



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 &
ANSI/NCSL Z540-1-1994

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

CALIBRATION

Valid until: December 31, 2017

Certificate Number: 1278.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

I. Dimensional

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Dial Indicators ³	Up to 1 in	76 µin	Dial indicator calibrator
Dial Indicators	Up to 1 in	47 µin	Gage blocks w/MuMeter
Micrometers ³ – Heads, Inside, Outside	Up to 8 in (6 to 18) in	(22 + 18L) µin (68 + 20L) µin	Gage blocks Reference bar
Calipers ³	Up to 8 in (8 to 18) in	(280 + 13L) µin (280 + 9.8L) µin	Gage blocks Reference bar
Height Gages ³ , Dual Column – MTI	Up to 18 in	(52 + 17L) µin	Reference bar with MuMeter
Pin Gages ³	Up to 1 in	47 µin	Bench mic w/gage blocks
Plain Plug Gages	Up to 6 in	(13 + 16L) µin	Pratt & Whitney Super Microcrometer ^{TM,6} w/ gage blocks

Parameter/Equipment	Range	CMC ^{2,4,7} (±)	Comments
Thickness Gages ³ – Blade Dial	Up to 1 in Up to 1 in	47 μin (280 + 13L) μin	Bench mic Gage blocks
Bore Gages ³	Up to 1 in	76 μin	Dial indicator calibrator
Thread Plugs ³ – Major Diameter Pitch Diameter	Non-Tapered, (4 to 80) TPI Up to 2 in	(39 + 14L) μin (82 + 8L) μin	Bench mic w/thread wires
Thread Plugs – Major Diameter Pitch Diameter	Non-Tapered, (4 to 80) TPI Up to 6 in	(13 + 11L) μin (70 + 5.7L) μin	Pratt & Whitney B w/ thread wires

II. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2,5,7} (±)	Comments
DC Voltage – Measure ³	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V	9.5 μV/V + 0.3 μV 4.7 μV/V + 0.3 μV 4.7 μV/V + 0.5 μV 7 μV/V + 30 μV 7.1 μV/V + 0.1 mV*	HP 3458A opt 002 *Add 12μV/V · (V _{IN} /1000) ² μV/V for inputs > 100 V
DC High Voltage – Measure ³	(0 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 (11 to 22) V (22 to 220) V (220 to 1100) V	9.1 μV/V + 0.4 μV 4.4 μV/V + 0.7 μV 3 μV/V + 2.5 μV 3 μV/V + 4 μV 4.3 μV/V + 40 μV 5 μV/V + 0.4 mV	Fluke 5720A (using artifact calibrations)

Parameter/Equipment	Range	CMC ^{2, 5, 7} (\pm)	Comments
DC Voltage – Generate, Fixed Points	100 mV 1 V 10 V 100 V 1000 V	3.6 μ V/V 2.4 μ V/V 1.8 μ V/V 2 μ V/V 2.4 μ V/V	Fluke 732B w/ Fluke 752A
DC Current – Measure ³	Up to 100 nA 100 nA to 1 μ A (1 to 10) μ A (10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 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 24 μ A/A + 0.8 nA 24 μ A/A + 50 nA 24 μ A/A + 50 nA 42 μ A/A + 0.5 μ A 0.013 % + 10 μ A 59 μ A/A 75 μ A/A 0.015 % 0.077 %	HP 3458A opt 002 HP 3458A w/ L&N 4221B current shunt HP 3458A w/ L&N 4222B HP 3458A w/ 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 Clamp On Only Toroidal (20 to 1000) A Non Toroidal (20 to 1000) 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 % rng 0.068 % + 0.03 % rng 0.47 % + 0.05 A 0.58 % + 0.5 A	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 Fluke 5522A w/ Fluke 5500 coil

