



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

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CALIBRATION

Valid until: February 29, 2012

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 | 73 µin | Dial indicator calibrator |
| Dial Indicators | Up to 1 in | 47 µin | Gage blocks w/MuMeter |
| Micrometers ³ | 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 | Up to 18 in | (52 + 17L) µin | Reference bar with Mu meter |
| Pin Gages ³ | Up to 1 in | 44 µin | Bench mic w/gage blocks |
| Plain Plug Gages | Up to 6 in | (13 + 16L) µin | Pratt & Whitney Super Mic w/ gage blocks |
| Steel Rules and Tapes | Up to 50' | 0.037" | Gage blocks with steel rule |

| Parameter/Equipment | Range | CMC ^{2,4} (±) | Comments |
|---|---|-----------------------------------|---------------------------------------|
| Thickness Gages ³ – Blade Dial | Up to 1 in Up to 1 in | 44 μin (280 + 13L) μin | Bench mic Gage blocks |
| Bore Gages ³ | Up to 1 in | 73 μin | Dial Indicator calibrator |
| ID Gages ³ | (1 to 18) in | (280 + 9.8L) μin | Gage blocks |
| 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 |
| NPT Plugs | Up to 6 in | (120 + 7.6L) μin | Pratt & Whitney B w/ Alameda TSB-3 |
| Plain Ring Gages | Up to 6 in | (14 + 11L) μin | Edmunds internal comparator |

II. Electrical – DC/Low Frequency

| Parameter/Equipment | Range | CMC ² (±) | 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 + 0.30 μV 4.7 μV/V + 0.30 μV 4.7 μV/V + 0.50 μV 7.0 μV/V + 30 μV 7.1 μV/V + 0.10 mV* | HP 3458A opt 002 *Add 12μV/V · (V _{IN} /1000) ² μV/V for inputs >100 V |

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|-------------------------------------|---|--|---|
| 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 + 0.40 μV 4.4 μV/V + 0.70 μV 3.0 μV/V + 2.5 μV 3.0 μV/V + 4.0 μV 4.3 μV/V + 5.0 μV 5.0 μV/V + 0.40 mV | Fluke 5700/EP (Using artifact calibrations) |
| DC Voltage – Generate, Fixed Points | 100 mV 1 V 10 V 100 V 1000 V | 3.6 μV/V + 0.40 μV 2.4 μV/V + 0.70 μV 1.8 μV/V + 2.5 μV 2.0 μV/V + 40 μV 2.4 μV/V + 0.40 mV | Fluke 732B w/Fluke 752A |
| DC Current – Measure ³ | Up to 100 nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA 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 μA/A + 0.040 nA 28 μA/A + 0.040 nA 24 μA/A + 0.10 nA 24 μA/A + 0.80 nA 24 μA/A + 50 nA 24 μA/A + 50 nA 42 μA/A + 0.50 μA 0.013 % + 10 μA 13 μA/A 22 μA/A 0.024 % 0.077 % | HP 3458A opt 002 HP 3458A with L&N 4221B current shunt HP 3458A with L&N 4222B HP 3458A with Valhalla 2575A |
| DC Current – Generate ³ | (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 (20 to 100) A | 39 μA/A + 6.0 nA 33 μA/A + 7.0 nA 36 μA/A + 40 nA 44 μA/A + 0.70 μA* 66 μA/A + 12 μA* 0.048 % + 0.33 mA 0.042 % + 0.030 % rng 0.068 % + 0.03 % rng | Fluke 5700/EP (Using artifact calibrations) *Add (200 x I ²) μA/A for I > 100 mA *Add (10 x I ²) μA/A for I > 1 A Fluke 5500A Valhalla 2555A |

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| Parameter/Equipment | Range | CMC ^{2,5} (±) | 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 + 0.50 mΩ 12 μΩ/Ω + 0.50 mΩ 13 μΩ/Ω + 5.0 mΩ 12 μΩ/Ω + 50 mΩ 18 μΩ/Ω + 2.0 Ω 30 μΩ/Ω + 0.10 kΩ 58 μΩ/Ω + 1.0 kΩ 0.058 % + 10 kΩ* | HP 3458A opt 002 *additional error from Tcal 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 5700/EP (Using artifact calibrations) |

| Parameter/Range | Frequency | CMC ^{2,5} (±) | 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 % 0.50 % | 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 % | |

