



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017
& ANSI NCSLI Z540.1-1996

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CALIBRATION

Valid to: August 31, 2024

Certificate Number: 2462.01

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, 5} ($\pm$)	Comments
DC Voltage – Generate	(0.001 to 0.004) V (0.004 to 0.01) V	23 μ V/V 14 μ V/V	Fluke 5720A into Keithley 262 divider
	Up to 0.22 V (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	6.0 μ V/V + 0.6 μ V 3.5 μ V/V + 0.7 μ V 2.5 μ V/V + 2.5 μ V 2.5 μ V/V + 4 μ V 3.5 μ V/V + 40 μ V 4.5 μ V/V + 0.4 mV	Fluke 5720A (based on 90-day specs)
	(300 to 3000) V	59 μ V/V + 30 mV	Characterized Keithley 2657A, Keithley 2002
	0 V	50 nV	Copper short
	10 V	0.55 μ V/V	Fluke 732B
	100 mV 1 V 100 V 1000 V	1.3 μ V/V 0.61 μ V/V 0.60 μ V/V 0.80 μ V/V	Characterized Fluke 5720A/ Fluke 752A
DC Voltage – Generate ³	Up to 0.2 V (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 500) V (500 to 1000) V	26 μ V/V + 5.1 μ V 15 μ V/V + 7.9 μ V 17 μ V/V + 79 μ V 29 μ V/V + 1 mV 34 μ V/V + 0.92 mV 49 μ V/V + 15 mV	Voltage source, Keithley 2002

Parameter/Equipment	Range	CMC ^{2, 4, 5} ($\pm$)	Comments
DC Voltage – Measure	(0 to 0.01) V	47 μ V/V + 63 nV	Keithley 2182A (based on 90-day specs)
	(0.01 to 0.1) V	3.4 μ V/V + 0.42 μ V	Agilent 3458A (based on 24 hr specs)
	(0.1 to 1) V	2.2 μ V/V + 0.42 μ V	
	(1 to 10) V	1.1 μ V/V + 1 μ V	
	(10 to 100) V	3.3 μ V/V + 42 μ V	
	(100 to 500) V	6.8 μ V/V + 0.16 mV	
	(500 to 1000) V	17 μ V/V + 0.33 mV	
	(300 to 3000) V	59 μ V/V + 25 mV	Voltage divider & Keithley 2002
	10 V	0.55 μ V/V	Fluke 734A 734A/Agilent 3458A
	1.018 V	0.68 μ V/V	
	1 V	0.72 μ V/V	
Fixed Points	100 mV	1.3 μ V/V	Keithley 2182A nullmeter & Fluke 752A, Fluke 734A
	1 V	0.61 μ V/V	
	10 V	0.55 μ V/V	
	100 V	0.60 μ V/V	
	1000 V	0.80 μ V/V	
DC Voltage – Measure ³	Up to 0.2 V (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 500) V (500 to 1000) V	26 μ V/V + 5.1 μ V 15 μ V/V + 7.9 μ V 17 μ V/V + 79 μ V 29 μ V/V + 1 mV 34 μ V/V + 0.92 mV 49 μ V/V + 15 mV	Keithley 2002
DC Current – Generate	Up to 100 nA 100 nA to 1 μ A (1 to 10) μ A (10 to 100) μ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1.05) A (1 to 10) A	36 μ A/A + 59 pA 19 μ A/A + 74 pA 19 μ A/A + 0.15 nA 19 μ A/A + 1.3 nA 12 μ A/A + 4 nA 13 μ A/A + 40 nA 36 μ A/A + 0.94 μ A 0.012 % + 17 μ A 0.038 % + 0.41 mA	Current source characterized w/ Agilent 3458A or Fluke 8508A
	Up to 100 nA 100 nA to 1 μ A (1 to 10) μ A	29 μ A/A + 17 pA 28 μ A/A + 0.12 nA 28 μ A/A + 1.2 nA	Current source characterized w/ Agilent 3458A/shunts
	(1 to 10) A (10 to 20) A (20 to 50) A	76 μ A/A + 0.29 mA 76 μ A/A + 0.93 mA 95 μ A/A + 3.2 mA	Agilent 3458A, 0.1 Ω shunt
Pulsed (1 ms Max)			

