 μΩ/Ω 9.8 μΩ/Ω	MIL 6000B system w/ SR104 and SRL standards
	0.1 mΩ (0.2 to 1) mΩ (1 to 2) mΩ (2 to 20) mΩ (20 to 100) mΩ (100 to 200) mΩ (0.2 to 1) Ω	0.050 % 29 μΩ/Ω + 41 nΩ 46 μΩ/Ω + 23 nΩ 57 μΩ/Ω 17 μΩ/Ω + 3 nΩ 25 μΩ/Ω 6 μΩ/Ω + 3.4 μΩ	Current characterization method w/standards

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Resistance – Measure (cont)	(1 to 2) Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 kΩ (2 to 20) kΩ (20 to 200) kΩ 200 kΩ to 2 MΩ (2 to 20) MΩ	7 μΩ/Ω + 2.4 μΩ 4 μΩ/Ω + 10 μΩ 2.7 μΩ/Ω + 20 μΩ 3.8 μΩ/Ω + 60 μΩ 0.9 μΩ/Ω + 2 mΩ 2.7 μΩ/Ω + 10 mΩ 3 μΩ/Ω + 0.6 Ω 6.3 μΩ/Ω + 2 Ω	Ratio transfer method
	(20 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ (20 to 200) GΩ	8.5 μΩ/Ω 0.0026 % 0.03 % 0.032 %	Voltage characterization method w/standards
	200 GΩ to 1 TΩ (1 to 2) TΩ (2 to 20) TΩ (20 to 200) TΩ	0.35 % 0.5 % 1.5 % 2.5 %	Keithley 6517A w/ faraday cage
DC Resistance – Generate, Fixed Points	0.1 mΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ 100 GΩ 1 TΩ 10 TΩ	4 μΩ/Ω 4 μΩ/Ω 4 μΩ/Ω 4 μΩ/Ω 4 μΩ/Ω 4 μΩ/Ω 1 μΩ/Ω 1.7 μΩ/Ω 0.5 μΩ/Ω 3.7 μΩ/Ω 3.7 μΩ/Ω 6.2 μΩ/Ω 10 μΩ/Ω 100 μΩ/Ω 100 μΩ/Ω 0.020 % 0.025 % 0.10 %	Otto Wolff 15283/61 L&N 4223-B Guildline 9334A SRL-0.1 SRL-1 SRL-10 IET (esi) SR-102 Guildline 9334A IET (esi) SR-104 SRL-100k SRL-1M SRL-10M Guildline 9334A SRL-1G SRC-10G SRL-100G OhmLabs 112 OhmLabs 113

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Capacitance – Measure, Fixed Points 1 pF 10 pF 100 pF 1000 pF	1000 Hz	0.013 % 5.7 µF/F 5.9 µF/F 4.8 µF/F	IET (GenRad) 1404 and 1620
Capacitance – Measure[5] 10 aF to 11 µF 10 aF to 100 mF 10 aF to 10 F	50 Hz to 1 kHz 12 Hz to 200 kHz 10 Hz to 2 MHz	0.010 % + 30 aF 0.010 % + 16 fF 0.050 % + 30 fF	IET (GenRad) 1620 IET (GenRad) 1689/1693 IET (Quadtech) 7600+
Capacitance – Measure[6] 1 fF to 1 µF	50 Hz to 20 kHz	5.5 µF/F + 1 aF	Direct measurement using capacitance bridge AH 2700A bridge
Dissipation Factor – Measure[6] 1 µ to 10 (unitless)	50 Hz to 20 kHz	0.024 % + 5 µ (unitless)	Direct measurement using capacitance bridge AH 2700A bridge

