



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

TRU CAL INTERNATIONAL, INC.
401 Country Club Drive
Bensenville, IL 60106
Scott Miller Phone: 630 238 8100

CALIBRATION

Valid to: April 30, 2024

Certificate Number: 1278.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory at the location listed above as well as the satellite laboratory location listed below to perform the following calibrations^{1, 7}:

I. Acoustical

Parameter/Frequency	Range	CMC ² (±)	Comments
Sound Level Meters – Measure at 1000 Hz	94 dB 114 dB	0.40 dB 0.40 dB	Larson Davis CAL200

II. Dimensional

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Dial Indicators ³	Up to 1 in	76 µin	Dial indicator calibrator
Micrometers ³ – Inside, Outside	Up to 8 in (6 to 18) in	(22 + 18L) µin (68 + 20L) µin	Gage blocks Step gage
Calipers ³	Up to 8 in (8 to 18) in	(280 + 6.1L) µin (280 + 9.8L) µin	Gage blocks with surface plate Step gage

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Height Gages ³	Up to 18 in	$(52 + 17L) \mu\text{in}$	Reference bar with MuMeter
Pin Gages ³	Up to 1 in	47 μin	Bench mic with gage blocks
Steel Rules 1/16 1/32	Up to 12 in Up to 12 in	0.036 in 0.018 in	Grade 3 gage blocks
Tape Measures	Up to 50'	0.02 in + 0.000 047 in/in	Steel rule
Thickness Gages ³ – Blade Dial	Up to 1 in Up to 1 in	47 μin $(280 + 13L) \mu\text{in}$	Bench mic gage blocks

III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 5, 6} (±)	Comments
DC Voltage – Measure ³	Up to 200 mV 200 mV to 2 V (1 to 20) V (20 to 200) V (200 to 1000) V	0.0001 mV + 0.000 005 V/V 0.000 000 41 V + 0.000 003 5 V/V 0.000 004 1 V + 0.000 003 5 V/V 0.000 042 V + 0.000 005 5 V/V 0.000 52 V + 0.000 005 5 V/V	Fluke 8508
DC High Voltage – Measure ³	(1 to 30) kV (31 to 120) kV	0.018 % 0.14 %	Ross VD30 Ross VD120
DC Voltage – Generate ³	(0 to 220) mV 220 mV to 2.2V (2.2 to 11) V	9.1 $\mu\text{V/V}$ + 0.4 μV 4.4 $\mu\text{V/V}$ + 0.7 μV 3 $\mu\text{V/V}$ + 2.5 μV	Fluke 5720A (using artifact calibrations)

Parameter/Equipment	Range	CMC ^{2, 5, 6} ($\pm$)	Comments
DC Voltage – Generate ³ (cont)	(11 to 22) V (22 to 220) V (220 to 1100) V	3 μ V/V + 4 μ V 4.3 μ V/V + 40 μ V 5 μ V/V + 0.4 mV	Fluke 5720A (using artifact calibrations)
DC Voltage – Generate, Fixed Points	10 V	1.8 μ V/V	Fluke 732B
DC Current – Measure ³	Up to 100 nA 100 nA to 1 μ A (1 to 10) μ A (10 to 200) μ A 200 μ A to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (1 to 2) A (2 to 10) A (10 to 20) A (20 to 100) A	43 μ A/A + 0.04 nA 28 μ A/A + 0.04 nA 24 μ A/A + 0.1 nA 0.000 41 μ A + 0.000 012 A/A 0.000 004 mA + 0.000 012 A/A 0.000 041 mA + 0.000 14 A/A 0.0008 mA + 0.000 048 A/A 0.000 016 A + 0.000 190 A/A 59 μ A/A 75 μ A/A 0.015 % 0.077 %	HP 3458A opt 002 Fluke 8508A HP 3458A with L&N 4221B current shunt HP 3458A with L&N 4222B HP 3458A with Fluke Y5020 Valhalla 2575A
DC Current – Generate ³	(0 to 220) μ A 220 μ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 10.9999) A (11 to 20) A (20 to 100) A	39 μ A/A + 6 nA 33 μ A/A + 7 nA 36 μ A/A + 40 nA 44 μ A/A + 0.7 μ A* 66 μ A/A + 12 μ A** 0.039 % + 0.5 mA 0.042 % + 0.03 % of range 0.068 % + 0.03 % of range	Fluke 5720A (using artifact calibrations) *Add (200 x I ₂) μ A/A for I > 100 mA **Add (10 x I ₂) μ A/A for I > 1 A Fluke 5522A Fluke 5500A Valhalla 2555A

