



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

BHD Test & Measurement
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CALIBRATION

Valid to: May 31, 2021

Certificate Number: 3104.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations^{1, 6}:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 4, 5} (±)	Comments
DC Voltage – Generate ³	Up to 220 mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	11.0 µV/V 7.0 µV/V 5.0 µV/V 5.8 µV/V 6.9 µV/V 1.9 µV/V	Fluke 5730A
Generate & Measure ³	(1.0 to 45) kV	0.076 %	Fluke 289. Ross Eng. HV divider 50 kV DC source
DC Voltage – Measure ³	Up to 220 mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1000) V	9.0 µV/V 6.0 µV/V 4.3 µV/V 5.8 µV/V 6.9 µV/V 6.9 µV/V	Fluke 5730A, Fluke 8508A

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Current – Generate & Measure ³	Up to 220 μ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 1.1) A (1.1 to 20.0) A	58 μ A/A 53 μ A/A 53 μ A/A 0.05 % 0.23 % 0.17 %	Fluke 5730A, Agilent 3458A
DC Resistance – Generate & Measure ³	1 Ω (1 to 100) Ω (0.10 to 1.0) k Ω (1.0 to 10) k Ω (10 to 100) k Ω (0.10 to 1.0) M Ω (1 to 10) M Ω (1 to 100) M Ω (100 to 300) M Ω (0.30 to 1.0) G Ω	0.012 % 47 $\mu\Omega/\Omega$ 19 $\mu\Omega/\Omega$ 18 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$ 35 $\mu\Omega/\Omega$ 27 $\mu\Omega/\Omega$ 0.068 % 0.43 % 0.13 %	Fluke 5730A, Agilent 3458A-02 IETVRS-100-10- 1kOhm-ROT Fluke 8508A
Fixed Points ³	1 Ω 10 Ω 100 Ω 10 k Ω	36 $\mu\Omega/\Omega$ 35 $\mu\Omega/\Omega$ 30 $\mu\Omega/\Omega$ 19 $\mu\Omega/\Omega$	Fluke-742A-1 IET-SRX-10 IET-SRX-100 Fluke-742A-10K

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage – Generate & Measure³			
(1 to 100) mV	(10 to 100) Hz	0.043 %	Fluke 5730A, Agilent 3458A-02
(1 to 100) mV	100 Hz to 1 kHz	0.051 %	
(1 to 100) mV	(1 to 10) kHz	0.066 %	
(1 to 100) mV	(10 to 100) kHz	0.33 %	
(100 to 1000) mV	(10 to 100) Hz	0.18 %	
(100 to 1000) mV	100 Hz to 1 kHz	0.016 %	
(100 to 1000) mV	(1 to 10) kHz	0.18 %	
(100 to 1000) mV	(10 to 100) kHz	0.37 %	
(1 to 10) V	(1 to 10) kHz	0.11 %	
(1 to 100) V	(10 to 100) Hz	0.027 %	
(1 to 100) V	100 Hz to 1 kHz	0.023 %	
(1 to 100) V	100 Hz to 1 kHz	0.058 %	
(100 to 1000) V	50 Hz to 30 kHz	0.052 %	
(0 to 10 V)	100 kHz to 1 MHz	0.090 %	
(1 to 30) kV	60 Hz	0.24 %	Fluke 289 Ross Eng. HV divider high voltage source
AC Current – Generate & Measure³			
Up to 0.220 mA	100 Hz to 10 kHz	0.21 %	Fluke 5730A, Agilent 3458A-02
(2.2) mA	100 Hz to 10 kHz	0.22 %	
(10 to 50) mA	100 Hz to 30 kHz	0.10 %	
(100 to 200) mA	100 Hz to 30 kHz	0.57 %	
(0.5 to 2.0) A	10 Hz to 10 kHz	0.11 %	

Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
AC Current – Generate & Measure (cont)			
(4.0 to 8.0) A (10.0 to 19.0) A	50 Hz to 10 kHz 50 Hz to 5 kHz	0.11 % 0.11 %	Fluke 5730A, Agilent 3458A-02, Fluke 8508A Fluke 5720A-03WB w/ Fluke 5725A amplifier & Fluke 8508A
(50 to 1000) A (20 to 3000) A	60 Hz (50 to 60) Hz	0.20 % 0.94 %	Fluke 5730A, Agilent 3458A-02 Fluke multi-turn coils
Capacitance – Generate & Measure ³			
Fixed Points			
1.0 pF	1 kHz	0.19 %	Capacitor Set, HP 16380A with Keysight E4980AL
10 pF	1 kHz	0.022 %	
100 pF	1 kHz	0.0018 %	
1000 pF	1 kHz	0.0072%	
1.0 pF	300 kHz	0.15 %	
10 pF	300 kHz	0.016 %	
100 pF	300 kHz	0.0032 %	
1000 pF	300 kHz	0.0001 %	
1 nF	1 kHz	0.093 %	
10 nF	1 kHz	0.012 %	
100 nF	1 kHz	0.01 %	IET 1413 capacitance decade with Keysight E4980AL
1 nF to 10 000 µF	At various frequencies ranging anywhere from 20 Hz to 1 kHz	0.62 %	Fluke 5730A calibrator with Keysight E4980AL

Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
Inductance – Generate & Measure Fixed Points ³			
1 mH	(20 Hz to 20) kHz	0.15 %	Genrad 1482 series standard inductors Keysight E4980A LCR meter
100 mH	(20 Hz to 10) kHz	0.13 %	
1 H	(20 Hz to 1) kHz	0.49 %	