Parameter/Equipment	Range	CMC ^{2, 4, 5} (±)	Comments
DC Current – Generate (cont)	(0.2 to 2) pA (2 to 20) pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA (10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA (0.22 to 1) A (1 to 2.2) A (2.2 to 11) A (0 to 100) nA (0.1 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 1.05) A	0.085 % + 4.1 fA 0.085 % + 4.1 fA 0.021 % + 41 fA 0.021 % + 41 fA 0.019 % + 0.41 pA 0.018 % + 4.1 pA 35 µA/A + 6 nA 30 µA/A + 7 nA 30 µA/A + 40 nA 40 µA/A + 0.7 µA 60 µA/A + 12 µA 0.011 % + 12 µA 0.034 % + 0.48 mA 6.7 µA/A + 1.7 pA 6.7 µA/A + 12 pA 6.8 µA/A + 18 pA 6.8 µA/A + 0.13 nA 5.9 µA/A + 0.76 nA 10 µA/A + 6.9 nA 17 µA/A + 0.13 µA 42 µA/A + 1.3 µA	Fluke 5720A, KI 5156 applied to virtual ground current meters Fluke 5720A (based on 90-day specs) Fluke 5725A Keithley 263, Fluke 5450A, Fluke 8508A
DC Current – Generate ³	Up to 1 pA (1 to 10) pA (10 to 100) pA (0.1 to 1) nA (1 to 10) nA (10 to 100) nA (0.1 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	0.049 % + 2 fA 0.049 % + 5.9 fA 0.012 % + 16 fA 0.010 % + 82 fA 75 µA/A + 0.73 pA 65 µA/A + 2.6 pA 50 µA/A + 21 pA 45 µA/A + 0.14 nA 30 µA/A + 1.1 nA 28 µA/A + 12 nA 63 µA/A + 0.12 µA 97 µA/A + 1.4 µA 0.046 % + 19 µA	Current source characterized w/ Keithley 2002 & Keithley 7177

Parameter/Equipment	Range	CMC ^{2, 4, 5} ($\pm$)	Comments
DC Current – Measure	(0.2 to 2) pA	0.076 % + 0.71 fA	Keithley high resistance transfer system plus Keithley 5155 resistors, Keithley 2002
	(2 to 20) pA	0.018 % + 0.77 fA	
	(20 to 200) pA	0.014 % + 3.3 fA	
	(0.2 to 2) nA	0.011 % + 32 fA	
	(2 to 20) nA	79 μ A/A + 0.32 pA	
	(20 to 200) nA	52 μ A/A + 3.2 pA	
	(0.2 to 2) μ A	19 μ A/A + 32 pA	
	Up to 100 nA	36 μ A/A + 59 pA	Agilent 3458A (based on 90-day specs)
	100 nA to 1 μ A	19 μ A/A + 59 pA	
	(1 to 10) μ A	19 μ A/A + 0.13 nA	
Continuous	(10 to 100) μ A	19 μ A/A + 1.1 nA	
	100 μ A to 1 mA	19 μ A/A + 7 nA	
	(1 to 10) mA	19 μ A/A + 70 nA	
	(10 to 100) mA	36 μ A/A + 0.7 μ A	
	100 mA to 1.1 A	0.012 % + 13 μ A	
	(0 to 11) A	67 μ A/A + 48 μ A	Fluke Y5020, Agilent 3458
	(0.1 to 1) pA	0.085 % + 4.1 fA	Keithley 5156 & Agilent 3458A
	(1 to 10) pA	0.085 % + 4.1 fA	
	(10 to 100) pA	0.021 % + 41 fA	
	(0.1 to 1) nA	0.021 % + 41 fA	
	(1 to 10) nA	0.019 % + 0.41 pA	
Pulsed (1 ms Max)	(10 to 100) nA	0.018 % + 4.1 pA	Various resistors & Agilent 3458A
	Up to 100 nA	29 μ A/A + 17 pA	
	(0.1 to 1) μ A	28 μ A/A + 0.12 nA	
	(1 to 10) μ A	28 μ A/A + 1.2 nA	
	(10 to 220) μ A	3.9 μ A/A + 0.15 nA	
	(0.22 to 2.2) mA	3.9 μ A/A + 1.5 nA	
	(2.2 to 22) mA	5.4 μ A/A + 52 nA	
	(22 to 220) mA	4.4 μ A/A + 0.53 μ A	
	(0.22 to 2.2) A	27 μ A/A + 4.3 μ A	
	(1 to 10) A	76 μ A/A + 0.38 mA	
Pulsed (1 ms Max)	(10 to 20) A	76 μ A/A + 0.72 mA	Agilent 3458A, 0.1 Ω shunt
	(20 to 50) A	95 μ A/A + 6.4 mA	