Parameter/Equipment	Range	CMC ^{2, 5, 6} ($\pm$)	Comments
DC Current – Generate ³ (cont)			
Clamp-On Only Toroidal	(20 to 1000) A	0.47 % + 0.05 A	Fluke 5522A w/ Fluke 5500 coil
Non-Toroidal	(20 to 1000) A	0.58 % + 0.5 A	
Resistance – Measure ³	Up to 2 Ω (2 to 20) Ω 20 Ω to 2 k Ω (2 to 20) k Ω (20 to 200) k Ω 200 k Ω to 2 M Ω (2 to 20) M Ω (20 to 200) M Ω 200 M Ω to 2 G Ω (2 to 20) G Ω	0.000 004 2 Ω + 0.000 017 Ω/Ω 0.000 014 Ω + 0.000 097 Ω/Ω 0.000 000 53 Ω + 0.000 008 2 Ω/Ω 0.000 005 8 k Ω + 0.000 008 14 Ω/Ω 0.000 056 k Ω + 0.000 082 Ω/Ω 0.000 001 1 M Ω + 0.000 009 2 Ω/Ω 0.0001 M Ω + 0.000 020 Ω/Ω 0.0095 M Ω + 0.0013 Ω/Ω 0.0001 G Ω + 0.000 18 Ω/Ω 0.01 G Ω + 0.0015 Ω/Ω	Fluke 8508
Resistance – Generate, Fixed Values ³	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω (1, 1.9) k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω 1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω	93 $\mu\Omega/\Omega$ 86 $\mu\Omega/\Omega$ 26 $\mu\Omega/\Omega$ 27 $\mu\Omega/\Omega$ 12 $\mu\Omega/\Omega$ 11 $\mu\Omega/\Omega$ 8.8 $\mu\Omega/\Omega$ 8.6 $\mu\Omega/\Omega$ 8.7 $\mu\Omega/\Omega$ 10 $\mu\Omega/\Omega$ 11 $\mu\Omega/\Omega$ 18 $\mu\Omega/\Omega$ 19 $\mu\Omega/\Omega$ 35 $\mu\Omega/\Omega$ 44 $\mu\Omega/\Omega$ 0.013 %	Fluke 5720A (using artifact calibrations)

Parameter/Equipment	Range	CMC ^{2, 6} ($\pm$)	Comments
Resistance – Generate	(0 to 10.999) Ω (11 to 32.999) Ω (33 to 109.999) Ω (110 to 329.999) Ω 330 Ω to 1.0999 k Ω (1.1 to 3.299) k Ω (3.3 to 10.999) k Ω (11 to 32.999) k Ω (33 to 109.99) k Ω (110 to 329.999) k Ω 330 k Ω to 1.0999 M Ω (1.1 to 3.299) M Ω (3.3 to 10.999) M Ω (11 to 32.999) M Ω (33 to 109.999) M Ω (110 to 329.999) M Ω (330 to 1100) M Ω	46 $\mu\Omega/\Omega$ + 0.001 Ω 27 $\mu\Omega/\Omega$ + 0.0015 Ω 24 $\mu\Omega/\Omega$ + 0.0014 Ω 24 $\mu\Omega/\Omega$ + 0.002 Ω 23 $\mu\Omega/\Omega$ + 0.002 Ω 23 $\mu\Omega/\Omega$ + 0.02 Ω 24 $\mu\Omega/\Omega$ + 0.02 Ω 24 $\mu\Omega/\Omega$ + 0.2 Ω 24 $\mu\Omega/\Omega$ + 0.2 Ω 26 $\mu\Omega/\Omega$ + 2 Ω 26 $\mu\Omega/\Omega$ + 2 Ω 54 $\mu\Omega/\Omega$ + 30 Ω 0.011 % + 50 Ω 0.022 % + 2.5 k Ω 0.039 % + 3 k Ω 0.24 % + 0.1 M Ω 1.2 % + 0.5 M Ω	Fluke 5522A