Parameter/Equipment	Range	CMC ^{2,5,7} (±)	Comments
Resistance – Measure ³	Up to 10 Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	24 μΩ/Ω + 50 μΩ 16 μΩ/Ω + 0.5 mΩ 12 μΩ/Ω + 0.5 mΩ 13 μΩ/Ω + 5 mΩ 12 μΩ/Ω + 50 mΩ 18 μΩ/Ω + 2 Ω 58 μΩ/Ω + 0.10 kΩ 0.058 μΩ/Ω + 1 kΩ 0.58 % + 10 kΩ*	HP 3458A opt 002 *additional error from Teal for last ACAL +/- 1 °C
Resistance – Generate, Fixed Values ³	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω (1, 1.9) kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	93 μΩ/Ω 86 μΩ/Ω 26 μΩ/Ω 27 μΩ/Ω 12 μΩ/Ω 11 μΩ/Ω 8.8 μΩ/Ω 8.6 μΩ/Ω 8.7 μΩ/Ω 10 μΩ/Ω 11 μΩ/Ω 18 μΩ/Ω 19 μΩ/Ω 35 μΩ/Ω 44 μΩ/Ω 0.013 %	Fluke 5720A (using artifact calibrations)
Resistance – Generate	(0 to 10.999) Ω (11 to 32.999) Ω (33 to 109.999) Ω (110 to 329.999) Ω 330Ω to 1.0999 kΩ (1.1 to 3.299) kΩ (3.3 to 10.999) kΩ (11 to 32.999) kΩ (33 to 109.99) kΩ (110 to 329.999) kΩ 330 kΩ to 1.0999 MΩ (1.1 to 3.299) MΩ (3.3 to 10.999) MΩ (11 to 32.999) MΩ (33 to 109.999) MΩ (110 to 329.999) MΩ (330 to 1100) MΩ	46 μΩ/Ω + 0.001 Ω 27 μΩ/Ω + 0.0015 Ω 24 μΩ/Ω + 0.0014 Ω 24 μΩ/Ω + 0.002 Ω 23 μΩ/Ω + 0.002 Ω 23 μΩ/Ω + 0.02 Ω 24 μΩ/Ω + 0.02 Ω 24 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 0.2 Ω 26 μΩ/Ω + 2 Ω 26 μΩ/Ω + 2 Ω 54 μΩ/Ω + 30 Ω 0.011 % + 50 Ω 0.022 % + 2.5 kΩ 0.039 % + 3 kΩ 0.24 % + 0.1 MΩ 1.2 % + 0.5 MΩ	Fluke 5522A

Parameter/Range	Frequency	CMC ^{2,7} (±)	Comments
AC Voltage – Measure ³			
3 mV	(10 to 100) Hz 100 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.11 % 0.093 % 0.13 % 0.25 % 0.5 %	Datron 4920A
10 mV	(10 to 100) Hz 100 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.034 % 0.021 % 0.052 % 0.14 % 0.35 %	
30 mV	(10 to 100) Hz 100 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.027 % 0.017 % 0.039 % 0.11 % 0.27 %	
100 mV	(10 to 100) Hz 100 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.02 % 0.01 % 0.019 % 0.058 % 0.16 %	
300 mV	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.029 % 0.013 % 30 µV/V 33 µV/V 0.018 % 0.029 % 0.079 %	
1V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.029 % 0.013 % 30 µV/V 32 µV/V 77 µV/V 0.029 % 0.078 %	

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
AC Voltage – Measure ³ (cont)			
3V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.029 % 0.013 % 30 µV/V 32 µV/V 80 µV/V 0.029 % 0.078 %	Datron 4920A
10 V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.029 % 0.013 % 30 µV/V 30 µV/V 68 µV/V 0.029 % 0.078 %	
30 V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 30 kHz (30 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	0.029 % 0.013 % 37 µV/V 30 µV/V 68 µV/V 0.029 % 0.078 %	
100 V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 30 kHz (30 to 200) kHz	0.029 % 0.013 % 37 µV/V 31 µV/V 83 µV/V	
300 V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 20 kHz (20 to 100) kHz	0.031 % 0.016 % 46 µV/V 46 µV/V 0.011 %	
1000 V	(1 to 2) Hz (2 to 10) Hz (10 to 40) Hz 40 Hz to 20 kHz (20 to 100) kHz	0.032 % 0.016 % 46 µV/V 52 µV/V 0.011 %	
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

