SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017
& ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3-2006

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CALIBRATION

Valid To: August 31, 2025 Certificate Number: 2044.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations[1, 9]:

I. Dimensional

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Dial Indicators[3]	Up to 1 in	60 µin	Comparison to gage blocks or bench micrometer
Micrometers[3]	Up to 36 in	(4 + 8*L* + 0.6*R*) µin	Comparison to gage blocks
Calipers[3]	Up to 36 in	(4 + 8*L* + 0.6*R*) µin	Comparison to gage blocks
Go/No-Go Gauges[3]	Up to 1 in	22 µin	High resolution micrometer compared to gage blocks

II. Electrical – DC/ Low Frequency

Parameter/Equipment	Range	CMC[2, 5, 6] (±)	Comments
DC Voltage[3] – 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 + 0.11 µV 3 µV/V + 0.41 µV 3 µV/V + 5 µV 4.5 µV/V + 41 µV 4.5 µV/V + 500 µV	Long scale multimeter
Fixed Points	10 V Reference	8.4 µV	Standard cell inter-comparison to standard reference voltage cell
DC Voltage[3] – Generate	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	7.5 µV/V + 0.4 µV 5 µV/V + 0.7 µV 3.5 µV/V + 2.5 µV 3.5 µV/V + 4 µV 5 µV/V + 40 µV 6.5 µV/V + 400 µV	Precision multi-function calibrator
DC Voltage – Generate & Measure, Fixed Points	0.1 V 1 V 10 V 19 V 100 V 1000 V	3.5 µV/V 2.1 µV/V 2.1 µV/V 2.1 µV/V 2.1 µV/V 2.1 µV/V	Ratiometric measurement techniques performed utilizing standard reference voltage cell & standard divider
DC High Voltage[3, 9] – Measure & Generate	(1 to 100) kV (100 to 200) kV 150 kV 200 kV	0.02 % 0.08 % 0.06 % 0.06 %	Precision high voltage divider with long scale multimeter
DC High Voltage[3, 7] – Measure	(200 to 700) kV	1.1 %	Precision high voltage divider with long scale multimeter
DC Linearity[3, 9]	(200 to 450) kV	0.4 %	Precision current meter & high voltage DC resistor
DC Current[3] – 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 + 0.4 nA 12 µA/A + 4 nA 13 µA/A + 41 nA 36 µA/A + 800 nA 0.017 % + 17 µA 0.039 % + 500 µA	Long scale multimeter

Parameter/Equipment	Range	CMC[2, 5, 6] (±)	Comments
DC Current[3] – Generate	(0 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 11) A (11 to 20) A	40 µA/A + 6 nA 35 µA/A + 7 nA 35 µA/A + 40 nA 45 µA/A + 0.7 µA 80 µA/A + 12 µA 0.036 % + 480 µA 0.1 % + 750 µA	Precision multi-function calibrator with precision amplifier (> 100 to 220) mA, add $200I^2$ µA/A to the CMC. I = current (> 1 to 2.2) A, add $10I^2$ µA/A to the CMC I = current
DC Current[8] – Generate & Measure	(0 to 1) µA (1 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 20) A	0.043 nA 0.011 % 15 µA/A 11 µA/A 5 µA/A 7 µA/A 8.5 µA/A 35 µA/A 89 µA/A	Standard resistors & long scale voltmeter
Resistance – Generate & Measure	(0.01 to 0.1) Ω (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (100 to 1000) kΩ (1 to 10) MΩ (10 to 100) MΩ (> 100 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ (20 to 200) GΩ 200 GΩ to 2 TΩ (2 to 20) TΩ (20 to 200) TΩ	0.85 µΩ/Ω 0.8 µΩ/Ω 0.85 µΩ/Ω 0.9 µΩ/Ω 0.95 µΩ/Ω 0.95 µΩ/Ω 0.75 µΩ/Ω 1 µΩ/Ω 3 µΩ/Ω 20 µΩ/Ω 60 µΩ/Ω + 1 kΩ 0.015 % 0.04 % 0.06 % 0.1 % 0.25 % 0.4 %	Primary resistance bridge & working standard resistors Primary resistance bridge & working standard resistors Long scale multimeter Precision high resistance meter
Fixed Point	1 GΩ	0.011 %	Precision high resistance standard, long scale multimeter & precision multi-function calibrator

Parameter/Equipment	Range	CMC[2, 5, 6] (±)	Comments
Resistance – Measure	(0 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 (20 to 200) MΩ (200 to 2000) MΩ	15 μΩ/Ω + 4.1 μΩ 9 μΩ/Ω + 15 μΩ 7.5 μΩ/Ω + 50 μΩ 7.5 μΩ/Ω + 500 μΩ 7.5 μΩ/Ω + 5 mΩ 7.5 μΩ/Ω + 50 mΩ 8.5 μΩ/Ω + 1 Ω 15 μΩ/Ω + 11 Ω 60 μΩ/Ω + 1 kΩ 0.015 % + 100 kΩ	Long scale multimeter
Resistance[3] – Generate, Fixed Points	0.0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ 1 GΩ 10 GΩ 100 GΩ 1 TΩ 10 TΩ 100 TΩ	40 μΩ 95 μΩ/Ω 95 μΩ/Ω 23 μΩ/Ω 23 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 8.5 μΩ/Ω 8.5 μΩ/Ω 13 μΩ/Ω 18 μΩ/Ω 40 μΩ/Ω 47 μΩ/Ω 100 μΩ/Ω 48 μΩ/Ω 0.012 % 0.024 % 0.054 % 0.079 % 0.27 %	Precision multi-function calibrator Precision high resistance standard
Resistance[3] – Generate, Variable	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω 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	40 μΩ/Ω + 1 mΩ 30 μΩ/Ω + 1.5 mΩ 28 μΩ/Ω + 1.4 mΩ 28 μΩ/Ω + 2 mΩ 28 μΩ/Ω + 2 mΩ 28 μΩ/Ω + 20 mΩ 28 μΩ/Ω + 20 mΩ 28 μΩ/Ω + 200 mΩ 28 μΩ/Ω + 200 mΩ 32 μΩ/Ω + 2 Ω	Precision multi-function calibrator