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Capacitance – Generate			
10 aF to 11 µF	50 Hz to 1 kHz	0.010 % + 30 aF	Various standard capacitors characterized at time of use[5]
10 aF to 100 mF	12 Hz to 200 kHz	0.010 % + 16 fF	
10 aF to 10 F	10 Hz to 2 MHz	0.050 % + 30 fF	
Fixed Points:			
1 pF	1 kHz	0.013 %	IET (Genrad) 1403
10 pF		13 µF/F	IET (GenRad) 1404-C
100 pF		11 µF/F	IET (GenRad) 1404-B
1000 pF		13 µF/F	IET (GenRad) 1404-A
10 nF		0.012 %	IET SC-10 nF
100 nF		0.014 %	IET SC-100 nF
1 µF		0.013 %	IET SC-1 µF
10 µF		0.015 %	IET SC-10 µF
100 µF		0.043 %	IET S-100 µF
1 mF		0.23 %	IET (GenRad) 1417
10 mF		0.38 %	IET (GenRad) 1417
100 mF	100 Hz	0.34 %	IET (GenRad) 1417
1 F		0.41 %	IET (GenRad) 1417
Fixed Points Algorithmic Derivation @ Freq:			
50 pF	1 kHz to 1 MHz	0.017 %	GR/IET 1406E
100 pF		0.021 %	GR/IET 1406D
200 pF		0.014 %	GR/IET 1406C
500 pF		0.012 %	GR/IET 1406B
1 nF		0.013 %	GR/IET 1406A
2 nF		0.016 %	GR/IET 1407B
10 nF		0.057 %	GR/IET 1407D
20 nF		0.12 %	GR/IET 1407E
50 nF		0.028 %	GR/IET 1407F
100 nF		0.56 %	GR/IET 1407G