Parameter/Range	Frequency	CMC ^{2, 5, 7} (\pm)	Comments
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 μ V 0.016 % + 4 μ V 0.015 % + 4 μ V 0.028 % + 4 μ V 0.067 % + 5 μ V 0.13 % + 10 μ V 0.17 % + 20 μ V 0.36 % + 20 μ V	Fluke 5720A
(2.2 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	0.026 % + 4 μ V 0.015 % + 4 μ V 0.015 % + 4 μ V 0.027 % + 4 μ V 0.055 % + 5 μ V 0.099 % + 10 μ V 0.14 % + 20 μ V 0.27 % + 20 μ V	
(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 μ V 0.013 % + 7 μ V 0.012 % + 7 μ V 0.021 % + 7 μ V 0.045 % + 17 μ V 0.078 % + 20 μ V 0.12 % + 25 μ V 0.26 % + 450 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 (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.023 % + 40 μ V 95 μ V/V + 15 μ V 62 μ V/V + 8 μ V 89 μ V/V + 10 μ V 0.012 % + 30 μ V 0.036 % + 80 μ V 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 μ V/V + 0.15 mV 46 μ V/V + 50 μ V 78 μ V/V + 0.1 mV 0.011 % + 0.2 mV 0.028 % + 0.6 mV 0.093 % + 2 mV 0.14 % + 3.2 mV	

Parameter/Range	Frequency	CMC ^{2, 5, 7} (\pm)	Comments
AC Voltage – Generate ³ (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	0.023 % + 4 mV 0.010 % + 1.5 mV 76 μ V/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	Fluke 5720A
(220 to 330V)	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
(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			
(20 to 100) μ A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.46 % + 0.03 μ A 0.17 % + 0.03 μ A 0.070 % + 0.03 μ A 0.070 % + 0.03 μ A	HP 3458A opt 002
100 μ A to 1 mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.46 % + 0.2 μ A 0.17 % + 0.2 μ A 0.07 % + 0.2 μ A 0.036 % + 0.2 μ A 0.07 % + 0.2 μ A 0.46 % + 0.4 μ A 0.64 % + 1.5 μ A	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.46 % + 2 μ A 0.17 % + 2 μ A 0.07 % + 2 μ A 0.036 % + 2 μ A 0.07 % + 2 μ A 0.46 % + 4 μ A 0.64 % + 15 μ A	

Parameter/Range	Frequency	CMC ^{2, 5, 7} (\pm)	Comments
AC Current – Measure ³ (cont)			
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.46 % + 20 μ A 0.17 % + 20 μ A 0.07 % + 20 μ A 0.036 % + 20 μ A 0.07 % + 20 μ A 0.46 % + 40 μ A 0.64 % + 150 μ A	HP 3458A opt 002
100 mA to 1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.46 % + 0.2 mA 0.19 % + 0.2 mA 0.093 % + 0.2 mA 0.12 % + 0.2 mA 0.35 % + 0.2 mA 1.2 % + 0.4 mA	
(1 to 2) A	10 Hz to 5 kHz 5 kHz to 10 kHz	0.088 % 0.12 %	Datron 4920M w/ Fluke Y5020A Datron 4920M w/ Valhalla 2575A
(2 to 20) A	10 Hz to 5 kHz (5 to 10) kHz	0.091 % 0.58 %	Datron 4920M Fluke Y5020A Valhalla 2575A
(20 to 100) A	10 Hz to 1 kHz	0.12 %	Datron 4920M w/ Valhalla 2575A
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	