Peter Meyer

| Parameter/Range | Frequency | CMC ^{2, 5} (±) | Comments |
|---|------------------|-------------------------|--------------|
| AC Voltage – Measure ³ (cont) | | | |
| 30 mV | (10 to 100) Hz | 0.027 % | Datron 4920A |
| | 100 Hz to 30 kHz | 0.017 % | |
| | (30 to 200) kHz | 0.039 % | |
| | (200 to 500) kHz | 0.11 % | |
| | 500 kHz to 1 MHz | 0.27 % | |
| 100 mV | (10 to 100) Hz | 0.020 % | |
| | 100 Hz to 30 kHz | 0.010 % | |
| | (30 to 200) kHz | 0.019 % | |
| | (200 to 500) kHz | 0.058 % | |
| | 500 kHz to 1 MHz | 0.16 % | |
| 300 mV | (1 to 2) Hz | 0.029 % | |
| | (2 to 10) Hz | 0.013 % | |
| | (10 to 40) Hz | 30 μV/V | |
| | 40 Hz to 30 kHz | 33 μV/V | |
| | (30 to 200) kHz | 0.018 % | |
| | (200 to 500) kHz | 0.029 % | |
| 1V | 500 kHz to 1 MHz | 0.079 % | |
| | (1 to 2) Hz | 0.029 % | |
| | (2 to 10) Hz | 0.013 % | |
| | (10 to 40) Hz | 30 μV/V | |
| | 40 Hz to 30 kHz | 32 μV/V | |
| | (30 to 200) kHz | 77 μV/V | |
| 3V | (200 to 500) kHz | 0.029 % | |
| | 500 kHz to 1 MHz | 0.078 % | |
| | (1 to 2) Hz | 0.029 % | |
| | (2 to 10) Hz | 0.013 % | |
| | (10 to 40) Hz | 30 μV/V | |
| | 40 Hz to 30 kHz | 32 μV/V | |
| 10 V | (30 to 200) kHz | 80 μV/V | |
| | (200 to 500) kHz | 0.029 % | |
| | 500 kHz to 1 MHz | 0.078 % | |
| | (1 to 2) Hz | 0.029 % | |
| | (2 to 10) Hz | 0.013 % | |
| | (10 to 40) Hz | 30 μV/V | |
| 40 Hz to 30 kHz | 30 μV/V | | |
| (30 to 200) kHz | 68 μV/V | | |
| (200 to 500) kHz | 0.029 % | | |
| 500 kHz to 1 MHz | 0.078 % | | |