Parameter/Equipment	Range	CMC[2, 5] (±)	Comments
Resistance[3] – Generate, Variable (cont)	330 kΩ 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 1100) MΩ	32 μΩ/Ω + 2 Ω 60 μΩ/Ω + 30 Ω 0.013 % + 50 Ω 0.025 % + 2.5 kΩ 0.05 % + 3 kΩ 0.3 % + 100 kΩ 1.5 % + 500 kΩ	Precision multi-function calibrator

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Resistance[3] – Measure			
(0.1 to 1) Ω	1 kHz	0.64 %	Precision impedance meter
(1 to 10) Ω	1 kHz	0.074 %	
10 Ω to 100 kΩ	1 kHz	0.021 %	
100 kΩ to 1 MΩ	1 kHz	0.036 %	
(1 to 10) MΩ	1 kHz	0.29 %	
(0.1 to 1) Ω	250 Hz to 2.5 kHz	1.3 %	
(1 to 10) Ω	(12 to 50) Hz	0.53 %	
	(50 to 250) Hz	0.27 %	
	250 Hz to 2.5 kHz	0.14 %	
	(2.5 to 5) kHz	0.21 %	
	(5 to 10) kHz	0.27 %	
	(10 to 50) kHz	1.1 %	
10 Ω to 10 kΩ	(12 to 50) Hz	0.091 %	
	(50 to 250) Hz	0.051 %	
	250 Hz to 2.5 kHz	0.031 %	
	(2.5 to 10) kHz	0.051 %	
	(10 to 50) kHz	0.18 %	
	(50 to 100) kHz	0.33 %	
(10 to 100) kΩ	(12 to 50) Hz	0.091 %	
	(50 to 250) Hz	0.051 %	
	250 Hz to 1 kHz	0.031 %	
	(1 to 2.5) kHz	0.041 %	
	(2.5 to 5) kHz	0.081 %	
	(5 to 10) kHz	0.18 %	
100 kΩ to 1 MΩ	(12 to 50) Hz	0.21 %	
	(50 to 100) Hz	0.11 %	
	(100 to 250) Hz	0.084 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Resistance[3] – Measure (cont)			
100 kΩ to 1 MΩ	250 Hz to 1 kHz (1 to 2.5) kHz (2.5 to 5) kHz (5 to 10) kHz	0.06 % 0.089 % 0.21 % 0.48 %	Precision impedance meter
(1 to 10) MΩ	(50 to 100) Hz (100 to 250) Hz 250 Hz to 1 kHz (1 to 2.5) kHz	1 % 0.75 % 0.54 % 0.97 %	

Parameter/Equipment	Range	CMC[2, 6] (±)	Comments
Impulse, Lightning Impulse[3] –	(50 to 500) kV	1.3 %	Direct comparison with high voltage divider & precision data acquisition system
Voltage	(500 to 2500) kV	1.7 %	
Linearity	(50 to 2500) kV	0.85 %	DC charge ratio comparison
Time Parameters: Front Time (T1) Time to Half Value (T2)	 1.2 µs 60 µs	 4.3 % 4.3 %	 Direct comparison with high voltage divider & precision data acquisition system
Impulse, Switching Impulse[3] –			
Voltage	(50 to 500) kV (500 to 1000) kV	1.3 % 1.7 %	Direct comparison with high voltage divider & precision data acquisition system
Linearity	(50 to 1000) kV	0.85 %	DC charge ratio comparison
Time Parameters: Front Time (T1) Time to Peak (Tp)	 250 µs 2500 µs	 4.3 % 4.3 %	 Direct comparison with high voltage divider & precision data acquisition system