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Inductance – Measure[5]			
10 nH to 100 kH	12 Hz to 100 kHz	0.01 % + 50 nH	IET (GenRad) 1689/1693
1 pH to 100 H	10 Hz to 2 MHz	0.05 % + 120 pH	IET (Quadtech) 7600+
Inductance – Measure, Fixed Points			
10 µH	100 Hz 400 Hz 1 kHz 10 kHz 100 kHz	1.5 % 0.29 % 0.12 % 0.07 % 0.10 %	IET (GenRad) 1482 standard inductors w/ precision LCR meter
50 µH	100 Hz 400 Hz 1 kHz 10 kHz	0.31 % 0.08 % 0.04 % 0.06 %	
100 µH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.017 % 0.017 % 0.017 % 0.011 % 0.017 %	
200 µH	100 Hz 400 Hz 1 kHz 10 kHz	0.1 % 0.04 % 0.03 % 0.06 %	
500 µH	100 Hz 400 Hz 1 kHz 10 kHz	0.06 % 0.03 % 0.02 % 0.06 %	
1 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.012 % 0.012 % 0.012 % 0.011 % 0.017 %	
2 mH	100 Hz 400 Hz 1 kHz 10 kHz	0.04 % 0.03 % 0.02 % 0.06 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Inductance – Measure, Fixed Points (cont)			
5 mH	100 Hz 400 Hz 1 kHz 10 kHz	0.03 % 0.02 % 0.02 % 0.06 %	IET (GenRad) 1482 standard inductors with precision LCR meter
10 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.013 % 0.013 % 0.013 % 0.011 % 0.015 %	
20 mH	100 Hz 400 Hz 1 kHz 10 kHz	0.03 % 0.02 % 0.02 % 0.07 %	
50 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.015 % 0.015 % 0.015 % 0.014 % 0.023 %	
100 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.012 % 0.012 % 0.012 % 0.011 % 0.021 %	
200 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.015 % 0.015 % 0.015 % 0.014 % 0.051 %	
500 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.015 % 0.015 % 0.015 % 0.014 % 0.051 %	
1 H	100 Hz 200 Hz 400 Hz 1 kHz	0.011 % 0.011 % 0.011 % 0.011 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Inductance – Measure, Fixed Points (cont)			
2 H	100 Hz 400 Hz 1 kHz	0.03 % 0.03 % 0.03 %	IET (GenRad) 1482 standard inductors w/ precision LCR meter
5 H	100 Hz 200 Hz 400 Hz 1 kHz	0.03 % 0.03 % 0.03 % 0.04 %	
10 H	100 Hz 200 Hz 400 Hz 1 kHz	0.012 % 0.012 % 0.012 % 0.011 %	
Inductance – Generate, Fixed Points			
10 µH	100 Hz 400 Hz 1 kHz 10 kHz 100 kHz	1.5 % 0.29 % 0.12 % 0.07 % 0.10 %	IET (GenRad) 1482 standard inductors
50 µH	100 Hz 400 Hz 1 kHz 10 kHz	0.31 % 0.08 % 0.04 % 0.06 %	
100 µH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.017 % 0.017 % 0.017 % 0.011 % 0.017 %	
200 µH	100 Hz 400 Hz 1 kHz 10 kHz	0.1 % 0.04 % 0.03 % 0.06 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Inductance – Generate, Fixed Points (cont)			
500 µH	100 Hz 400 Hz 1 kHz 10 kHz	0.06 % 0.03 % 0.02 % 0.06 %	IET (GenRad) 1482 standard inductors
1 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.012 % 0.012 % 0.012 % 0.011 % 0.017 %	
2 mH	100 Hz 400 Hz 1 kHz 10 kHz	0.04 % 0.03 % 0.02 % 0.06 %	
5 mH	100 Hz 400 Hz 1 kHz 10 kHz	0.03 % 0.02 % 0.02 % 0.06 %	
10 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.013 % 0.013 % 0.013 % 0.011 % 0.015 %	
20 mH	100 Hz 400 Hz 1 kHz 10 kHz	0.03 % 0.02 % 0.02 % 0.07 %	
50 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.015 % 0.015 % 0.015 % 0.014 % 0.023 %	
100 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.012 % 0.012 % 0.012 % 0.011 % 0.021 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Inductance – Generate, Fixed Points (cont)			
200 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.015 % 0.015 % 0.015 % 0.014 % 0.051 %	IET (GenRad) 1482 standard inductors
500 mH	100 Hz 200 Hz 400 Hz 1 kHz 10 kHz	0.015 % 0.015 % 0.015 % 0.014 % 0.051 %	
1 H	100 Hz 200 Hz 400 Hz 1 kHz	0.011 % 0.011 % 0.011 % 0.011 %	
2 H	100 Hz 400 Hz 1 kHz	0.03 % 0.03 % 0.03 %	
5 H	100 Hz 400 Hz 1 kHz	0.03 % 0.03 % 0.04 %	
10 H	100 Hz 200 Hz 400 Hz 1 kHz	0.012 % 0.012 % 0.012 % 0.011 %	

Parameter/Equipment	Range	CMC[2, 3] (±)	Comments
DC Voltage Generate – Cardinal Points	1 V 1.018 V 10 V	51 µV/V 39 µV/V 37 µV/V	Koep Trancell DC voltage standard model VTS6001-1
DC Voltage – Measure	(0 to 200) mV 200 mV to 2 V (2 to 20) V (20 to 200) V (200 to 1000) V	4.5 µV/V + 0.1 µV 3 µV/V + 0.4 µV 3 µV/V + 4 µV 4.5 µV/V + 40 µV 4.5 µV/V + 0.5 mV	Fluke 8508A

Parameter/Equipment	Range	CMC[2, 3] (±)	Comments
DC Current – Measure	(0 to 200) µA 200 µA to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 20) A	12 µA/A + 0.2 nA 12 µA/A + 2 nA 13 µA/A + 20 nA 36 µA/A + 0.4 µA 0.017 % + 8 µA 0.038 % + 20 µA	Fluke 8508A