Parameter/Equipment	Range	CMC ^{2, 4, 5} ($\pm$)	Comments
DC Current – Measure ³	Up to 1 pA (1 to 10) pA (10 to 100) pA (0.1 to 1) nA (1 to 10) nA (10 to 100) nA (0.1 to 1) μ A (1 to 10) μ A (10 to 100) μ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	0.049 % + 2 fA 0.049 % + 5.9 fA 0.012 % + 16 fA 0.010 % + 82 fA 75 μ A/A + 0.73 pA 65 μ A/A + 2.6 pA 50 μ A/A + 21 pA 45 μ A/A + 0.14 nA 30 μ A/A + 1.1 nA 28 μ A/A + 12 nA 63 μ A/A + 0.12 μ A 97 μ A/A + 1.4 μ A 0.046 % + 19 μ A	Keithley 2002, Keithley 7177
DC Resistance – Generate	(0 to 1000) Ω	16 $\mu\Omega/\Omega$ + 45 m Ω	Resistors characterized w/ Agilent 3458A
Fixed Points	0.1 Ω 1 Ω 1.9 Ω 10 Ω 100 Ω 1 k Ω 10 k Ω 19 k Ω 100 k Ω 1 M Ω 10 M Ω 19 M Ω 100 M Ω 100 M Ω 900 M Ω 1 G Ω 10 G Ω 100 G Ω 1 T Ω 10 T Ω 0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω	0.78 $\mu\Omega/\Omega$ 0.28 $\mu\Omega/\Omega$ 0.37 $\mu\Omega/\Omega$ 0.56 $\mu\Omega/\Omega$ 0.85 $\mu\Omega/\Omega$ 0.30 $\mu\Omega/\Omega$ 0.18 $\mu\Omega/\Omega$ 0.40 $\mu\Omega/\Omega$ 0.95 $\mu\Omega/\Omega$ 1.2 $\mu\Omega/\Omega$ 3.1 $\mu\Omega/\Omega$ 6.5 $\mu\Omega/\Omega$ 36 $\mu\Omega/\Omega$ 74 $\mu\Omega/\Omega$ 0.014 % 97 $\mu\Omega/\Omega$ 0.013 % 0.018 % 0.07 % 0.57 % 40 $\mu\Omega$ 80 $\mu\Omega/\Omega$ 80 $\mu\Omega/\Omega$ 21 $\mu\Omega/\Omega$ 21 $\mu\Omega/\Omega$ 9 $\mu\Omega/\Omega$ 9 $\mu\Omega/\Omega$ 7.5 $\mu\Omega/\Omega$ 7.5 $\mu\Omega/\Omega$ 7.5 $\mu\Omega/\Omega$ 7.5 $\mu\Omega/\Omega$ 9 $\mu\Omega/\Omega$	MI 6010B system w/ standard resistors MI 6000B system w/ standard resistors Keithley high resistance transfer system Fluke 5720A (based on 90-day specs)