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| Parameter/Range | Frequency | CMC ^{2, 5} (±) | Comments |
|---|--|---|---------------|
| AC Voltage – Measure ³ (cont) | | | |
| 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 % | Datron 4920A |
| 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 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 % + 4.0 µV 0.016 % + 4.0 µV 0.015 % + 4.0 µV 0.028 % + 4.0 µV 0.067 % + 5.0 µV 0.13 % + 10 µV 0.17 % + 20 µV 0.36 % + 20 µV | Fluke 5700/EP |
| (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 % + 4.0 µV 0.015 % + 4.0 µV 0.015 % + 4.0 µV 0.027 % + 4.0 µV 0.055 % + 5.0 µV 0.055 % + 10 µV 0.099 % + 20 µV 0.027 % + 20 µV | |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|--|--|---|---------------|
| AC Voltage – Generate ³ (cont) | | | |
| (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 % + 7.0 μV 0.012 % + 7.0 μV 0.021 % + 7.0 μV 0.045 % + 17 μV 0.078 % + 20 μV 0.12 % + 25 μV 0.26 % + 450 μV | Fluke 5700/EP |
| 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 + 8.0 μV 89 μV/V + 10 μV 0.012 % + 30 μV 0.036 % + 80 μV 0.093 % + 0.20 mV 0.13 % + 0.30 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 % + 0.40 mV 84 μV/V + 0.15 mV 46 μV/V + 50 μV 78 μV/V + 0.10 mV 0.011 % + 0.20 mV 0.028 % + 0.60 mV 0.093 % + 2.0 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 % + 4.0 mV 0.010 % + 1.5 mV 76 μV/V + 0.60 mV 0.010 % + 1.0 mV 0.015 % + 2.5 mV 0.082 % + 16 mV 0.43 % + 40 mV 0.71 % + 80 mV | |
| (220 to 1100) V | 50 Hz to 1 kHz | 75 μV/V + 3.5 mV | |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|-----------------------------------|---|--|-------------------------------------|
| AC Current – Measure ³ | | | |
| (20 to 100) μA | (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz | 0.46 % + 0.03 μA 0.17 % + 0.03 μA 0.070 % + 0.03 μA 0.070 % + 0.03 μA | HP 3458A opt 002 |
| 100 μA 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 μA 0.17 % + 0.2 μA 0.070 % + 0.2 μA 0.036 % + 0.2 μA 0.070 % + 0.2 μA 0.46 % + 0.4 μA 0.64 % + 1.5 μA | |
| (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 μA 0.17 % + 2 μA 0.070 % + 2 μA 0.036 % + 2 μA 0.070 % + 2 μA 0.46 % + 4 μA 0.64 % + 15 μA | |
| (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 μA 0.17 % + 20 μA 0.070 % + 20 μA 0.036 % + 20 μA 0.070 % + 20 μA 0.46 % + 40 μA 0.64 % + 150 μA | 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 10 kHz | 0.12 % | Datron 4920M with Valhalla 2575A |
| (2 to 20) A | 10 Hz to 1 kHz (1 to 10) kHz | 0.12 % 0.58 % | Datron 4920M Valhalla 2575A |
| (20 to 100) A | 10 Hz to 1 kHz | 0.12 % | Datron 4920M with Valhalla 2575A |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|------------------------------------|---|--|--------------------|
| AC Current – Generate ³ | | | |
| (0 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 % + 16 nA 0.015 % + 10 nA 0.012 % + 8.0 nA 0.030 % + 12 nA 0.095 % + 65 nA | Fluke 5700/EP |
| 220 µA 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 µA 0.093 % + 0.65 µA | |
| (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 % + 0.40 µA 0.016 % + 0.35 µA 0.013 % + 0.35 µA 0.020 % + 0.55 µA 0.092 % + 5.0 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 % + 4.0 µA 0.016 % + 3.5 µA 0.013 % + 2.5 µA 0.020 % + 3.5 µA 0.095 % + 10 µA | |
| 220 mA to 2.2 A | 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.027 % + 35 µA 0.041 % + 80 µA 0.61 % + 0.16 mA | |
| (2.2 to 11) A | (45 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz | 0.048 % + 2 mA 0.079 % + 2 mA 0.26 % + 2 mA | Fluke 5500A |
| (11 to 20) A | 10 Hz to 1 kHz (1 to 10) kHz | 0.12 % of rng 0.58 % of rng | Vallhalla 2555A |
| (11 to 100) A | 20 Hz to 1 kHz | 0.12 % of rng | w/ Vallhalla 2575A |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|--|--|--|---|
| Capacitance – Generate ³ (0.33 to 0.4999) nF (0.5 to 1.0999) nF (1.1 to 3.2999) nF (3.3 to 10.2999) nF (11 to 32.999) nF (33 to 109.99) nF (110 to 329.99) nF (0.33 to 1.0999) μF (1.1 to 3.2999) μF (3.3 to 10.999) μF (11 to 32.999) μF (33 to 109.99) μF (110 to 329.99) μF (0.33 to 1.1) mF | 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz (50 to 400) Hz (50 to 400) Hz (50 to 200) Hz (50 to 100) Hz (50 to 100) Hz | 0.57 % + 0.01 nF 0.44 % + 0.01 nF 0.39 % + 0.01 nF 0.39 % + 0.01 nF 0.21 % + 0.10 nF 0.21 % + 0.10 nF 0.21 % + 0.30 nF 0.21 % + 1.0 nF 0.31 % + 3.0 nF 0.28 % + 10 nF 0.32 % + 30 nF 0.41 % + 0.10 μF 0.57 % + 0.30 μF 0.81 % + 0.30 μF | Fluke 5500A |
| Capacitance – Generate, Fixed Points ³ 1 pF 10 pF 100 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 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 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 | 0.038 % 0.039 % 0.058 % 0.12 % 0.20 % 0.31 % 1.2 % 2.2 % 0.037 % 0.037 % 0.037 % 0.037 % 0.038 % 0.041 % 0.079 % 0.15 % 0.038 % 0.046 % 0.046 % 0.050 % 0.059 % 0.078 % 0.18 % 0.24 % | HP 16381A HP 16382A, 16383A HP 16382A, 16383A |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|---|--|--|---------------------------------|
| Oscilloscope – Generate ³ (cont) | | | |
| DC Signal 50 Ω Load 1 MΩ Load | 1.0 mV to 6.6 V (0 to 33) V | 0.25 % + 0.10 mV 0.25 % + 0.10 mV | Fluke 5500A SC300 |
| Squarewave Signal 50 Ω Load 1 MΩ Load | 1.8 mV to 2.2 V _{pk-pk} 1.8 mV to 105 V _{pk-pk} | 0.25 % + 0.10 mV 0.25 % + 0.10 mV | |
| Edge Characteristics (50 Ω Load) | 4.5 mV to 2.75 V | 2.0 % + 0.20 mV | |
| 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 | 2.0 % + 0.20 mV 3.5 % + 0.30 mV 4.0 % + 0.30 mV | |
| Time Marker, 50 Ω | 5 s to 100 μs 50 μs to 2 μs 1 μs to 2 ns | (25 + 1000*t) μs/s (25 + 15 000*t) μs/s 25 μs/s | t = time in seconds |
| Oscilloscope – Measure ³ | | | |
| Risetime | Up to 12.4 GHz | 73 ps | HP 54120B sampling oscilloscope |
| DC High Voltage – Measure ³ | Up to 2 kV (2 to 40) kV (41 to 120) kV | 0.048 % + 0.02 % rng 0.065 % + 0.02 % rng 0.14 % | Vitrek 4640A Ross VD120 |
| DC High Voltage – Generate ³ | Up to 10 kV | 0.33 % rng | Fluke 410B |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|--|-----------------|------------------------|--------------|
| AC High Voltage – Measure ³ | | | |
| (Up to 2) kV | (20 to 100) Hz | 0.11 % + 0.1 % rng | Vitrek 4640A |
| (2 to 40) kV (25 kV RMS) | (100 to 400) Hz | 0.25 % + 0.2 % rng | |
| | (50 to 60) Hz | 0.47 % + 0.15 % rng | |
| (20 to 85) kV | 60 Hz | 0.64 % | Ross VD120 |