Parameter/Equipment	Frequency	CMC ^{2, 5, 6} ($\pm$)	Comments
AC High Voltage – Measure ³			
Up to 21 kV (20 to 85) kV	60 Hz 60 Hz	0.71 % 0.99 %	Ross VD30 Ross VD120
AC Voltage – Measure ³			
200 mV	(1 to 10) Hz (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	0.014 mV + 0.000 17 V / V 0.0035 mV + 0.000 3 V/V 0.004 mV + 0.000 12 V / V 0.002 mV + 0.000 11 V / V 0.002 mV + 0.000 11 V / V 0.008 mV + 0.000 34 V / V 0.02 mV + 0.000 77 V / V	Fluke 8508
2 V	(1 to 10) Hz (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	0.000 12 V + 0.000 15 V/V 0.000 021 V + 0.000 12 V/V 0.000 02 V + 0.000 093 V/V 0.000 021 V + 0.000 077 V/V 0.000 021 V + 0.000 11 V/V 0.000 04 V + 0.000 22 V/V 0.0002 V + 0.000 57 V/V 0.002 V + 0.003 V/V 0.02 V + 0.01 V/V	

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
AC Voltage – Measure ³ (cont)			Fluke 8508
20 V	(1 to 10) Hz (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	0.0012 V + 0.001 52 V/V 0.000 18 V + 0.001 16 V/V 0.000 18 V + 0.000 91 V/V 0.0002 V + 0.000 075 V/V 0.0002 V + 0.000 11 V/V 0.0004 V + 0.000 22 V/V 0.002 V + 0.000 57 V/V 0.02 V + 0.003 V/V 0.2 V + 0.01 V/V	
200 V	(1 to 10) Hz (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	0.012 V + 0.000 15 V/V 0.002 V + 0.000 12 V/V 0.002 V + 0.000 091 V/V 0.002 V + 0.000 076 V/V 0.002 V + 0.000 11 V/V 0.0068 V + 0.000 085 V/V 0.02 V + 0.000 57 V/V 0.2 V + 0.003 V/V 0.2 V + 0.003 V/V	
1000 V	(1 to 10) Hz (10 to 40) Hz 40 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.07 V + 0.000 15 V/V 0.021 V + 0.000 11 V/V 0.02 V + 0.000 12 V/V 0.04 V + 0.000 23 V/V 0.2 V + 0.000 58 V/V	
AC Voltage – Generate ³			
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	0.033 % + 4 µV 0.016 % + 4 µV 0.015 % + 4 µV 0.028 % + 4 µV 0.067 % + 5 µV 0.13 % + 10 µV 0.17 % + 20 µV 0.36 % + 20 µV	
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	0.026 % + 4 µV 0.015 % + 4 µV 0.015 % + 4 µV 0.027 % + 4 µV	

Parameter/Range	Frequency	CMC ^{2, 6} (±)	Comments
AC Voltage – Generate ³ (cont)			
(2.2 to 22) mV	(50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.055 % + 5 µV 0.099 % + 10 µV 0.14 % + 20 µV 0.27 % + 20 µV	Fluke 5720A
(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	0.025 % + 12 µV 0.013 % + 7 µV 0.012 % + 7 µV 0.021 % + 7 µV 0.045 % + 17 µV 0.078 % + 20 µV 0.12 % + 25 µV 0.26 % + 450 µV	
220 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	0.023 % + 40 µV 95 µV/V + 15 µV 62 µV/V + 8 µV 89 µV/V + 10 µV 0.012 % + 30 µV 0.036 % + 80 µV 0.093 % + 0.2 mV 0.15 % + 0.3 mV	
(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	0.023 % + 0.4 mV 84 µV/V + 0.15 mV 46 µV/V + 50 µV 78 µV/V + 0.1 mV 0.011 % + 0.2 mV 0.028 % + 0.6 mV 0.093 % + 2 mV 0.14 % + 3.2 mV	
(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	0.023 % + 4 mV 0.010 % + 1.5 mV 76 µV/V + 0.6 mV 0.01 % + 1 mV 0.015 % + 2.5 mV 0.082 % + 16 mV 0.43 % + 40 mV 0.71 % + 80 mV	
(220 to 330) V	45 Hz to 1kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.016 % + 2 mV 0.017 % + 6 mV 0.021 % + 6 mV 0.026 % + 6 mV 0.16 % + 50 mV	Fluke 5522A