Parameter/Range	Frequency	CMC ^{2, 5, 7} (\pm)	Comments
AC Current – Generate ³ (cont)			
(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	Fluke 5720A
(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 (1 to 10) kHz	0.097 % + 5 mA 0.12 % + 5 mA 0.58 % of rng	Fluke 5522A Vallhalla 2555A w/ Vallhalla 2575A
(11 to 100) A	20 Hz to 1 kHz	0.12 % of rng	Vallhalla 2555A w/ Vallhalla 2575A
Clamp On Only Toroidal			
(20 to 1000) A	(45 to 65) Hz	0.97 % + 0.09 A	Fluke 5522A w/ Fluke
(20 to 1000) A	(65 to 440) Hz	1.4 % + 0.1 A	5500 coil
Non Toroidal			
(20 to 1000) A	(45 to 65) Hz	1.3 % + 0.25 A	Fluke 5522A w/ Fluke
(20 to 1000) A	(65 to 440) Hz	1.5 % + 0.9 A	5500 coil

Parameter/Range	Frequency	CMC ^{2,5,7} (±)	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 ³ –			
1 pF	100 Hz to 1 kHz	0.038 %	HP 16381A
	1 kHz to 1 MHz	0.039 %	
	(1 to 2) MHz	0.058 %	
	(2 to 3) MHz	0.12 %	
	(3 to 4) MHz	0.2 %	
	(4 to 5) MHz	0.31 %	
	(5 to 10) MHz	1.2 %	
	(10 to 13) MHz	2.2 %	
10 pF	100 Hz to 1 kHz	0.037 %	HP 16382A, 16383A
	1 kHz to 1 MHz	0.037 %	
	(1 to 2) MHz	0.037 %	
	(2 to 3) MHz	0.037 %	
	(3 to 4) MHz	0.038 %	
	(4 to 5) MHz	0.041 %	
	(5 to 10) MHz	0.079 %	
	(10 to 13) MHz	0.15 %	
100 pF	100 Hz to 1 kHz	0.038 %	HP 16382A, 16383A
	1 kHz to 1 MHz	0.046 %	
	(1 to 2) MHz	0.046 %	
	(2 to 3) MHz	0.05 %	
	(3 to 4) MHz	0.059 %	
	(4 to 5) MHz	0.078 %	
	(5 to 10) MHz	0.18 %	
	(10 to 13) MHz	0.24 %	

Parameter/Range	Frequency	CMC ^{2,5,7} (±)	Comments
Capacitance – Generate, Fixed Points ³ (cont)			
1000 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 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 to 100) kHz	0.13 %	HP 16385A
0.1 μF	(0.12 to 100) kHz	0.13 %	HP 16386A
1 μF	(0.12 to 100) kHz	0.13 %	HP 16386A
Inductance – Generate, Fixed Points ³	100 μH 1 mH 10 mH 100 mH	2.3 % 2.4 % 2.4 % 1.2 %	Gen Rad 1490F
AC 4 Terminal Resistance –			
1 mΩ 10 mΩ 100 mΩ 1 Ω	DC DC DC DC	0.23 % 0.23 % 0.23 % 0.23 %	Agilent 42030A