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
AC Voltage[3] – Measure			
(1 to 12) mV	(1 to 10) Hz	0.03 % + 3 µV	Long scale multimeter
(12 to 120) mV	(1 to 10) Hz	72 µV/V + 4 µV	
120 mV to 1.2 V	(1 to 10) Hz	72 µV/V + 40 µV	
(1.2 to 12) V	(1 to 10) Hz	72 µV/V + 0.4 mV	
(12 to 120) V	(1 to 10) Hz	0.02 % + 4 mV	
(120 to 700) V	(1 to 10) Hz	0.04 % + 40 mV	
600 µV to 2.2 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.17 % + 1.3 µV 0.074 % + 1.3 µV 0.042 % + 1.3 µV 0.081 % + 2 µV 0.12 % + 2.5 µV 0.23 % + 4 µV 0.24 % + 8 µV 0.35 % + 8 µV	Precision AC/DC transfer standard
(2.2 to 7) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.085 % + 1.3 µV 0.037 % + 1.3 µV 0.021 % + 1.3 µV 0.04 % + 2 µV 0.06 % + 2.5 µV 0.12 % + 4 µV 0.13 % + 8 µV 0.23 % + 8 µV	
(7 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.029 % + 1.3 µV 0.019 % + 1.3 µV 0.011 % + 1.3 µV 0.021 % + 2 µV 0.031 % + 2.5 µV 0.081 % + 4 µV 0.089 % + 8 µV 0.17 % + 8 µV	
(22 to 70) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 1.5 µV 0.012 % + 1.5 µV 65 µV/V + 1.5 µV 0.013 % + 2 µV 0.026 % + 2.5 µV 0.051 % + 4 µV 0.067 % + 8 µV 0.11 % + 8 µV	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Voltage[3] – Measure (cont)			
(70 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.021 % + 1.5 µV 85 µV/V + 1.5 µV 38 µV/V + 1.5 µV 69 µV/V + 2 µV 0.016 % + 2.5 µV 0.025 % + 4 µV 0.038 % + 8 µV 0.1 % + 8 µV	Precision AC/DC transfer standard
(220 to 700) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.021 % + 1.5 µV 76 µV/V + 1.5 µV 33 µV/V + 1.5 µV 51 µV/V + 2 µV 79 µV/V + 2.5 µV 0.018 % + 4 µV 0.03 % + 8 µV 0.096 % + 8 µV	
700 mV to 2.2 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % 66 µV/V 24 µV/V 46 µV/V 71 µV/V 0.016 % 0.026 % 0.09 %	
(2.2 to 7) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % 67 µV/V 24 µV/V 48 µV/V 81 µV/V 0.019 % 0.04 % 0.12 %	
(7 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % 67 µV/V 27 µV/V 48 µV/V 81 µV/V 0.019 % 0.04 % 0.12 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Voltage[3] – Measure (cont)			
(22 to 70) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % 68 µV/V 32 µV/V 57 µV/V 94 µV/V 0.02 % 0.041 % 0.12 %	Precision AC/DC transfer standard
(70 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.02 % 68 µV/V 31 µV/V 69 µV/V 98 µV/V 0.021 % 0.05 %	
(220 to 700) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.02 % 99 µV/V 41 µV/V 0.013 % 0.05 %	
(700 to 1000) V	(20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	99 µV/V 38 µV/V 0.013 % 0.05 %	
Flatness – (Relative to 1 kHz):			
600 µV to 2.2 mV	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.05 % 0.05 % 0.05 % 0.07 % + 1 µV 0.07 % + 1 µV 0.07 % + 1 µV 0.17 % + 1 µV 0.3 % + 1 µV 0.7 % + 2 µV	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Voltage[3] – Measure (cont)			
Flatness – (Relative to 1 kHz):			
(2.2 to 7) mV	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.05 % 0.05 % 0.05 % 0.07 % + 1 µV 0.07 % + 1 µV 0.07 % + 1 µV 0.1 % + 1 µV 0.17 % + 1 µV 0.37 % + 1 µV	Precision AC/DC transfer standard
(7 to 22) mV	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.05 % 0.05 % 0.05 % 0.07 % 0.07 % 0.07 % 0.1 % 0.17 % 0.37 %	
(22 to 70) mV	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.05 % 0.05 % 0.05 % 0.05 % 0.05 % 0.05 % 0.1 % 0.15 % 0.35 %	
(70 to 220) mV	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.04 % 0.04 % 0.04 % 0.04 % 0.05 % 0.05 % 0.1 % 0.15 % 0.35 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Voltage[3] – Measure (cont)			
Flatness – (Relative to 1 kHz):			
(220 to 700) mV	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.03 % 0.03 % 0.03 % 0.03 % 0.05 % 0.05 % 0.1 % 0.15 % 0.35 %	Precision AC/DC transfer standard
700 mV to 2.2 V	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.03 % 0.03 % 0.03 % 0.03 % 0.05 % 0.05 % 0.1 % 0.15 % 0.35 %	
(2.2 to 7) V	(10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.1 % 0.03 % 0.03 % 0.03 % 0.03 % 0.05 % 0.05 % 0.1 % 0.15 % 0.35 %	
AC High Voltage[3, 11] – Generate & Measure			
(1 to 100) kV_{RMS} (100 to 200) kV_{RMS}	50, 60 Hz 50, 60 Hz	0.14 % 0.18 %	Precision high voltage divider with long scale multimeter
150 kV_{RMS} 200 kV_{RMS}	50, 60 Hz 50, 60 Hz	0.14 % 0.18 %	Note: measurements made at RMS & peak/√2 voltages
(1 to 100) $kV_{pK \div \sqrt{2}}$ (100 to 200) $kV_{pK \div \sqrt{2}}$	50, 60 Hz 50, 60 Hz	0.14 % 0.18 %	
150 $kV_{pK \div \sqrt{2}}$ 200 $kV_{pK \div \sqrt{2}}$	50, 60 Hz 50, 60 Hz	0.14 % 0.18 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Linearity[3, 11]			Peak AC meter & field probe
(200 to 800) kV	@50, 60 Hz	0.5 %	
AC Voltage[3] – Generate			
(0.22 to 2.2) mV	(10 to 20) Hz	0.024 % + 4 µV	Precision multi-function calibrator
	(20 to 40) Hz	90 µV/V + 4 µV	
	40 Hz to 20 kHz	80 µV/V + 4 µV	
	(20 to 50) kHz	0.02 % + 4.1 µV	
	(50 to 100) kHz	0.05 % + 5.2 µV	
	(100 to 300) kHz	0.11 % + 10 µV	
	(300 to 500) kHz	0.14 % + 20 µV	
	500 kHz to 1 MHz	0.27 % + 22 µV	
(2.2 to 22) mV	(10 to 20) Hz	0.024 % + 4 µV	
	(20 to 40) Hz	90 µV/V + 4 µV	
	40 Hz to 20 kHz	80 µV/V + 4 µV	
	(20 to 50) kHz	0.02 % + 4 µV	
	(50 to 100) kHz	0.05 % + 5 µV	
	(100 to 300) kHz	0.11 % + 10 µV	
	(300 to 500) kHz	0.14 % + 20 µV	
	500 kHz to 1 MHz	0.27 % + 20 µV	
(22 to 220) mV	(10 to 20) Hz	0.024 % + 12 µV	
	(20 to 40) Hz	90 µV/V + 7 µV	
	40 Hz to 20 kHz	57 µV/V + 7 µV	
	(20 to 50) kHz	0.012 % + 7 µV	
	(50 to 100) kHz	0.031 % + 18 µV	
	(100 to 300) kHz	0.066 % + 22 µV	