Parameter/Equipment	Range	CMC ^{2, 4, 5} (±)	Comments
Electrical Calibration of Thermocouples – Thermocouple Simulation ³			
Generate & Measure			
E-Type	(-250 to -100) °C	0.41 °C	Fluke 5522A
	(-100 to -25) °C	0.18 °C	
	(-25 to 350) °C	0.17 °C	
	(350 to 650) °C	0.18 °C	
	(650 to 1000) °C	0.21 °C	
J-Type	(-210 to -100) °C	0.25 °C	
	(-100 to -30) °C	0.18 °C	
	(-30 to 150) °C	0.17 °C	
	(150 to 760) °C	0.19 °C	
	(760 to 1200) °C	0.23 °C	
K-Type	(-200 to -100) °C	0.29 °C	
	(-100 to -25) °C	0.20 °C	
	(-25 to 120) °C	0.18 °C	
	(120 to 1000) °C	0.24 °C	
	(1000 to 1372) °C	0.34 °C	
T-Type	(-250 to -150) °C	0.51 °C	
	(-150 to 0) °C	0.23 °C	
	(0 to 120) °C	0.18 °C	
	(120 to 400) °C	0.17 °C	
ESD Impulse Current – Measure	Voltage: (1 to 30) kV	4.5 %	Tek 694C oscilloscope, EMC partner ESD Veri-V, target 2-DN, Agilent 34401A DMM

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Oscilloscope – Rise Time, Generate and Measure ³	150 ps	36 ps	Fluke 9500B, active head 9530, Tek 694C oscilloscope

II. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Voltage Low Frequency – Generate & Measure ³	10 Hz to 1.0 MHz	0.06 V _{RMS}	Fluke 9640A-LPN, Fluke 8508A DMM
RF Power – Low to Medium Frequency Generate & Measure ³ (-110 to +20) dBm	(1 to 120) MHz	0.19 dBm	Fluke 9640A-LPN synthesized signal generator, HP8902A-050 measuring receiver, HP 11722A sensor
RF Power – Generate & Measure ³ (10 to -40) dBm	20 MHz to 1 GHz	0.082 dBm	HP 8902A-050 measuring receiver; 11793A microwave converter; Fluke 9640B-LPN & HP 8340B generators w/ 11722A sensor
(-50 to -110) dBm	20 MHz to 1.3 GHz	0.84 dBm	w/ 11722A sensor
(10 to -30) dBm	(2 to 8) GHz	0.49 dBm	w/ 11792A sensor
(10 to -30) dBm	(10 to 20) GHz	0.9 dBm	w/ 11792A sensor
(0 to -30) dBm	(22 to 26.5) GHz	1.3 dBm	w/ 11792A sensor

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Attenuation Tuned RF Level – Generate & Measure ³ (10 to 100) dB	10 MHz	0.41 dB	Agilent 8902A-050 measuring receiver Agilent 11793A microwave converter, HP 8496B / 8494B step attenuators w/ Agilent 11722A sensor w/ 11792A power sensor
	50 MHz	0.43 dB	
	1 GHz	0.50 dB	
	4 GHz	0.35 dB	
	10 GHz	0.71 dB	
	15 GHz	1.0 dB	
	18 GHz	0.45 dB	

III. Mechanical

Parameter/Equipment	Range	CMC ^{2,7} (±)	Comments
Pressure Measuring Equipment & Measure ³	(-5 to 3000) PSI	0.021 % Full Scale	Additel ADT 783K automatic pressure standard Crystal 33 series pressure standard
	(4000 to 10 000) PSI	0.022 % Full Scale	Fluke RPM4-E-DWT dead weight calibrator

IV. Thermodynamics

Parameter/Equipment	Range	CMC ^{2,7} (±)	Comments
Temperature – Measuring Equipment & Measure, Actual Temperatures			
Using a Heated Metrology Well ³	(50 °C to 650 °C)	0.018 °C	Fluke 9173A- Heat generating well w/ Fluke 5628 platinum RTD
Using a Cold Metrology Well ³	(-90 °C to +40 °C)	0.045 °C	Fluke 9190A-Cold generating well w/ Fluke 5628 platinum RTD

V. Time & Frequency

Parameter/Equipment	Range	CMC ^{2,7} (±)	Comments
Frequency – Measuring Equipment & Measure ³	(10 MHz Reference) 1.0 mHz to 26.5 GHz	4.6 pHz/Hz 36 nHz/Hz	Agilent 5071A (cesium beam) Symetricom GPS receiver, Agilent 8340B synthesized sweeper, HP 3325B & HP 5343A frequency counter & time interval counter

¹ This laboratory offers commercial calibration service.

² Calibration and Measurement Capability (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. Calibration and Measurement Capabilities 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 Field calibration service is available for this calibration and this laboratory meets A2LA R104 – General Requirements: Accreditation of Field Testing and Field Calibration Laboratories for these calibrations. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.
- ⁴ The stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMC's are expressed as either a specific value that covers the full range or as a percent or fraction of the reading plus a fixed floor specification.
- ⁵ The statement of CMC, percentages are percentages of reading.
- ⁶ This scope meets A2LA's *P112 Flexible Scope Policy*.
- ⁷ 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

BHD TEST & MEASUREMENT

Broomfield, CO

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/NCSLI 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 19th day of August 2019.

A blue ink signature of the Vice President of Accreditation Services.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3104.01
Valid to May 31, 2021

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