Parameter/Range	Frequency	CMC ^{2.5} (±)	Comments
AC 4 Terminal Resistance (cont) –			
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 %	Agilent 42030A
100 Ω	DC 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.12 % 0.12 % 0.13 % 0.13 % 0.13 % 0.13 % 0.24 % 0.33 %	
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 ^{2,5,7} (\pm)	Comments
Oscilloscope – Generate ³			
DC Signal 50 Ω Load 1 M Ω Load	1 mV to 6.6 V (0 to 130) V	0.19 % + 40 μ V 0.039 % + 40 μ V	Fluke 5500A SC600
Squarewave Signal 50 Ω Load 1 M Ω Load	1.0 mV to 6.6 V _{pk-pk} 1.0 mV to 130 V _{pk-pk}	0.19 % + 40 μ V 0.078 % + 40 μ V*	* > 1 kHz, uncertainty is 0.25 % + 40 μ V
Edge Characteristics (50 Ω Load)	5 mV to 2.5 V	1.6 % + 0.2 mV	
Risetime (50 Ω Load)	\leq 300 ps	(+ 0 / - 78) ps	
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*t) μ s/s 25 μ s/s	t = time in seconds
DC High Voltage – Generate ³	Up to 10 kV	0.33 % rmg	Fluke 410B
Electrical Calibration of Thermocouple Indicating Devices ³ –			
Type J	(-210 to -100) $^{\circ}$ C (-100 to 760) $^{\circ}$ C (760 to 1200) $^{\circ}$ C	0.21 $^{\circ}$ C 0.14 $^{\circ}$ C 0.18 $^{\circ}$ C	Fluke 5500A
Type K	(-200 to -100) $^{\circ}$ C (-100 to 120) $^{\circ}$ C (120 to 1000) $^{\circ}$ C (1000 to 1372) $^{\circ}$ C	0.2 $^{\circ}$ C 0.11 $^{\circ}$ C 0.15 $^{\circ}$ C 0.24 $^{\circ}$ C	
Type T	(-250 to -150) $^{\circ}$ C (-150 to 0) $^{\circ}$ C (0 to 120) $^{\circ}$ C (120 to 400) $^{\circ}$ C	0.2 $^{\circ}$ C 0.11 $^{\circ}$ C 0.1 $^{\circ}$ C 0.15 $^{\circ}$ C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Indicating Devices ³ – (cont) 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
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 0.1 °C 0.19 °C	Fluke 5522A

III. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ² (±)	Comments
Attenuation ³ – (1 to 2) dB (3 to 4) dB (5 to 6) dB (7 to 10) dB 11 dB (1 to 6) dB (6 to 9) dB (10 to 11) dB	DC to 12.4 GHz (12.4 to 18) GHz	0.77 dB 0.83 dB 0.9 dB 0.98 dB 1.1 dB 1.3 dB 1.4 dB 1.5 dB	HP 8494H 1 dB step attenuator

Parameter/Range	Frequency	CMC ² (±)	Comments
Attenuation ³ – (cont)			
10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	DC to 12.4 GHz	0.91 dB 1.1 dB 1.3 dB 1.6 dB 1.9 dB 2.2 dB 2.6 dB 2.9 dB 3.2 dB 3.6 dB 3.9 dB	HP 8496H 10 dB step attenuator
10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	(12.4 to 18) GHz	1.2 dB 1.4 dB 1.7 dB 2.1 dB 2.5 dB 3 dB 3.4 dB 3.9 dB 4.3 dB 4.8 dB 5.2 dB	
RF Power (Tuned)– Measure ³			
(10 to -100) dBm (-100 to -120) dBm (-120 to -127) dBm	(0.1 to 1.3) GHz	0.18 dB 0.22 dB 0.37 dB	HP 8902A w/ opt 050 and HP 11722A power sensor
(4 to 0) dBm	(1.3 to 26) GHz	0.29 dB	HP 8902A w/ 11793A down converter and HP 11792A power sensor
RF Absolute Power – Measure			
10 MHz to 18 GHz 100 kHz to 26 GHz	(-70 to -20) dB (-20 to 10) dB	0.16 dB 0.16 dB	HP 438A w/8481A/8482A/8484A