	(300 to 500) kHz	0.14 % + 25 µV	
	500 kHz to 1 MHz	0.27 % + 45 µV	
220 mV to 2.2 V	(10 to 20) Hz	0.024 % + 40 µV	
	(20 to 40) Hz	90 µV/V + 15 µV	
	40 Hz to 20 kHz	42 µV/V + 8 µV	
	(20 to 50) kHz	67 µV/V + 11 µV	
	(50 to 100) kHz	85 µV/V + 30 µV	
	(100 to 300) kHz	0.034 % + 80 µV	
	(300 to 500) kHz	0.1 % + 200 µV	
	500 kHz to 1 MHz	0.17 % + 300 µV	
(2.2 to 22) V	(10 to 20) Hz	0.024 % + 400 µV	
	(20 to 40) Hz	90 µV/V + 150 µV	
	40 Hz to 20 kHz	42 µV/V + 60 µV	
	(20 to 50) kHz	67 µV/V + 100 µV	
	(50 to 100) kHz	83 µV/V + 200 µV	
	(100 to 300) kHz	0.02 % + 600 µV	
	(300 to 500) kHz	0.1 % + 2 mV	
	500 kHz to 1 MHz	0.15 % + 3.2 mV	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Voltage[3] – Generate (cont)			
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 4 mV 90 µV/V + 1.5 mV 52 µV/V + 0.7 mV 80 µV/V + 1.5 mV 0.015 % + 2.5 mV 0.09 % + 16 mV 0.44 % + 40 mV 0.8 % + 80 mV	Voltage limited to 2.2×10^7 Volt-Hertz
(220 to 250) V	(15 to 50) Hz	0.03 % + 16 mV	
(220 to 1100) V	50 Hz to 1 kHz 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	70 µV/V + 3.5 mV 90 µV/V + 4 mV 0.017 % + 6 mV 0.06 % + 11 mV	With precision amplifier
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.06 % + 11 mV 0.23 % + 45 mV	
AC Current[3] – Generate & Measure			
(0.02 to 0.1) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.021 % + 1.9 nA 0.017 % + 1.4 nA 90 µA/A + 1.4 nA 97 µA/A + 1.4 nA	Precision multi-function calibrators, precision AC/DC transfer standard & precision AC current shunts
(0.03 to 0.1) mA	(10 to 30) kHz	0.013 % + 1.6 nA	
(0.1 to 0.3) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 2.9 nA 86 µA/A + 1.2 nA 62 µA/A + 0.9 nA 82 µA/A + 0.6 nA 98 µA/A + 1.3 nA	
(0.3 to 0.9) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 2.9 nA 81 µA/A + 1 nA 61 µA/A + 0.6 nA 79 µA/A + 0.7 nA 140 µA/A + 0.9 nA	
(0.9 to 1) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % 76 µA/A 59 µA/A 78 µA/A 84 µA/A	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Current[3] – Generate & Measure (cont)			
(1 to 3) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 10 nA 72 µA/A + 13 nA 39 µA/A + 13 nA 39 µA/A + 13 nA 59 µA/A + 19 nA	Precision multi-function calibrators, precision AC/DC transfer standard & precision AC current shunts
(3 to 9) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 1.5 nA 66 µA/A + 12 nA 39 µA/A + 10 nA 38 µA/A + 10 nA 47 µA/A + 20 nA	
(9 to 10) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.016 % 58 µA/A 33 µA/A 33 µA/A 46 µA/A	
(10 to 18) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 1 nA 65 µA/A + 24 nA 37 µA/A + 19 nA 37 µA/A + 19 nA 47 µA/A + 39 nA	
(18 to 20) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.016 % 58 µA/A 33 µA/A 33 µA/A 45 µA/A	
(20 to 44) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % 63 µA/A + 80 nA 35 µA/A + 49 nA 35 µA/A + 49 nA 47 µA/A + 83 nA	
(44 to 50) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.016 % 57 µA/A 30 µA/A 30 µA/A 46 µA/A	
(50 to 88) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % 64 µA/A + 130 nA 36 µA/A + 120 nA 36 µA/A + 120 nA 48 µA/A + 200 nA	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Current[3] – Generate & Measure (cont)			
(88 to 100) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.016 % 59 µA/A 33 µA/A 39 µA/A 46 µA/A	Precision multi-function calibrators, precision AC/DC transfer standard & precision AC current shunts
(100 to 180) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 10 nA 64 µA/A + 350 nA 38 µA/A + 200 nA 37 µA/A + 200 nA 49 µA/A + 390 nA	
(180 to 200) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.016 % 59 µA/A 37 µA/A 36 µA/A 45 µA/A	
(200 to 440) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz	0.017 % + 120 nA 65 µA/A + 860 nA 37 µA/A + 970 nA 37 µA/A + 970 nA 52 µA/A + 1.1 µA	
(440 to 500) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.016 % 58 µA/A 33 µA/A 33 µA/A	
(0.5 to 0.88) A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.017 % 71 µA/A 45 µA/A 46 µA/A	
(0.88 to 1) A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.016 % 59 µA/A 37 µA/A 37 µA/A	
(1 to 1.8) A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.017 % 71 µA/A 45 µA/A 47 µA/A	
(1.8 to 2) A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.016 % 59 µA/A 35 µA/A 38 µA/A	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Current[3] – Generate & Measure (cont)			
(2 to 4.4) A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	0.018 % 76 µA/A 52 µA/A 52 µA/A	Precision multi-function calibrators, precision AC/DC transfer standard & precision AC current shunts
(4.4 to 5) A	40 Hz to 1 kHz (1 to 10) kHz	37 µA/A 38 µA/A	
(5 to 8.8) A	40 Hz to 1 kHz (1 to 10) kHz	48 µA/A + 130 µA 68 µA/A + 97 µA	
(8.8 to 10) A	40 Hz to 1 kHz (1 to 10) kHz	45 µA/A 65 µA/A	
(10 to 18) A	45 Hz to 1 kHz (1 to 5) kHz	55 µA/A + 310 µA 58 µA/A + 300 µA	
(18 to 20) A	45 Hz to 1 kHz (1 to 5) kHz	51 µA/A 59 µA/A	
(20 to 5000) A	60 Hz	0.08 %	Primary current transformers & precision current monitor
AC Current[3] – Measure			
(2 to 200) µA	10 Hz to 10 kHz	0.048 % + 20 nA	Long scale multimeter
200 µA to 2 mA	10 Hz to 10 kHz	0.028 % + 220 nA	
(2 to 20) mA	10 Hz to 10 kHz	0.028 % + 2.2 µA	
(20 to 200) mA	10 Hz to 10 kHz	0.025 % + 21 µA	
200 mA to 2 A	10 Hz to 2 kHz (2 to 10) kHz	0.06 % + 200 µA 0.071 % + 210 µA	
(2 to 20) A	10 Hz to 2 kHz (1 to 10) kHz	0.08 % + 2 mA 0.25 % + 2 mA	
(20 to 5000) A	60 Hz	0.08 %	Current transformer & current meter