Parameter/Range	Frequency	CMC[2, 3] (±)	Comments
AC Voltage – Measure			
(0 to 200) mV	(10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.013 % + 4 µV 0.011 % + 4 µV 0.011 % + 2 µV 0.011 % + 4 µV 0.030 % + 8 µV 0.071 % + 20 µV	Fluke 8508A
(0.2 to 2) V	(10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.011 % + 20 µV 85 µV/V + 20 µV 65 µV/V + 20 µV 85 µV/V + 20 µV 0.021 % + 40 µV 0.051 % + 200 µV 0.3 % + 2 mV 1 % + 2 mV	
(2 to 20) V	(10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.011 % + 200 µV 85 µV/V + 200 µV 65 µV/V + 200 µV 85 µV/V + 200 µV 0.021 % + 400 µV 0.051 % + 2 mV 0.3 % + 20 mV 1 % + 20 mV	

Parameter/Range	Frequency	CMC[2, 3, 4] (±)	Comments
AC Voltage – Measure (cont)			
(20 to 200) V	(10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.011 % + 2 mV 85 µV/V + 2 mV 65 µV/V + 2 mV 85 µV/V + 2 mV 0.021 % + 4 mV 0.051 % + 20 mV 0.3 % + 200 mV 1 % + 200 mV	Fluke 8508A
(200 to 1050) V	(10 to 40) Hz (40 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.011 % + 0.02 V 95 µV/V + 0.02 V 0.021 % + 0.04 V 0.051 % + 0.2 V	
AC Current – Measure			
(0 to 200) µA	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.028 % + 0.02 µA 0.065 % + 0.02 µA 0.4 % + 0.02 µA	Fluke 8508A
200 µA to 2 mA	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.028 % + 0.2 µA 0.065 % + 0.2 µA 0.4 % + 0.2 µA	
(2 to 20) mA	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.028 % + 2 µA 0.065 % + 2 µA 0.4 % + 2 µA	
(20 to 200) mA	10 Hz to 10 kHz (10 to 30) kHz	0.025 % + 20 µA 0.060 % + 20 µA	
200 mA to 2 A	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.060 % + 200 µA 0.070 % + 200 µA 0.3 % + 200 µA	
(2 to 20) A	10 Hz to 2 kHz (2 to 10) kHz	0.08 % + 2 mA 0.25 % + 2 mA	
AC Resistance – Measure[5]			
0.01 mΩ to 100 MΩ 0.1 mΩ to 100 MΩ	12 Hz to 200 kHz 10 Hz to 2 MHz	0.02 % 0.05 %	IET (GenRad) 1689/1693 Quadtech 7600

Parameter/Range	Frequency	CMC[2, 8] (±)	Comments
AC Resistance – Generate Fixed Points: 24.9 Ω 374 Ω 5.97 kΩ 95.317 kΩ	 1 kHz 1 kHz 1 kHz 1 kHz	 20 μΩ/Ω 20 μΩ/Ω 20 μΩ/Ω 20 μΩ/Ω	 IET (GenRad) 1689-9604 Digibridge calibration kit

II. Time & Frequency

Parameter/Equipment	Range	CMC[2, 8] (±)	Comments
Frequency – Measure	0.01 Hz to 125 MHz	20 μHz/Hz	Precision counter

[1] This laboratory offers commercial calibration service.

[2] Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

[3] The measurands stated are measured with the Fluke 8508A. This capability is suitable for the calibration of the parameters indicated. CMCs are expressed as either a specific value that covers the full range or as a combination of the fraction/percent of the reading/output plus a range specification.

[4] In the statement of CMC, percentages are to be read as percent of reading unless otherwise noted.

[5] CMC is defined at 1 kHz only. The laboratory implements the IET Uncertainty calculator for intermediate values and frequencies.

[6] CMC is defined at 1 kHz only. The laboratory implements the IET Uncertainty calculator for intermediate values and frequencies which utilizes the "AH2700a Complete Specifications in Excel" spreadsheet from Andeen-Hagerling.

[7] This laboratory meets A2LA's *P112 Flexible Scope Policy*.

[8] The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter

Accredited Laboratory

A2LA has accredited

IET LABS, INC.

West Roxbury, MA

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and R205 – Specific Requirements: Calibration Laboratory Accreditation Program. 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*).

Presented this 4th day of March, 2020.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2073.01
Valid to April 30, 2022

For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.