Parameter/Range	Frequency	CMC ^{2, 5, 6} ($\pm$)	Comments
AC Voltage – Generate ³ (cont)			
(220 to 1100) V	50 Hz to 1 kHz	75 μ V/V + 3.5 mV	Fluke 5720A
(330 to 1020) V	(1 to 5) kHz (5 to 10) kHz	0.021 % + 10 mV 0.025 % + 10 mV	Fluke 5522A
AC Current – Measure ³			
Up to 200 μ A	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.021 μ A + 0.000 50 A/A 0.022 μ A + 0.000 50 A/A 0.022 μ A + 0.000 71 A/A	Fluke 8508
200 μ A to 2 mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz 30 kHz to 100 kHz	0.0002 mA + 0.000 31 A/A 0.0002 mA + 0.000 31 A/A 0.0002 mA + 0.000 71 A/A 0.0002 mA + 0.004 A/A	
(2 to 20) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.0019 mA + 0.000 32 A/A 0.002 mA + 0.000 31 A/A 0.002 mA + 0.000 71 A/A 0.002 mA + 0.004 A/A	
(20 to 200) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.02 mA + 0.000 31 A/A 0.02 mA + 0.000 29 A/A 0.02 mA + 0.000 63 A/A	
100 mA to 1 A	(20 to 50) kHz 10 Hz to 2 kHz	1.2 % + 0.4 mA 0.0002 A + 0.000 62 A/A	HP 3458A opt 002
200 mA to 2 A	(2 to 10) kHz (10 to 30) kHz	0.0002 A + 0.000 74 A/A 0.0002 A + 0.003 A/A	
(1 to 2) A	10 Hz to 5 kHz	0.03 %	Fluke 8508 with Fluke Y5020A
	(5 to 10) kHz	0.12 %	Fluke 8508 with Valhalla 2575A
(2 to 20) A	10 Hz to 5 kHz (5 to 10) kHz	0.09 % 0.58 %	Fluke 8508, Fluke Y5020A, Valhalla 2575A
(20 to 100) A	10 Hz to 1 kHz	0.12 %	Fluke 8508 with Valhalla 2575A

Parameter/Range	Frequency	CMC ^{2, 5, 6} ($\pm$)	Comments
AC Current – Generate ³			
(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	0.025 % + 16 nA 0.015 % + 10 nA 0.012 % + 8 nA 0.03 % + 12 nA 0.095 % + 65 nA	Fluke 5720A
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	0.025 % + 40 nA 0.017 % + 35 nA 0.015 % + 35 nA 0.021 % + 0.11 μ A 0.093 % + 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	0.025 % + 0.4 μ A 0.016 % + 0.35 μ A 0.013 % + 0.35 μ A 0.02 % + 0.55 μ A 0.092 % + 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	0.025 % + 4 μ A 0.016 % + 3.5 μ A 0.013 % + 2.5 μ A 0.02 % + 3.5 μ A 0.095 % + 10 μ A	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.027 % + 35 μ A 0.041 % + 80 μ A 0.61 % + 0.16 mA	
(2.2 to 11) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.055 % + 2 mA 0.084 % + 2 mA 2.4 % + 5 mA	Fluke 5522A
(11 to 20) A	(45 to 100) Hz 100 Hz to 1 kHz	0.097 % + 5 mA 0.12 % + 5 mA	
	(1 to 10) kHz	0.58 %	Vallhalla 2555A with Vallhalla 2575A
(11 to 100) A	20 Hz to 1 kHz	0.12 %	
Clamp-On Only Toroidal (20 to 1000) A	(45 to 65) Hz (65 to 440) Hz	0.97 % + 0.09 A 1.4 % + 0.1 A	Fluke 5522A with Fluke 5500 coil
Non-Toroidal (20 to 1000) A	(45 to 65) Hz (65 to 440) Hz	1.3 % + 0.25 A 1.5 % + 0.9 A	