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Power – Generate +25 dBm	(0.1 to 1300) MHz	2.4 dB	HP 8447F opt H64 w/ HP8340B
RF Power – Generate ³ (+13 to -56) dBm	0.001 Hz to 10 MHz	0.24 dB	Agilent 3325B
(-13 to -16) dBm (-16 to -56) dBm	10Mhz to 20 MHz	0.69 dB 1 dB	
(0 to -18) dBm (-20 to -58) dBm (-60 to -98) dBm	200 Hz to 81 MHz 200 Hz to 81 MHz 200 Hz to 81 MHz	0.05 dB 0.11 dB 0.23 dB	HP 3335A
(+16 to -119.9) dBm (-120 to -129.9) dBm	100 kHz to 2.56 GHz 100 kHz to 2.56 GHz	1.4 dB 3.6 dB	HP 8663A
(+10 to -9.95) dBm (-10 to -19.95) dBm (-20 to -49.95) dBm (-50 to -79.95) dBm (-80 to -100) dbm (-100 to -110) dBm	(0.05 to 2.3) GHz	1 dB 1.4 dB 1.7 dB 2.1 dB 2.4 dB 3.4 dB	HP 8340B
(+18 to +10) dBm (+10 to -9.95) dBm (-10 to -19.95) dBm (-20 to -49.95) dBm (-50 to -79.95) dBm (-80 to -100) dbm (-100 to -110) dBm	(2.3 to 20) GHz	2.1 dB 1.8 dB 2.3 dB 2.7 dB 3 dB 3.4 dB 4.3 dB	HP 8340B
(+18 to +10) dBm (+10 to -9.95) dBm (-10 to -19.95) dBm (-20 to -49.95) dBm (-50 to -79.95) dBm (-80 to -100) dbm (-100 to -110) dBm	(20 to 26.5) GHz	2.7 dB 2.3 dB 2.9 dB 3.2 dB 3.6 dB 4 dB 4.3 dB	

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
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 w/ HP 11722A power sensor
Rate: 20 Hz to 10 kHz Depths: 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	
Rate: 20 Hz to 100 kHz Depths: to 99 %	10 MHz to 1.3 GHz	3.7 % + 1 digit	
Rate: 50 Hz to 50 kHz Depths: 5 % to 99 %	(1.3 to 18) GHz	3.2 % + 1 digit	HP 8902A w/ HP 11792A power sensor
Rate: 20 Hz to 100 kHz Depths: 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	250 kHz to 10 MHz	2.9 % + 1 digit	HP 8902A w/ HP 11722A power sensor

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
Frequency Modulation – Measure ³ (cont) Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz pk Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz pk Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz pk Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz pk	10 MHz to 1.3 GHz 10 MHz to 1.3 GHz 10 MHz to 26.5 GHz 10 MHz to 1.3 GHz	1.9 % + 1 digit 6 % + 1 digit 3.5 % + 1 digit 6.6 % + 1 digit	HP 8902A w/ HP 11792A power sensor
Phase Modulation – Measure ³ Rate: 200 Hz to 10 kHz Rate: 200 Hz to 20 kHz Rate: 200 Hz to 20 kHz	150 kHz ≤ f_c < 10 MHz 10 MHz ≤ f_c ≤ 1.3 GHz 10 MHz ≤ f_c ≤ 26.5 GHz	5.3 % + 1 digit 4.3 % + 1 digit 5.2 % + 1 digit	HP 8902A w/ HP 11722A power sensor HP 8902A w/ HP 11792A power sensor f_c represents the frequency carrier
Power Meters, Fixed Points ³ – Instrument Accuracy	(3, 10, 30, 100, 300) μW (1, 3, 10, 30, 100) mW	0.32 % 0.32 %	Range calibrator, Agilent 11683A

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
Pulse – Generate Transition Time	10 % to 90 %	6.1 %	HP 8131A
Width	500 ps to 99.9 ms	230 ps	
Distortion-Measure Total Harmonic Distortion			Panasonic VP-7722A
≥140 dB	10 Hz to 15.99 kHz 16 Hz to 110 kHz	1.5 dB 3.7 dB	
ESD Guns	Contact & Air Discharge Voltage: (1 to 16) kV		Tektronix TDS 794D and SR -ESH
	Amplitude Rise Time	6 % 0.24 nS	
Surge Generator ³ –			Tektronix TDS 460 and P 6015A, Pearson 110s
Open Circuit Front Time Open Circuit Time to Half Value	(1.2 to 50) μs (1.2 to 50) μs	0.06 μs 1.3 μs	
Open Circuit Front Time Open Circuit Time to Half Value	(10 to 700) μs (10 to 700) μs	0.06 μs 2.4 μs	
Short Circuit Front Time Short Circuit Time to Half Value	(8 to 20) μs (8 to 20) μs	0.24 μs 0.24 μs	
Short Circuit Front Time Short Circuit Time to Half Time	(5 to 320) μs (5 to 320) μs	0.17 μs 5.1 μs	
Open Circuit Voltage Short Circuit Current	10 V to 6 kV (0.125 to 3) kA	4.6 % 6.2 %	