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC Current[3] – Generate			
(10 to 220) µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.025 % + 18 nA 0.016 % + 10 nA 0.01 % + 9 nA 0.028 % + 12 nA 0.11 % + 65 nA	Precision multi-function calibrator
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.025 % + 60 nA 0.016 % + 35 nA 0.01 % + 35 nA 0.02 % + 110 nA 0.11 % + 650 nA	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.026 % + 600 nA 0.016 % + 350 nA 0.01 % + 350 nA 0.02 % + 550 nA 0.11 % + 5 µA	
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.025 % + 5 µA 0.016 % + 3.5 µA 0.01 % + 2.5 µA 0.02 % + 3.5 µA 0.11 % + 10 µA	
(0.22 to 2.2) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.024 % + 40 µA 0.045 % + 80 µA 0.70 % + 160 µA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.046 % + 170 µA 0.095 % + 380 µA 0.36 % + 750 µA	With precision amplifier
(29 to 330) µA	(10 to 30) kHz	1.6 % + 0.4 µA	Precision multi-function calibrator
(0.33 to 3.3) mA	(10 to 30) kHz	1 % + 0.6 µA	
(3.3 to 33) mA	(10 to 30) kHz	0.4 % + 4 µA	
(33 to 330) mA	(10 to 30) kHz	0.4 % + 200 µA	
(11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.12 % + 5 mA 0.15 % + 5 mA 3 % + 5 mA	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
Impulse – Exponential Current[3]			
Current	(0.165 to 100) kA	1.4 %	Direct comparison with current shunt & precision data acquisition system
Time Parameters:			
Front (T1)	(1 to 40) µs	1.9 %	
Time to Half-Value (T2)	(10 to 100) µs	1.9 %	
Capacitance[3] – Measure			Precision impedance meter
(10 to 100) pF	1 kHz	0.42 %	
(100 to 1000) pF	1 kHz	0.051 %	
1 nF to 10 µF	1 kHz	0.021 %	
(10 to 100) µF	1 kHz	0.052 %	
100 µF to 1 mF	1 kHz	0.82 %	
(10 to 100) pF	750 Hz to 1 kHz	1.1 %	
	(1 to 5) kHz	0.58 %	
	(5 to 10) kHz	0.87 %	
100 pF to 1 nF	(250 to 500) Hz	0.34 %	
	500 Hz to 10 kHz	0.18 %	
(1 to 10) nF	(50 to 250) Hz	0.34 %	
	250 Hz to 2.5 kHz	0.043 %	
	(2.5 to 7.5) kHz	0.081 %	
	(7.5 to 10) kHz	0.051 %	
	(10 to 50) kHz	0.18 %	
	(50 to 100) kHz	0.33 %	
(10 to 100) nF	(12 to 50) Hz	0.28 %	
	(50 to 100) Hz	0.052 %	
	(100 to 250) Hz	0.041 %	
	250 Hz to 2.5 kHz	0.032 %	
	(2.5 to 5) kHz	0.041 %	
	(5 to 10) kHz	0.051 %	
	(10 to 50) kHz	0.18 %	
	(50 to 100) kHz	0.33 %	
100 nF to 1 µF	(12 to 50) Hz	0.091 %	
	(50 to 100) Hz	0.051 %	
	(100 to 250) Hz	0.041 %	
	250 Hz to 2.5 kHz	0.032 %	
	(2.5 to 5) kHz	0.041 %	
	(5 to 10) kHz	0.052 %	
	(10 to 25) kHz	0.18 %	
	(25 to 50) kHz	0.37 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
Capacitance[3] – Measure (cont)			
(1 to 10) µF	(12 to 50) Hz (50 to 100) Hz (100 to 250) Hz 250 Hz to 2.5 kHz (2.5 to 5) kHz (5 to 7.5) kHz (7.5 to 10) kHz	0.11 % 0.052 % 0.041 % 0.032 % 0.074 % 0.14 % 0.19 %	Precision impedance meter
(10 to 100) µF	(12 to 50) Hz (50 to 100) Hz (100 to 250) Hz 250 Hz to 1 kHz (1 to 2.5) kHz	0.12 % 0.059 % 0.041 % 0.071 % 0.22 %	
100 µF to 1 mF	(12 to 50) Hz (50 to 100) Hz (100 to 250) Hz (250 to 500) Hz 500 Hz to 1 kHz	0.13 % 0.18 % 0.32 % 0.62 % 0.92 %	
(1 to 10) mF	(12 to 50) Hz	0.47 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
Capacitance – Measure on Fluke 55xx Series Calibrators	200 µF 300 µF 0.33 mF 0.7 mF 1.09 mF 1.1 mF 2 mF 3 mF 3.3 mF 10.9 mF 20 mF 30 mF 33 mF 110 mF	0.021 % 0.018 % 0.018 % 0.015 % 0.015 % 0.016 % 0.014 % 0.014 % 0.015 % 0.015 % 0.014 % 0.014 % 0.015 % 0.016 %	Charge technique using a precision DC current source & long scale voltmeter