Parameter/Range	Frequency	CMC ^{2, 5, 6} (±)	Comments
Capacitance – Generate ³			
(220.0 to 399.9) pF	10 Hz to 10 kHz	0.64 % + 0.01 nF	Fluke 5522A
(0.4 to 1.0999) nF	10 Hz to 10 kHz	0.42 % + 0.01 nF	
(1.1 to 3.2999) nF	10 Hz to 3 kHz	0.42 % + 0.01 nF	
(3.3 to 10.2999) nF	10 Hz to 1 kHz	0.42 % + 0.01 nF	
(11 to 32.999) nF	10 Hz to 1 kHz	0.23 % + 0.1 nF	
(33 to 109.99) nF	10 Hz to 1 kHz	0.22 % + 0.1 nF	
(110 to 329.99) nF	10 Hz to 1 kHz	0.27 % + 0.3 nF	
(0.33 to 1.0999) µF	(10 to 600) Hz	0.21 % + 1 nF	
(1.1 to 3.2999) µF	(10 to 300) Hz	0.25 % + 3 nF	
(3.3 to 10.999) µF	(10 to 150) Hz	0.22 % + 10 nF	
(11 to 32.999) µF	(10 to 120) Hz	0.34 % + 30 nF	
(33 to 109.99) µF	(10 to 80) Hz	0.38 % + 100 nF	
(110 to 329.99) µF	(0 to 50) Hz	0.38 % + 300 nF	
(0.33 to 1.099) mF	(0 to 20) Hz	0.37 % + 1 µF	
(1.1 to 3.29) mF	(0 to 6) Hz	0.37 % + 3 µF	
(3.3 to 10.99) mF	(0 to 2) Hz	0.37 % + 10 µF	
(11 to 32.99) mF	(0 to 0.6) Hz	0.56 % + 30 µF	
(33 to 110) mF	(0 to 0.2) Hz	0.88 % + 100 µF	
Fixed Points – 1 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.038 % 0.039 % 0.058 % 0.12 % 0.2 % 0.31 % 1.2 % 2.2 %	HP 16381A
10 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.037 % 0.037 % 0.037 % 0.037 % 0.038 % 0.041 % 0.079 % 0.15 %	
100 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.038 % 0.046 % 0.046 % 0.05 % 0.059 % 0.078 % 0.18 % 0.24 %	HP 16382A, 16383A

Parameter/Equipment	Frequency	CMC ^{2, 5, 6} (±)	Comments
Capacitance – Generate ³ (cont)			
Fixed Points 1000 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.037 % 0.068 % 0.079 % 0.15 % 0.19 % 0.25 % 0.61 % 0.86 %	HP 16384A
0.01 µF	(0.12, 1, 10, 100) kHz	0.13 %	HP 16385A
0.1 µF	(0.12, 1, 10, 100) kHz	0.13 %	HP 16386A
1 µF	(0.12, 1, 10, 100) kHz	0.13 %	
Inductance – Generate ³			
Fixed Points ³	100 µH (100 µH step) 1 mH (1 mH step) 10 mH (10 mH step) 100 mH (100 mH step)	2.3 % 2.4 % 2.4 % 1.2 %	Gen Rad 1490F
AC 4 Terminal Resistance – Generate			
1 mΩ 10 mΩ 100 mΩ 1 Ω	DC DC DC DC	0.23 % 0.23 % 0.23 % 0.23 %	Agilent 42030A
10 Ω	DC 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.12 % 0.12 % 0.13 % 0.14 % 0.14 % 0.16 % 0.42 % 0.62 %	
100 Ω	DC 1 MHz 2 MHz 3 MHz	0.12 % 0.12 % 0.13 % 0.13 %	