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|--|--------------------|----------------------|-------------|
| Electrical Calibration of Thermocouple Indicating Devices ³ – | | | |
| Type J | -210 °C to -100 °C | 0.27 °C | Fluke 5500A |
| | -100 °C to 760 °C | 0.17 °C | |
| | 760 °C to 1200 °C | 0.23 °C | |
| Type K | -200 °C to -100 °C | 0.33 °C | |
| | -100 °C to 120 °C | 0.18 °C | |
| | 120 °C to 1000 °C | 0.26 °C | |
| | 1000 °C to 1372 °C | 0.40 °C | |
| Type T | -250 °C to -150 °C | 0.63 °C | |
| | -150 °C to 0 °C | 0.24 °C | |
| | 0 °C to 400 °C | 0.16 °C | |
| Type E | -250 °C to -100 °C | 0.50 °C | |
| | -100 °C to 650 °C | 0.16 °C | |
| | 650 °C to 1000 °C | 0.21 °C | |

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III. Electrical – RF/Microwave

| Parameter/Range | Frequency | CMC ² (±) | Comments |
|---|---|---|---|
| Attenuation ³ – | | | |
| DC to 12.4 GHz | (1 to 2) dB (3 to 4) dB (5 to 6) dB (7 to 10) dB 11 dB | 0.44 dB 0.58 dB 0.72 dB 0.86 dB 1.0 dB | HP 8902A 1 dB step attenuator |
| (12.4 to 18) GHz | (1 to 6) dB (6 to 9) dB (10 to 11) dB | 1.1 dB 1.2 dB 1.3 dB | |
| DC to 12.4 GHz | 10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB | 0.73 dB 1.0 dB 1.3 dB 1.7 dB 2.1 dB 2.6 dB 3.0 dB 3.4 dB 3.9 dB 4.3 dB 4.7 dB | HP 8902A 10 dB step attenuator |
| (12.4 to 18) GHz | 10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB | 0.89 dB 1.2 dB 1.8 dB 2.3 dB 2.9 dB 3.4 dB 4.0 dB 4.6 dB 5.1 dB 5.7 dB 6.3 dB | |
| RF Power (tuned)– Measure ³ | | | |
| (20 to -127) dBm | (0.1 to 1.3) GHz (1.3 to 26.5) GHz | 0.20 dB 0.43 dB | HP 8902A w/opt 050 and HP 11722A power sensor HP 8902A w/11793A down converter and HP 11792A power sensor |