Parameter/Equipment	Range	CMC ^{2, 4, 5} ($\pm$)	Comments
DC Resistance – Generate, Fixed Points (cont)	190 k Ω 1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω 1 Ω 10 Ω	9 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 16 $\mu\Omega/\Omega$ 31 $\mu\Omega/\Omega$ 39 $\mu\Omega/\Omega$ 95 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$ 11 $\mu\Omega/\Omega$	Fluke 5720A (based on 90-day specs) R-source characterized w/ Fluke 8508A
DC Resistance – Generate, Fixed Points ³	10 Ω 100 Ω 1 k Ω 10 k Ω 100 k Ω 1 M Ω 10 M Ω 100 M Ω 1 G Ω 10 G Ω 100 G Ω	96 $\mu\Omega/\Omega$ 61 $\mu\Omega/\Omega$ 24 $\mu\Omega/\Omega$ 27 $\mu\Omega/\Omega$ 42 $\mu\Omega/\Omega$ 48 $\mu\Omega/\Omega$ 63 $\mu\Omega/\Omega$ 74 $\mu\Omega/\Omega$ 0.01 % 0.012 % 0.049 %	Keithley 7177
DC Resistance – Measure	0.01 Ω (0.1 to 10) Ω (> 10 to 100) Ω (> 100 to < 1000) Ω 1 k Ω (> 1 to 10) k Ω (> 10 to 100) k Ω > 100 k Ω to 1 M Ω (> 1 to 10) M Ω (> 10 to 100) M Ω > 100 M Ω to 1 G Ω (85 to 115) M Ω (0.85 to 1.15) G Ω (8.5 to 11.5) G Ω (85 to 115) G Ω (0.85 to 1.15) T Ω (8.5 to 11.5) T Ω	31 $\mu\Omega/\Omega$ 0.3 $\mu\Omega/\Omega$ 0.72 $\mu\Omega/\Omega$ 0.72 $\mu\Omega/\Omega$ 0.22 $\mu\Omega/\Omega$ 0.32 $\mu\Omega/\Omega$ 0.2 $\mu\Omega/\Omega$ 0.9 $\mu\Omega/\Omega$ 3.1 $\mu\Omega/\Omega$ 5 $\mu\Omega/\Omega$ 40 $\mu\Omega/\Omega$ 64 $\mu\Omega/\Omega$ 87 $\mu\Omega/\Omega$ 0.012 % 0.013 % 0.051 % 0.27 %	Standard shunt, current transfer MI 6010B & standard resistors MI 6010B & standard resistors MI 6000B system w/ standard resistors Keithley high resistance transfer system

Parameter/Equipment	Range	CMC ^{2, 6} ($\pm$)	Comments
Thermocouple Simulation – Generate Thermocouple Type: K	(-25 to 150) °C	0.50 °C	Ectron 1140A (1120 emulation mode), TC simulator

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
AC Current – Generate			
(0 to 220) μ A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.023 % + 16 nA 0.014 % + 10 nA 0.011 % + 8 nA 0.025 % + 12 nA 0.09 % + 65 nA	Fluke 5720A (based on 90-day specs)
220 μ A 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	0.023 % + 40 nA 0.014 % + 35 nA 0.011 % + 35 nA 0.018 % + 0.11 μ A 0.09 % + 0.65 μ A	
(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	0.023 % + 0.4 μ A 0.014 % + 0.35 μ A 0.011 % + 0.35 μ A 0.018 % + 0.55 μ A 0.090 % + 5 μ A	
(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	0.023 % + 4 μ A 0.014 % + 3.6 μ A 0.011 % + 2.5 μ A 0.018 % + 3.5 μ A 0.09 % + 10 μ A	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.024 % + 35 μ A 0.039 % + 80 μ A 0.6 % + 0.16 mA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.04 % + 0.17 mA 0.085 % + 0.38 mA 0.33 % + 0.75 mA	Plus 5725A amplifier

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
AC Current – Measure			
Fixed Points			
190 μ A	10 Hz	0.017 %	Fluke 5790A w/ external current shunts
	20 Hz	59 μ A/A	
	40 Hz	23 μ A/A	
	400 Hz	23 μ A/A	
	1 kHz	23 μ A/A	
	5 kHz	23 μ A/A	
	10 kHz	23 μ A/A	
1.9 mA	10 Hz	0.017 %	
	20 Hz	58 μ A/A	
	40 Hz	22 μ A/A	
	400 Hz	22 μ A/A	
	1 kHz	22 μ A/A	
	5 kHz	51 μ A/A	
	10 kHz	0.018 %	
19 mA	10 Hz	0.017 %	
	20 Hz	69 μ A/A	
	40 Hz	36 μ A/A	
	400 Hz	36 μ A/A	
	1 kHz	36 μ A/A	
	5 kHz	36 μ A/A	
	10 kHz	36 μ A/A	
190 mA	10 Hz	0.017 %	
	20 Hz	72 μ A/A	
	40 Hz	36 μ A/A	
	400 Hz	36 μ A/A	
	1 kHz	36 μ A/A	
	5 kHz	36 μ A/A	
	10 kHz	40 μ A/A	
1.9 A	20 Hz	0.018 %	Fluke 5790A w/ external current shunts
	40 Hz	54 μ A/A	
	400 Hz	54 μ A/A	
	1 kHz	54 μ A/A	
	5 kHz	54 μ A/A	
	10 kHz	65 μ A/A	
10 A	40 Hz	0.011 %	
	400 Hz	0.011 %	
	1 kHz	0.011 %	
	5 kHz	0.011 %	
	10 kHz	0.014 %	