Parameter/Range	Frequency	CMC ^{2, 5, 6} (±)	Comments
AC 4 Terminal Resistance – Generate (cont)			
100 Ω	4 MHz 5 MHz 10 MHz 13 MHz	0.13 % 0.13 % 0.24 % 0.33 %	Agilent 42030A
1 kΩ	DC 100 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.12 % 0.12 % 0.12 % 0.12 % 0.12 % 0.13 % 0.13 % 0.24 % 0.33 %	
10 kΩ	DC 100 kHz 1 MHz	0.12 % 0.12 % 0.12 %	
100 kΩ	DC 100 kHz 1 MHz	0.12 % 0.13 % 0.13 %	

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Oscilloscope – Generate ³			
DC Signal 50 Ω Load 1 MΩ Load	1 mV to 6.6 V (0 to 130) V	0.19 % + 40 μV 0.039 % + 40 μV	Fluke 5500A SC600 *** > 1 kHz, uncertainty is 0.25 % + 40 μV
Squarewave Signal 50 Ω Load 1 MΩ Load	1.0 mV _{pk-pk} to 6.6 V _{pk-pk} 1.0 mV _{pk-pk} to 130 V _{pk-pk}	0.19 % + 40 μV 0.078 % + 40 μV***	
Edge Characteristics (50 Ω Load)	5 mV to 2.5 V	1.6 % + 0.2 mV	
Risetime (50 Ω Load)	≤ 300 ps	(+0 / -78) ps	

Parameter/Equipment	Range	CMC ^{2, 6} ($\pm$)	Comments
Oscilloscope – Generate ³ (cont)			
Level Sine Wave, Into 50 Ω Load 5 mV _{pk-pk} to 5.5 V _{pk-pk}	50 kHz reference 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	1.9 % + 0.3 mV 2.9 % + 0.3 mV 3.3 % + 0.3 mV 4.8 % + 0.3 mV	Fluke 5500A SC600
Time Marker, 50 Ω	5 s to 50 ms 20 ms to 2 ns	(25 + 1000 <i>t</i>) μ s/s 25 μ s/s	<i>t</i> = time in seconds
DC High Voltage – Generate ³	Up to 10 kV	0.33 % of range	Fluke 410B
Electrical Calibration of Thermocouple Indicating Devices ³ –			
Type E	(-250 to -100) °C (-100 to 650) °C (650 to 1000) °C	0.39 °C 0.14 °C 0.17 °C	Fluke 5500A
Type J	(-210 to -100) °C (-100 to 760) °C (760 to 1200) °C	0.21 °C 0.14 °C 0.18 °C	
Type K	(-200 to -100) °C (-100 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.20 °C 0.11 °C 0.15 °C 0.24 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.20 °C 0.11 °C 0.10 °C 0.15 °C	
Electrical Calibration of RTD Devices ³			
PT 385, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.04 °C 0.04 °C 0.05 °C 0.08 °C 0.08 °C 0.10 °C 0.19 °C	Fluke 5522A

IV. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2,6} ($\pm$)	Comments
RF Attenuation (Tuned) – RF Power Measure ³			
(10 to -100) dBm	2.5 MHz to 1.3 GHz	0.17 dB	HP 8902A with opt 050 and HP 11722A power sensor
(10 to -100) dBm	(1.3 to 26.5) GHz	0.28 dB	HP 8902A w/ 11793A down converter and HP
(-100 to -120) dBm	(1.3 to 26.5) GHz	0.32 dB	11792A power sensor
RF Absolute Power – Measure			
10 MHz to 18 GHz	(-70 to -20) dB	0.15 dB	HP 438A
100 kHz to 26.5 GHz	(-20 to 10) dB	0.15 dB	w/8481A/8482A/8484A/ 8485A
RF Power – Generate ³			
(0 to -18) dBm	200 Hz to 81 MHz	0.05 dB	HP 3335A
(-18 to -58) dBm	200 Hz to 81 MHz	0.11 dB	
(-58 to -98) dBm	200 Hz to 81 MHz	0.23 dB	
(+10 to -100) dBm	2.5 MHz to 26.5 GHz	0.6 dB	HP 8340B synthesizer w/8902; 11722A, 11792A sensors, 11793A converter
Amplitude Modulation – Measure ³			
Rate: 50 Hz to 10 kHz Depths: (5 to 99) %	150 kHz to 10 MHz	2.8 % + 1 digit	HP 8902A
Rate: 20 Hz to 10 kHz Depths: Up to 99 %	150 kHz to 10 MHz	3.8 % + 1 digit	
Rate: 50 Hz to 50 kHz Depths: (5 to 99) %	10 MHz to 1.3 GHz	1.7 % + 1 digit	