Parameter/Equipment	Range	CMC[2, 5, 6] (±)	Comments
Capacitance[3] – Generate	(0.19 to 0.3999) nF (0.4 to 1.0999) nF (1.1 to 3.2999) nF (3.3 to 10.9999) nF (11 to 32.9999) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) µF (1.1 to 3.299 99) µF (3.3 to 10.9999) µF (11 to 32.9999) µF (33 to 109.9999) µF (110 to 329.9999) µF (0.33 to 1.099 99) mF (1.1 to 3.2999) mF (3.3 to 10.9999) mF (11 to 32.9999) mF (33 to 110) mF	0.5 % + 0.01 nF 0.5 % + 0.01 nF 0.5 % + 0.01 nF 0.25 % + 0.01 nF 0.25 % + 0.1 nF 0.25 % + 0.1 nF 0.25 % + 0.3 nF 0.25 % + 1 nF 0.25 % + 3 nF 0.25 % + 10 nF 0.4 % + 30 nF 0.45 % + 100 nF 0.45 % + 300 nF 0.45 % + 1 µF 0.45 % + 3 µF 0.45 % + 10 µF 0.75 % + 30 µF 1.1 % + 100 µF	Precision multi-function calibrator with capacitance generation

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
Inductance[3] – Measure			
200 µH to 1 mH	1 kHz	0.071 %	Precision impedance meter
1 mH to 10 H	1 kHz	0.021 %	
200 µH to 1 mH	500 Hz to 1 kHz (1 to 10) kHz (10 to 50) kHz (50 to 100) kHz	0.29 % 0.071 % 0.18 % 0.33 %	
(1 to 10) mH	(50 to 100) Hz (100 to 250) Hz (250 to 500) Hz 500 Hz to 10 kHz (10 to 25) kHz	1.1 % 0.36 % 0.096 % 0.052 % 0.18 %	
(10 to 100) mH	(12 to 50) Hz (50 to 100) Hz (100 to 250) Hz 250 Hz to 2.5 kHz (2.5 to 10) kHz	1.1 % 0.11 % 0.043 % 0.031 % 0.051 %	
100 mH to 10 H	(12 to 50) Hz (50 to 100) Hz (100 to 250) Hz 250 Hz to 1 kHz	0.14 % 0.056 % 0.043 % 0.031 %	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
Phase[3] – Measure			
(0.01 to 0.032) V	20 Hz to 10 kHz (10 to 50) kHz	0.2° 0.35°	Precision phase meter
(0.032 to 100) V	20 Hz to 50 kHz	0.05°	
(100 to 320) V	20 Hz to 5 kHz	0.1°	
Voltage to Current	(20 to 500) Hz	0.05°	Precision phase meter with voltage to current capability
Phase[3] – Generate			
Equal V @ 0°	10 Hz to 250 KHz 250 KHz to 10 MHz	0.005° (f (Hz) x 2.5E^{-8})°	Single source with equal length cables f is frequency
0.000° to ± 999.999°:			
5 V/@ Equal V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	0.0067 ° 0.0066 ° 0.012 ° 0.022 °	Precision phase generator
50 mV to 10 V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	0.020 ° 0.017 ° 0.016 ° 0.041 °	
(10 to 100) V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	0.017 ° 0.017 ° 0.019 ° 0.042 °	
(100 to 120) V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	0.016 ° 0.022 ° 0.032 ° 0.080 °	
Voltage & Current Phase	(10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.1 ° 0.25 ° 0.5 ° 2.5 ° 5 ° 10 °	Precision multi-function calibrator with phase generation

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Calibration of Thermocouple Devices[3] –			
Type B	(600 to 800) ºC (800 to 1000) ºC (1000 to 1550) ºC (1550 to 1820) ºC	0.44 ºC 0.34 ºC 0.3 ºC 0.33 ºC	Precision multi-function calibrator with temperature generation
Type C	(0 to 150) ºC (150 to 650) ºC (650 to 1000) ºC (1000 to 1800) ºC (1800 to 2316) ºC	0.3 ºC 0.26 ºC 0.31 ºC 0.5 ºC 0.84 ºC	
Type E	(-250 to -100) ºC (-100 to -25) ºC (-25 to 350) ºC (350 to 650) ºC (650 to 1000) ºC	0.5 ºC 0.16 ºC 0.14 ºC 0.16 ºC 0.21 ºC	
Type J	(-210 to -100) ºC (-100 to -30) ºC (-30 to 150) ºC (150 to 760) ºC (760 to 1200) ºC	0.27 ºC 0.16 ºC 0.14 ºC 0.17 ºC 0.23 ºC	
Type K	(-200 to -100) ºC (-100 to -30) ºC (-25 to 120) ºC (120 to 1000) ºC (1000 to 1372) ºC	0.33 ºC 0.18 ºC 0.16 ºC 0.26 ºC 0.4 ºC	
Type N	(-200 to -100) ºC (-100 to -25) ºC (-25 to 120) ºC (120 to 410) ºC (410 to 1300) ºC	0.4 ºC 0.22 ºC 0.19 ºC 0.18 ºC 0.27 ºC	
Type R	(0 to 250) ºC (250 to 400) ºC (400 to 1000) ºC (1000 to 1767) ºC	0.57 ºC 0.35 ºC 0.33 ºC 0.4 ºC	
Type S	(0 to 250) ºC (250 to 1000) ºC (1000 to 1400) ºC (1400 to 1767) ºC	0.47 ºC 0.36 ºC 0.37 ºC 0.46 ºC	