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
AC Current – Measure (cont)			
(5 to 100) μ A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.47 % + 35 nA 0.18 % + 35 nA 0.069 % + 35 nA 0.069 % + 35 nA	Agilent 3458A
(0.1 to 1) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.47 % + 0.23 μ A 0.18 % + 0.23 μ A 0.069 % + 0.23 μ A 0.035 % + 0.23 μ A	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.47 % + 2.3 μ A 0.19 % + 2.3 μ A 0.069 % + 2.3 μ A 0.035 % + 2.3 μ A	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.47 % + 23 μ A 0.18 % + 23 μ A 0.069 % + 23 μ A 0.035 % + 23 μ A	
(0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.47 % + 0.23 mA 0.19 % + 0.23 mA 0.092 % + 0.23 mA 0.12 % + 0.23 mA	
AC Voltage – Generate			
(0 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	0.022 % + 4 μ V 85 μ V/V + 4 μ V 75 μ V/V + 4 μ V 0.018 % + 4 μ V 0.046 % + 5 μ V 0.09 % + 10 μ V 0.12 % + 20 μ V 0.25 % + 20 μ V	Fluke 5720A (based on 90-day specs)
(22 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	0.022 % + 12 μ V 85 μ V/V + 7.2 μ V 75 μ V/V + 7 μ V 0.018 % + 7 μ V 0.042 % + 17 μ V 0.075 % + 20 μ V 0.12 % + 25 μ V 0.25 % + 45 μ V	
220 mV to 2.2 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	0.022 % + 40 μ V 80 μ V/V + 17 μ V 40 μ V/V + 8.0 μ V 70 μ V/V + 10 μ V	

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
AC Voltage – Generate (cont)			
220 mV to 2.2 V	(50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.011 % + 30 μ V 0.034 % + 80 μ V 0.09 % + 0.2 mV 0.15 % + 0.3 mV	Fluke 5720A
(2.2 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	0.022 % + 0.4 mV 80 μ V/V + 0.16 mV 40 μ V/V + 50 μ V 70 μ V/V + 0.1 mV 95 μ V/V + 0.2 mV 0.026 % + 0.6 mV 0.09 % + 2 mV 0.13 % + 3.2 mV	
(22 to 220) V (Limited to 2.2×10^7 V·Hz)	(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	0.022 % + 4 mV 80 μ V/V + 1.7 mV 47 μ V/V + 0.6 mV 75 μ V/V + 1 mV 0.013 % + 2.5 mV 0.08 % + 16 mV 0.42 % + 40 mV 0.7 % + 80 mV	
For the 1100 V Range:			
(220 to 250) V	(15 to 40) Hz	0.026 % + 16 mV	Fluke 5720A, Fluke 5725A
(220 to 1100) V	(40 to 50) Hz 50 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	80 μ V/V + 4 mV 60 μ V/V + 3.5 mV 0.013 % + 6 mV 0.036 % + 11 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.036 % + 11 mV 0.13 % + 45 mV	
AC Voltage – Measure			
Up 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	0.13 % + 1 μ V 0.057 % + 1 μ V 0.033 % + 1 μ V 0.063 % + 1.6 μ V 0.093 % + 1.9 μ V 0.18 % + 3.1 μ V 0.19 % + 6.2 μ V 0.27 % + 6.3 μ V	Fluke 5790A
(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	0.066 % + 1 μ V 0.029 % + 1 μ V 0.016 % + 1 μ V 0.031 % + 1.6 μ V 0.047 % + 1.9 μ V	