Parameter/Range	Frequency	CMC ^{2, 6} ($\pm$)	Comments
Amplitude Modulation – Measure ³ (cont)			
Rate: 20 Hz to 100 kHz Depths: (5 to 99) %	10 MHz to 1.3 GHz	3.7 % + 1 digit	HP 8902A
Rate: 50 Hz to 50 kHz Depths: (5 to 99) %	(1.3 to 18) GHz	3.2 % + 1 digit	HP 8902A, 11793A
Rate: 20 Hz to 100 kHz Depths: Up to 99 %	10 MHz to 26.5 GHz	4.7 % + 1 digit	
Frequency Modulation – Measure ³			
Rate: 20 Hz to 10 kHz Dev: ≤ 40 kHz pk	150 kHz to 10 MHz	2.9 % + 1 digit	HP 8902A
Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz pk	10 MHz to 1.3 GHz	1.9 % + 1 digit	HP 8902A, 11793A
Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz pk	10 MHz to 1.3 GHz	6 % + 1 digit	
Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz pk	10 MHz to 26.5 GHz	3.5 % + 1 digit	
Phase Modulation – Measure ³			
Rate: 200 Hz to 10 kHz	$150 \text{ kHz} \leq f_c < 10 \text{ MHz}$	5.3 % + 1 digit	HP 8902A
Rate: 200 Hz to 20 kHz	$10 \text{ MHz} \leq f_c \leq 1.3 \text{ GHz}$	4.3 % + 1 digit	
Rate: 200 Hz to 20 kHz	$10 \text{ MHz} \leq f_c \leq 26.5 \text{ GHz}$	5.2 % + 1 digit	HP 8902A, 11793A
			f_c represents the frequency carrier
Harmonic Distortion/Total Harmonic Distortion – Measure	30 Hz to 26.5 GHz (2 to 6) GHz (6 to 13) GHz (13 to 21) GHz (21 to 26) GHz	1.5 dB 1.7 dB 2.6 dB 2.9 dB 3.8 dB	HP 8563E

V. Mechanical

Parameter/Equipment	Range	CMC ^{2, 5, 8} ($\pm$)	Comments
Torque Wrench ³	Up to 100 lbf·in Up to 240 lbf·in (20 to 650) lbf·ft	0.55 % 0.60 % 0.50 %	AKO TSD 1200, TSD 821, TSD 011 torque calibrator
Pressure – Hydraulic ³	(1 to 30) psi (30 to 100) psi (100 to 1000) psi (1000 to 10 000) psi	0.01 psi 0.03 psi 0.25 psi 2.2 psi	Pressure calibrator, Fluke 525B w/750 sensors
RPM – Measure ³ (Non-Contact)	(6 to 599.9) rpm (600 to 9999) rpm (10 000 to 99 999) rpm	1.2 rpm 0.6 rpm + 0.000 075 rpm/rpm 1.7 rpm + 0.000 073 rpm/rpm	Shimpo MT-200 optical tachometer
Vacuum ³	(-14 to 0) psi	0.0099 psi	Pressure calibrator Fluke 525B w/750 sensors
Scales ³	(1 to 100) g (100 to 400) g (400 to 500) g (0.5 to 1.5) kg (1.5 to 2.5) kg (2.5 to 3.5) kg (3.5 to 8.5) kg (8.5 to 15) kg (15 to 60) kg (5 to 350) lb	0.0006 g 0.0009 g 0.003 g 0.009 g 0.013 g 0.014 g 0.030 g 0.087 g 0.02 g 0.0014 lb + 0.000 019 lb/lb	Class 2 weights Class F weights
Balances ³	(50 to 500) mg (5 to 100) g	0.029 mg 0.000 11g + 0.000 002 g/g	Class S weights