Parameter/Equipment	Range	CMC[2, 6] (±)	Comments
Electrical Calibration of Thermocouple Devices[3] – (cont)			
Type T	(-250 to -150) ºC (-150 to 0) ºC (0 to 120) ºC (120 to 400) ºC	0.63 ºC 0.24 ºC 0.16 ºC 0.14 ºC	Precision multi-function calibrator with temperature generation
Type U	(-200 to 0) ºC (0 to 600) ºC	0.56 ºC 0.27 ºC	
Oscilloscope[3] –			
50 Ω Load	(0 to 6.6) V	0.25 % of output + 40 µV	Precision multi-function calibrator with waveform generation
1 MΩ Load	(0 to 130) V	0.05 % of output + 40 µV	
Squarewave Signal:			
50 Ω @ 1 kHz	1.8 mV to 2.2 V_{pk-pk}	0.25 % of output + 40 µV	
1 MΩ @ 10 Hz to 1 kHz	1.8 mV to 105 V_{pk-pk}	0.1 % of output + 40 µV	
1 MΩ @ (1 to 10) kHz	1.8 mV to 105 V_{pk-pk}	0.25 % of output + 40 µV	
Level Sine Wave: Amplitude (50 kHz Reference)	50 kHz 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	2 % + 300 µV 3.5 % + 300 µV 4 % + 300 µV 6 % + 300 µV	
Flatness (50 kHz Reference)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	1.5 % + 100 µV 2 % + 100 µV 4 % + 100 µV	
Time Markers – Generate & Period into a 50 Ω Load	5 s to 50 ms 20 ms to 2 ns	(25 + 1000*t*) parts in 10^6 2.5 parts in 10^6	*t* is the time in seconds
Rise Time –			
≤ 2 MHz > 2 MHz	(24 to 300) ps (24 to 350) ps	+0 ps / -100 ps +0 ps / -100 ps	

Parameter/Equipment	Range	CMC[2, 5, 6] (±)	Comments
Oscilloscope[3] – (cont)			
Wave Generator:			
Amplitude:			
1 MΩ	1.8 mV to 55 V_{pk-pk}	3 % of output + 100 µV	Precision high sampling oscilloscope Δt is the nominal time interval
50 Ω	1.8 mV to 2.5 V_{pk-pk}	3 % of output + 100 µV	
Frequency	10 Hz to 100 kHz	25 parts in 10^6 + 15 mHz	
Time Interval – Measure	100 ps to 100 µs	0.1 % Δt + 10 ps	

III. Electrical – RF/ Microwave

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
Power – Measure[3, 7]			
1 mW, 50 Ω	(10 to 30) MHz	0.41 %	Precision power meter with reference mount & long scale multimeter
(-60 to -30) dBm, 50 Ω	(10 to 30) MHz SWR ≤ 1.4:1	0.13 dB	Precision power meter with precision power sensor
	30 MHz to 4 GHz SWR ≤ 1.15:1	0.13 dB	
	(4 to 10) GHz SWR ≤ 1.2:1	0.13 dB	
(-30 to +20) dBm, 50 Ω	(10 to 15) GHz SWR ≤ 1.3:1	0.13 dB	
	(15 to 18) GHz SWR ≤ 1.35:1	0.14 dB	
	(100 to 300) kHz SWR ≤ 1.6:1	0.13 dB	
	300 kHz to 1 MHz SWR ≤ 1.2:1	0.081 dB	
	1 MHz to 2 GHz SWR ≤ 1.1:1	0.078 dB	
	(2 to 4.2) GHz SWR ≤ 1.3:1	0.1 dB	
	(10 to 30) MHz SWR ≤ 1.4:1	0.069 dB	
	(30 to 50) MHz SWR ≤ 1.18:1	0.069 dB	
	50 MHz to 2 GHz SWR ≤ 1.1:1	0.071 dB	
	(2 to 12.4) GHz SWR ≤ 1.18:1	0.078 dB	
	(12.4 to 18) GHz SWR ≤ 1.28:1	0.097 dB	

IV. Mechanical

Parameter/Equipment	Range	CMC[2, 6, 10] (±)	Comments
Torque Wrenches[3]	(0.4 to 6500) lbf·ft	0.63 %	Precision torque transducer system
Torque Transducers	(5 to 50) lbf·in (10 to 100) lbf·ft (100 to 1000) lbf·ft (650 to 6500) lbf·ft	0.057 % 0.077 % 0.077 % 0.18 %	Class F weights mounted on a precision torque arm
Mass – Measure	2 mg to 10 g (10 to 50) g (50 to 100) g (100 to 210) g (210 to 6200) g (6200 to 32 000) g	0.12 mg 0.14 mg 0.20 mg 0.30 mg 14 mg 130 mg	Comparison to Class 1 standard weights using a balance
Gauge Pressure – Measure & Measuring Equipment	(1 to 50) psig (30 to 1000) psig (1000 to 14 250) psig (14 250 to 24 200) psig	13 parts in 10^6 20 parts in 10^6 36 parts in 10^6 74 parts in 10^6	Primary deadweight tester
Absolute Pressure – Measure & Measuring Equipment	(0 to 50) psia (0 to 1000) psia	13 parts in 10^6 19 parts in 10^6	Primary deadweight tester
Differential Pressure – Measure & Measuring Equipment	(15 to 100) kPa absolute (2.2 to 15) psia	17 parts in 10^6	Primary deadweight tester
Gas Flow – Calibration of Gas Flow Measurement & Control Equipment	(0.02 to 30) slpm (30 to 100) slpm	0.37 % 0.63 %	Primary air flow measurement system
Force – Compression & Tension	(100 to 2000) lbf (2000 to 5000) lbf (5000 to 10 000) lbf (10 000 to 25 000) lbf (25 000 to 50 000) lbf (50 000 to 100 000) lbf	1.6 lbf 2.8 lbf 7.5 lbf 15 lbf 43 lbf 74 lbf	Primary load cell system

Parameter/Equipment	Range	CMC[2] (±)	Comments
Scales & Balances[3]	2 mg to 10 g (10 to 100) g (100 to 210) g (210 to 6200) g (6200 to 32 000) g	0.068 mg 0.17 mg 0.28 mg 8.7 mg 71 mg	Class 1 weights