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
AC Voltage – Measure (cont)			
(2.2 to 7) mV	(100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.093 % + 3.1 μ V 0.1 % + 6.2 μ V 0.18 % + 6.2 μ V	Fluke 5790A
(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	0.022 % + 1 μ V 0.015 % + 1 μ V 85 μ V/V + 1 μ V 0.016 % + 1.6 μ V 0.024 % + 1.9 μ V 0.063 % + 3.1 μ V 0.069 % + 6.2 μ V 0.13 % + 6.3 μ V	
(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	0.019 % + 1.2 μ V 93 μ V/V + 1.2 μ V 50 μ V/V + 1.2 μ V 0.01 % + 1.6 μ V 0.02 % + 1.9 μ V 0.40 % + 3.1 μ V 0.052 % + 6.2 μ V 0.085 % + 6.2 μ V	
(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	0.016 % + 1.9 μ V 66 μ V/V + 1.3 μ V 29 μ V/V + 1.2 μ V 53 μ V/V + 1.6 μ V 0.012 % + 2 μ V 0.019 % + 3.7 μ V 0.029 % + 6.2 μ V 0.078 % + 6.8 μ V	
(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	0.016 % + 1.2 μ V 59 μ V/V + 1.2 μ V 26 μ V/V + 1.2 μ V 40 μ V/V + 1.6 μ V 61 μ V/V + 1.9 μ V 0.014 % + 3.1 μ V 0.023 % + 6.2 μ V 0.074 % + 6.2 μ V	
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	0.016 % + 14 μ V 51 μ V/V + 4.4 μ V 19 μ V/V + 2.5 μ V 36 μ V/V + 1.6 μ V 55 μ V/V + 2.4 μ V 0.012 % + 16 μ V 0.02 % + 5.1 μ V 0.07 % + 16 μ V	

Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
AC Voltage – Measure (cont)			
(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	0.016 % + 0.6 µV 52 µV/V + 0.6 µV 19 µV/V + 0.6 µV 37 µV/V + 0.6 µV 63 µV/V + 0.6 µV 0.015 % + 0.6 µV 0.031 % + 0.6 µV 0.093 % + 0.6 µV	Fluke 5790A
(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	0.016 % + 0.16 mV 52 µV/V + 38 µV 21 µV/V + 19 µV 37 µV/V + 21 µV 63 µV/V + 27 µV 0.015 % + 0.24 mV 0.031 % + 0.17 mV 0.093 % + 0.5 mV	
(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	0.016 % + 1.4 mV 53 µV/V + 0.77 mV 24 µV/V + 0.49 mV 53 µV/V + 0.36 mV 76 µV/V + 0.38 mV 0.016 % + 0.38 mV	
(700 to 1000) V	40 Hz to 20 kHz (20 to 50) kHz	29 µV/V + 0.77 mV 0.01 % + 58 µV	
(10 to 100) mV	10 MHz	5.3 %	Digital oscilloscope
Capacitance – Generate			
Up to 0.7 nF 1 nF 10 nF (10 to 100) nF (0.1 to 1) µF	1 kHz	0.51 % + 0.53 pF 0.59 % 0.078 % 0.063 % + 7.2 pF 0.063 % + 72 pF	IET 1423-9801
(1 to 10) µF (10 to 100) µF	100 Hz	0.057 % + 0.74 nF 0.057 % + 7.2 nF	IET HACS-Z-A-3E-1 µF
Fixed Point 100 µF	100 Hz	0.082 %	

Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
AC Voltage Flatness – Measure			
1 mV	10 kHz	0.05 %	Fluke 5790A
	121 kHz	0.14 %	
	500 kHz	0.14 %	
	2.1 MHz	0.22 %	
	5 MHz	0.22 %	
	10.1 MHz	0.32 %	
	20.1 MHz	0.71 %	
	30 MHz	0.71 %	
3 mV	10 kHz	0.044 %	
	121 kHz	0.081 %	
	500 kHz	0.081 %	
	2.1 MHz	0.11 %	
	5 MHz	0.11 %	
	10.1 MHz	0.16 %	
	20.1 MHz	0.34 %	
	30 MHz	0.34 %	
10 mV	10 kHz	0.041 %	
	121 kHz	0.055 %	
	500 kHz	0.055 %	
	2.1 MHz	0.079 %	
	5 MHz	0.079 %	
	10.1 MHz	0.14 %	
	20.1 MHz	0.29 %	
	30 MHz	0.29 %	
30 mV	10 kHz	0.042 %	
	121 kHz	0.042 %	
	500 kHz	0.042 %	
	2.1 MHz	0.08 %	
	5 MHz	0.08 %	
	10.1 MHz	0.12 %	
	20.1 MHz	0.28 %	
	30 MHz	0.28 %	
100 mV	10 kHz	0.031 %	
	121 kHz	0.031 %	
	500 kHz	0.04 %	
	2.1 MHz	0.079 %	
	5 MHz	0.079 %	
	10.1 MHz	0.12 %	
	20.1 MHz	0.28 %	
	30 MHz	0.28 %	