Parameter/Equipment	Range	CMC ^{2, 4, 5} ($\pm$)	Comments
Torque Cells / Standards	(1 to 100) in/lbf (1 to 650) ft/lbf	0.014 % + 0.6 <i>R</i> 0.08 % + 0.6 <i>R</i>	Torque arm and class 6 weights
Force Gages	Up to 300 lbs	0.034 lb + 0.000 46 lb/lb	Class F weights

VI. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 5, 8} ($\pm$)	Comments
Temperature – Measure ³	(-170 to 660) °C	0.023 °C	Hart 5626 PRT probe with Azonix 1011 display
Temperature – Measuring Equipment ³	(35 to 200) °C	0.024 °C	Hart 5626 PRT with Azonix 1011 display, Hart 6102 bath
Relative Humidity – Measuring Equipment ³	11.5 % 33 % 75 %	1.4 % RH 1.4 % RH 1.4 % RH	Salt
Relative Humidity – Measure ³	(10 to 90) % RH	1.4 % RH	Vaisala HMT-337

VII. Time & Frequency

Parameter/Equipment	Range	CMC ^{2, 8} ($\pm$)	Comments
Timers and Stopwatches ³	Seconds per day	0.07 s/day	Timometer TM- 4500 from Helmut Klein
Frequency – Measuring Equipment, Fixed Point	10 MHz reference	4.1 parts in 10 ¹¹ Hz/Hz at 1 day	GPS with Symmetricom Xli

Parameter/Equipment	Range	CMC ^{2, 4, 5, 8} ($\pm$)	Comments
Frequency – Measuring Equipment	1 mHz to 100 Hz 100 Hz to 100 kHz 100 kHz to 100 MHz 100 MHz to 26.5 GHz	8.2 parts in 10^8 Hz/Hz 9.3 parts in 10^8 Hz/Hz 9 parts in 10^9 Hz/Hz 2.1 parts in 10^9 Hz/Hz	GPS with Symmetricom Xli w/HP 3325B HP8904A HP8648C HP8340A
Frequency – Measure	1 mHz to 100 Hz 100 Hz to 100 kHz 100 kHz to 100 MHz 100 MHz to 26.5 GHz	8.2 parts in 10^8 Hz/Hz 9.3 parts in 10^8 Hz/Hz 7.4 parts in 10^9 Hz/Hz 2.1 parts in 10^9 Hz/Hz	GPS with Symmetricom Xli w/HP53131A HP 5352B
Optical Tachometers	(10 to 100 000) rpm	0.0037 % + 6R	HP 3325B, HP 5334B, LED fixture

SATELLITE FACILITY

TRU CAL INTERNATIONAL, INC.
 333 Pfingsten Rd
 Northbrook, IL 60062
 Scott Miller Phone: 630 238 8100

I. Mechanical

Parameter/Equipment	Range	CMC ² (±)	Comments
Mass	5 g 10 g 20 g 50 g 100 g 200 g 300 g 400 g 500 g 1 kg 1.5 kg 2 kg 5 kg 10 kg 20 kg 30 kg 40 kg 50 kg 60 kg	2.5 mg 2.5 mg 2.5 mg 2.6 mg 2.6 mg 2.7 mg 2.8 mg 3.0 mg 3.1 mg 26 mg 27 mg 28 mg 38 mg 0.11 g 0.98 g 1.1 g 1.3 g 1.4 g 1.5 g	Mettler XP5003SDR Ohaus EX10202 AND GP-61K

¹ This laboratory offers commercial calibration service 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 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 In the statement of CMC, L is the numerical value of the nominal length of the device measured in inches; and R is the resolution of the device.
- ⁵ In the statement of CMC, percentages are percentage of reading, unless otherwise indicated.
- ⁶ The stated measured values are determined using indicated instruments (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 fixed floor specification.
- 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

TRU CAL INTERNATIONAL INC.

Bensenville, IL

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 6th day of May 2022.

A blue ink signature of a person, likely the Vice President of Accreditation Services.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1278.01
Valid to April 30, 2024
Revised March 27, 2024

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