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
EFT/Burst Generator ³ – Voltage (±)			
Rise Time	10 V to 6 kV	5 %	Tektronix TDS 460 and P 6015A
Impulse Duration	5 ns ± 30 %	14 ns	
Burst Duration	50 ns ± 30 %	14 ns	
Burst Period	15 ms ± 20 %	0.19 ms	
Repetition Rate	300 ms ± 20 %	3.6 ms	

IV. Mechanical

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	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 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 ASTM Class 1/2
Torque Wrench ³	Up to 100 in·lb Up to 240 in·lb (20 to 650) ft·lb	0.13 % + 0.6R 0.13 % + 0.6R 0.13 % + 0.6R	AKO TSD 1200 torque calibrator
Pressure (Liquid) ³	(1 to 30) psi (30 to 100) psi (100 to 1000) psi (1000 to 10 000) psi	0.011 psi 0.037 psi 0.34 psi 2.9 psi	Druck DPI 610 pressure calibrator
Vacuum	(-24 to 0) psi	0.01 inHg	Druck DPI 610 pressure calibrator

Parameter/Equipment	Range	CMC ^{2,4,5} (\pm)	Comments
Scales ³	(1 to 500) g (0.5 to 5) kg (50 to 300) lb	0.082 g 5.8 g 0.017 lb	Class 6 weights
Balances	(50 to 500) mg (5 to 100) g	0.029 mg 0.31 mg	Class S weights
Torque Cells / Standards	(1 to 100) in/lbf (1 to 650) ft/lbf	0.014 % + 0.6R 0.08 % + 0.6R	Torque arm and class 6 weights

V. Thermodynamics

Parameter/Equipment	Range	CMC ^{2,5} (\pm)	Comments
Temperature – Measure ³	(-170 to 660) °C	0.016 °C	Hart 5626 PRT probe w/ Azonix 1011 T9 display
Temperature – Measuring Equipment ³	(35 to 200) °C	0.024 °C	Hart 5626 PRT w/ Azonix 1011 display, Hart 6102 bath
Relative Humidity – Measuring Equipment ³	11.5 % 33 % 75 %	1.4 % 1.4 % 1.4 %	Vaisala HMT-337
Relative Humidity – Measure ³	(10 to 90) % RH	1.4 % RH	Vaisala HMT-337

VI. Time & Frequency

Parameter/Equipment	Range	CMC ² (\pm)	Comments
Timers & Stopwatches ³	Per day/month	0.1 s/day	T-9 Timometer TM-4500 from Helmut Klein

Parameter/Equipment	Range	CMC ² (±)	Comments
Frequency – Measuring Equipment, Fixed Point	10 MHz reference	4.1 parts in 10 ¹¹ Hz/Hz	GPS w/ Symmetricon Xli
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 w/ Symmetricon Xli w/HP 3325B HP8904A HP8648C HP8340A
Frequency – Measure	1 mHz to 100Hz 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 w/ Symmetricon Xli w/HP53131A HP 5352B

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 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 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 “Supermicrometer” is a trademark owned by Pratt & Whitney Measurement Systems, Inc. of Broomfield, CT.

⁷ 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.



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 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSLI Z540-1-1994 and any additional program requirements in the field of calibration. 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 8 January 2009).



Presented this 5th day of February 2016.

A handwritten signature in blue ink, appearing to read "J. C. Bennett".

Senior Director of Quality & Communications
For the Accreditation Council
Certificate Number 1278.01
Valid to December 31, 2017

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