Parameter/Range	Frequency	CMC ^{2, 4, 5} (±)	Comments
AC Voltage Flatness – Measure (cont)			
300 mV	10 kHz 121 kHz 500 kHz 2.1 MHz 5 MHz 10.1 MHz 20.1 MHz 30 MHz	0.022 % 0.022 % 0.041 % 0.08 % 0.08 % 0.12 % 0.28 % 0.28 %	Fluke 5790A
1 V	10 kHz 121 kHz 500 kHz 2.1 MHz 5 MHz 10.1 MHz 20.1 MHz 30 MHz	0.021 % 0.021 % 0.04 % 0.079 % 0.079 % 0.12 % 0.28 % 0.28 %	
3 V	10 Hz 31 Hz 10 kHz 121 kHz 500 kHz 2.1 MHz 5 MHz 10.1 MHz 20.1 MHz 30 MHz	0.082 % 0.022 % 0.022 % 0.022 % 0.041 % 0.08 % 0.08 % 0.12 % 0.28 % 0.28 %	
4 Terminal Parallel Capacitance – Generate			
1 pF	1 MHz 10 MHz	0.52 fF 3.9 fF	Set of standard capacitors from 1 pF to 100 nF
10 pF	100 kHz 1 MHz 10 MHz	2.3 fF 1.8 fF 10 fF	
100 pF	10 kHz 100 kHz 1 MHz 10 MHz	25 fF 18 fF 17 fF 97 fF	

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
4 Terminal Parallel Capacitance – Generate (cont)			
1000 pF	1 kHz 10 kHz 100 kHz 1 MHz 10 MHz	0.65 pF 0.20 pF 0.19 pF 0.20 pF 2.2 pF	Set of standard capacitors from 1 pF to 100 nF
10 nF	1 kHz 10 kHz 100 kHz	2.2 pF 1.9 pF 2.0 pF	
100 nF	1 kHz 10 kHz	22 pF 23 pF	
4 Terminal Parallel Conductance – Generate			
1 pF, (1 to 17) nS 1 pF, (5 to 200) nS	1 MHz 10 MHz	1.8 nS 89 nS	Keithley 4200-CVU-CAL-KIT, 5880-SRU
10 pF, (0.1 to 1.4) nS 10 pF, (2.2 to 17) nS 10 pF, (2 to 3) μ S	100 kHz 1 MHz 10 MHz	1.0 nS 2.5 nS 0.36 μ S	
100 pF, (1 to 22) nS 100 pF, (7.1 to 19.2) nS 100 pF, (0.26 to 122) nS 100 pF, (13 to 30) μ S	10 kHz 100 kHz 1 MHz 10 MHz	0.72 nS 2.5 nS 21 nS 1.5 μ S	
1000 pF, (1.4 to 2.8) nS 1000 pF, (8 to 31) nS 1000 pF, (122 to 535) nS 1000 pF, 1.7 nS to 14.2 μ S 1000 pF, (68 to 695) nS	1 kHz 10 kHz 100 kHz 1 MHz 10 MHz	2.7 nS 2.9 nS 23 nS 0.31 μ S 45 μ S	
10 nF, (0.07 to 9.6) nS 10 nF, (1.4 to 40) nS 10 nF, (67 to 324) nS	1 kHz 10 kHz 100 kHz	5.9 nS 27 nS 0.35 μ S	
100 nF, (34.4 to 68) nS 100 nF, (111 to 404) nS	1 kHz 10 kHz	39 nS 0.42 μ S	

Parameter/Range	Frequency	CMC ^{2, 4} ($\pm$)	Comments
4 Terminal AC Resistance – Generate 100 Ω 4.3 m Ω	1 kHz	49 m Ω 8.3 m Ω	Keithley 4200-CVU- CAL-KIT
4 Terminal Parallel Capacitance – Measure 1 pF 10 pF 100 pF 1000 pF 10 nF 100 nF	1 MHz 10 MHz 100 kHz 1 MHz 10 MHz 10 kHz 100 kHz 1 MHz 10 MHz 1 kHz 10 kHz 100 kHz 1 MHz 10 MHz 1 kHz 10 kHz 100 kHz 1 kHz 10 kHz	0.41 fF 3.4 fF 2.1 fF 1.8 fF 8.5 fF 18 fF 18 fF 17 fF 90 fF 0.21 pF 0.19 pF 0.19 pF 0.20 pF 2.2 pF 2.0 pF 2.0 pF 2.1 pF 23 pF 24 pF	Agilent 16380A & 16380C standard capacitors sett, Agilent 42036A, Agilent 4294A
4 Terminal Parallel Conductance – Measure 1 pF, (1 to 17) nS 1 pF, (5 to 200) nS	1 MHz 10 MHz	0.45 nS 37 nS	Agilent 16380A & 16380C standard capacitor sets, Agilent 42036A, Agilent 4294A