V. Thermodynamics

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Temperature – Measuring Equipment	(-60 to 232) ºC (232 to 500) ºC	0.03 ºC 0.035 ºC	Precision thermometer with reference SPRT, precision temperature baths
Temperature – Measure	(-200 to 100) °C (100 to 420) °C	0.03 °C 0.034 °C	Precision thermometer with PRT
Infrared Temperature – Measuring Equipment	(-15 to 0) °C (0 to 120) °C (120 to 200) °C (200 to 350) °C (350 to 500) °C	0.8 °C 0.71 °C 0.97 °C 1.8 °C 2.2 °C	Primary infrared temperature blackbody sources ε = 0.9 to 1.0 λ = (8 to 14) µm
Relative Humidity – Measuring Equipment	(10 to 95) % RH	0.51 % RH	Primary 2 pressure humidity generator
Electrical Calibration of Thermocouple Reference Junction	(22 to 25) °C	0.067 °C	Precision temperature indicator & PRT & reference thermocouple

VI. Time & Frequency

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Frequency[3] – Measuring Equipment	0.01 Hz to 2 MHz	2.5 µHz/Hz + 5 µHz	Precision multi-function calibrator
Fixed Point	10 MHz	1.0 nHz/Hz	Rubidium standard
Frequency – Measure	(1 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz 100 kHz to 1 MHz (1 to 10) MHz (10 to 100) MHz (100 to 225) MHz 100 MHz to 1 GHz (1 to 5) GHz (5 to 12.4) GHz	1.8 µHz 1 µHz 10 µHz 100 µHz 1 mHz 10 mHz 100 mHz 230 mHz 1 Hz 5 Hz 12 Hz	Signal generators & precision frequency counter referenced to GPS receiver

SATELLITE FACILITY

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I. Electrical – DC/ Low Frequency

Parameter/Equipment	Range	CMC[2, 5, 6] (±)	Comments
DC High Voltage[3, 7] – Measure & Generate	(1 to 100) kV (100 to 200) kV 150 kV 200 kV	0.02 % 0.08 % 0.06 % 0.06 %	Precision high voltage divider with long scale multimeter
DC High Voltage[3, 7] – Measure	(200 to 700) kV	1.1 %	Precision high voltage divider with long scale multimeter
Partial Discharge – Measure[3]	(-50,000 to -10,000) pC (-10,000 to -100) pC (-100 to 100) pC (100 to 10,000) pC (10,000 to 50,000) pC	2.0 % 1.0 % 1.5 % 1.0 % 2.0 %	(ΔT/R) * Σ Vi technique using long scale multimeter & digital oscilloscope ΔT is the time interval R is the resistance value Σ Vi is the sum of the voltage measurements taken at each time interval

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
AC High Voltage[3, 7] – Generate & Measure			
(1 to 100) kV_{RMS}	50, 60 Hz	0.14 %	Precision high voltage divider with long scale multimeter
(100 to 200) kV_{RMS}	50, 60 Hz	0.18 %	
150 kV_{RMS}	50, 60 Hz	0.14 %	Note: measurements made at RMS & peak/√2 voltages
200 kV_{RMS}	50, 60 Hz	0.18 %	
(1 to 100) $kV_{pK \div \sqrt{2}}$	50, 60 Hz	0.14 %	
(100 to 200) $kV_{pK \div \sqrt{2}}$	50, 60 Hz	0.18 %	
150 $kV_{pK \div \sqrt{2}}$	50, 60 Hz	0.14 %	
200 $kV_{pK \div \sqrt{2}}$	50, 60 H	0.18 %	

Parameter/Range	Frequency	CMC[2, 5, 6] (±)	Comments
High Voltage Capacitance – Measure (5 to 200) kV, 50, 60 Hz	(0.01 to 50) nF	0.19 %	Precision Tan Delta Bridge & high voltage capacitor
High Voltage Capacitance – Generate, Fixed Points (5 to 200) kV, 50, 60 Hz (0.5 to 2) kV, 60 Hz	100 pF 1000 pF 10000 pF	0.16 % 0.19 % 0.19 %	Precision high voltage capacitors
Dissipation Factor – Measure 60 Hz	(0 to 100) DF	0.1 % + 0.000 0037 DF	Precision Tan Delta bridge & standard capacitor
Dissipation Factor – Generate, Fixed Points (0.5 to 2) kV, 60 Hz	0.00005 DF 0.00010 DF 0.00015 DF 0.00050 DF 0.00100 DF 0.05000 DF 0.50000 DF	0.000 021 DF 0.000 021 DF 0.000 021 DF 0.000 021 DF 0.000 021 DF 0.000 062 DF 0.000 062 DF	Precision Tan Delta capacitance standards & dissipation resistors
AC Current[3] – Generate & Measure (20 to 5000) A	60 Hz	0.08 %	Primary current transformers & precision current monitor

[1] This laboratory offers commercial and field 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] Field calibration service is available for this laboratory. 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] In the statement of CMC, *L* is the numerical value of the nominal length of the device measured in inches, *R* is the resolution of the device under test.

[5] 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. CMCs 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.

[6] In the statement of CMC, percentages are percentage of reading, unless otherwise indicated.

[7] The CMC associated with RF Power measurement does not include mismatch.

[8] The CMC claim is smaller than that of the expanded uncertainty claim for NIST as listed in the BIPM Key Comparison Database. A2LA has evaluated the laboratory's CMC claim and has verified this information to be correct and appropriate.

[9] This scope meets A2LA's *P112 Flexible Scope Policy*.

[10] 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.

[11] High Voltage calibrations are performed to internal procedures written to requirements contained within IEEE STD 4, IEC 60060-2, and IEC 60270.

Accredited Laboratory

A2LA has accredited

CONSTELLATION POWERLABS

Coatesville, PA

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, the requirements of ANSI/NCSL Z540.3-2006 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 28th day of August 2023.

Mr. Trace McInturff, Vice President Accreditation Services
For the Accreditation Council
Certificate Number 2044.01
Valid to August 31, 2025

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