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| Parameter/Range | Frequency | CMC ² (±) | Comments |
|---|--------------------|--|------------------------------------|
| RF Power – Generate ³ | | | |
| (+10 to 0) dBm (0 to -10) dBm (-10 to -20) dBm (-20 to -30) dBm < -30 dbm | (0.05 to 6.6) GHz | 1.6 dB 1.3 dB 1.9 dB 2.1 dB 2.4 dB | HP 8673D generator |
| (+10 to 0) dBm (0 to -10) dBm (-10 to -20) dBm (-20 to -30) dBm < -30 dbm | (6.6 to 12.3) GHz | 1.8 dB 1.5 dB 2.1 dB 2.3 dB 2.7 dB | |
| (+10 to 0) dBm (0 to -10) dBm (-10 to -20) dBm (-20 to -30) dBm < -30 dbm | (12.3 to 18.6) GHz | 2.1 dB 1.8 dB 2.5 dB 2.7 dB 3.2 dB | |
| (+10 to 0) dBm (0 to -10) dBm (-10 to -20) dBm (-20 to -30) dBm < -30 dbm | (18.6 to 26) GHz | 2.7 dB 2.4 dB 3.0 dB 3.3 dB 3.9 dB | |
| 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 | HP 8902A w/ HP 11792A power sensor |
| 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 | |
| Rate: 20 Hz to 100 kHz Depths: to 99 % | 10 MHz to 26.5 GHz | 4.7 % + 1 digit | |

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| Parameter/Range | Frequency | CMC ^{2,5} (±) | Comments |
|---|--|------------------------|--|
| 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 |
| Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz pk | 10 MHz to 1.3 GHz | 1.9 % + 1 digit | |
| Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz pk | 10 MHz to 1.3 GHz | 6.0 % + 1 digit | |
| Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz pk | 10 MHz to 26.5 GHz | 3.5 % + 1 digit | HP 8902A w/ HP 11792A power sensor |
| Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz pk | 10 MHz to 1.3 GHz | 6.6 % + 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 w/ HP 11722A power sensor |
| 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 w/ HP 11792A power sensor |
| | | | f_c represents the frequency carrier |
| ESD Guns | Contact & Air Discharge Voltage: (1 to 16) kV | | LC574AL LeCroy oscilloscope and ESD target |
| | Amplitude Rise Time | 6.2 % 1.2 ns | |

IV. Mechanical

| Parameter/Equipment | Range | CMC ^{2, 4, 5} (±) | Comments |
|--------------------------------|---|----------------------------------|--------------------------------|
| Torque Wrench ³ | 1 in·oz to 650 ft·lb | 0.11 % + 0.6R | AKO TSD 1200 torque calibrator |
| Pressure (Liquid) ³ | (5 to 10 000) psi | 0.011 % + 0.6R | Dead weight |
| Force ³ | (1 to 300) lbf | 0.015 % | ASTM 6, weights |
| 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/lb (1 to 650) ft/lb | 0.014 % + 0.6R 0.018 % + 0.6R | Torque arm and class 6 weights |

V. Thermodynamics

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|--|-------------------|----------------------|--|
| Temperature – Measure ³ | -170 °C to 660 °C | 0.016 °C | Hart 5626 PRT probe with Azonix 1011 display |
| Temperature – Measuring Equipment ³ | 35 °C to 200 °C | 0.023 °C | Hart 5626 PRT with Azonix 1011 display, Hart 6102 bath |
| Infrared Measuring Equipment | (0 to 650) °C | 2.1 °C | EDL DBB-650 |
| Relative Humidity – Measuring Equipment ³ | ~13 and ~74 % | 2.5 % RH | ASTM E104-02 RH salts |

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| Parameter/Equipment | Range | CMC ² (±) | Comments |
|--|-----------------|----------------------|-----------------|
| Relative Humidity – Measure ³ | (10 to 90) % RH | 1.5 % RH | Vaisala HMT-337 |

VI. Time and Frequency

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|-----------------------------------|------------------|-----------------------------|-------------------------------------|
| Timers & Stopwatches ³ | Per day/month | 0.072 s/day | Timometer TM-4500 from Helmut Klein |
| Frequency ³ | 10 MHz reference | 1 parts in 10 ¹² | GPS w. Symmetricon XLi |

¹ This laboratory offers commercial calibration service and field calibration service.

² Calibration and Measurement Capability (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. Calibration and Measurement Capabilities represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

³ Field calibration service is available for this calibration and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

⁴ 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 All numbers stated as % should be taken as % of reading unless stated otherwise.





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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/NCSL 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 26th day of August 2010.





President & CEO

For the Accreditation Council
Certificate Number 1278.01
Valid to February 29, 2012
Revised December 27, 2011

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