Parameter/Range	Frequency	CMC ^{2, 4, 5} ($\pm$)	Comments
4 Terminal Parallel Conductance – Measure (cont)			
10 pF, (0.1 to 1.4) nS	100 kHz	0.78 nS	Agilent 16380A & 16380C standard capacitor sets, Agilent 42036A, Agilent 4294A
10 pF, (2.2 to 17) nS	1 MHz	1.7 nS	
10 pF, (2 to 3) μ S	10 MHz	47 nS	
100 pF, (1 to 2.2) nS	10 kHz	0.30 nS	
100 pF, (7.1 to 19.20) nS	100 kHz	2.2 nS	
100 pF, (0.26 to 122) nS	1 MHz	16 nS	
100 pF, (13 to 30) μ S	10 MHz	1.1 μ S	
1000 pF, (1.4 to 2.8) nS	1 kHz	0.37 nS	
1000 pF, (8 to 31) nS	10 kHz	2.7 nS	
1000 pF, (122 to 535) nS	100 kHz	22 nS	
1000 pF, 1.7 nS to 14.2 μ S	1 MHz	0.31 μ S	
1000 pF, (68 to 695) nS	10 MHz	44 μ S	
10 nF, (0.07 to 9.6) nS	1 kHz	3.1 nS	
10 nF, (1.4 to 40) nS	10 kHz	25 nS	
10 nF, (67 to 324) nS	100 kHz	0.35 μ S	
100 nF, (34.4 to 68) nS	1 kHz	23 nS	
100 nF, (111 to 404) nS	10 kHz	0.42 μ S	
4 Terminal AC Resistance – Measure			
100 Ω 4.3 m Ω	1 kHz	49 m Ω 4.8 m Ω	Keysight 42036A, Keysight 4294A, Keithley 2002
Pulse Characterization – Measure, Fixed Points ³			
Overshoot	0.5 V 2 V 5 V 20 V	1.3 % 0.23 % 0.16 % 0.11 %	Oscilloscope Tektronix DPO7x54, TDS5054B

Parameter/Equipment	Range	CMC ^{2, 4} ($\pm$)	Comments
Pulse Characterization – Measure, Fixed Points (cont)			
Preshoot	20 mV 80 mV	11 mV 19 mV	Oscilloscopes Tektronix DP07x54, TDS5054B
Pulse Width	500 ns	0.11 ns	
Settling Time	0 s	2.3 ns	
RMS Jitter	0 s	12 ps	
Slew Rate	0.5 V/ns 0.2 V/ns	0.019 V/ns 0.0060 V/ns	

II. Time & Frequency

Parameter/Equipment	Range	CMC ^{2, 5, 8} ($\pm$)	Comments
Frequency – Measuring Equipment	(1 to 10) Hz 10 Hz to 1 kHz 1 kHz to 20 MHz	6.2 μ Hz/Hz 5.9 μ Hz/Hz 5.9 μ Hz/Hz	Agilent 33220A & Fluke 910R
Fixed Point	10 MHz	33 pHz/Hz	Fluke 910R
Frequency – Measure	10 Hz to 30 MHz	0.02 μ Hz/Hz	Agilent 53131A & Fluke 910R
Time Interval – Measure ³	500 ns	13 ns	Oscilloscopes Tektronix DPO7x54, TDS5054B

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 Field calibration service is available for this calibration. 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 CMC is $[\mu X/X \text{ of Reading}] + \text{offset}$ (where listed) for the ranges indicated in the Parameter/Equipment column of table, where "X" equals V, Ω , A or Hz, percentages are percentages of reading, unless otherwise indicated
- ⁶ Electrically simulated thermocouple temperatures. CMC is expressed as a specific value relative to the indicated value.
- ⁷ This scope 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

KEITHLEY PRIMARY STANDARDS LABORATORY

Cleveland, OH

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 8th day of August 2022.

A blue ink signature of a person, likely the Vice President of Accreditation Services, written over a horizontal line.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2462.01
Valid to August 31, 2024

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