



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

SOUTHWEST RESEARCH INSTITUTE
6220 Culebra Road
San Antonio, TX 78228-0510
Jorge Lopez Phone: 210 522 5400
Email: Jorge.lopez@swri.org

CALIBRATION

Valid To: June 30, 2020

Certificate Number: 3759.01

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

I. Chemical Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
Conductivity	10 µS/cm 1000 µS/cm 10 mS/cm	0.68 µS/cm 9.1 µS/cm 53 µS/cm	Standard solutions
pH	4, 7, 10 pH	0.02 pH	Standard solutions

II. Dimensional

Parameter/Equipment	Range	CMC ² (±)	Comments
Cylindrical Square, Sine Plate, and 90° Angle Plate	Up to 12 in	72 µin	Indicator
Digital Protractor and Clinometer	Up to 360°	0.016°	Sine plate, gage blocks, and angle plate

Parameter/Equipment	Range	CMC ^{2,3} (±)	Comments
Optical Protractor, Weather Vane, and Protractor	Up to 360°	0.078°	Optical comparator
Sine Plate	Up to 75°	1.1"	Gage blocks, angle blocks, surface plate, and indicator
90° Angle Plate	90°	0.0013°	Comparison to cylindrical square with indicator
Tool Maker's Microscope	Up to 45°	60"	Angle blocks
Gage Blocks, Ring Gages, and Plug Gages	Up to 11 in	(5.9 + 2.1L) μin	Comparison in to gage blocks with Labmaster™
Height Transfer Standard	Up to 40 in	(44 + 1.3L) μin	Comparison to gage blocks with indicator
Indicators, Feeler Gages, Bore Gages 2 Contact, and LVDT	Up to 11 in	(16 + 1.4L) μin	Labmaster™
Gaging Amplifier Micrometers, Calipers, Height Gages, Rules, and Laser Distance Meters	(0.001 to 0.1) in Up to 12 in (12 to 84) in	8 μin (19 + 14L) μin (160 + 0.78L) μin	Gage blocks
Measuring Tapes	Up to 30 ft	(0.017 + 0.0016L) in	Master rule
Bore Gages 3 Contact	(0.275 to 5) in	(55 + 1.8L) μin	Ring gages
Position Transducers	Up to 30 in	0.0029 in	Height gage, DMM
Laser Range Finder	Up to 10 m Up to 16 m (5 to 300) m	0.0027 m 0.0035 m 1.4 m	Tape measure

Parameter/Equipment	Range	CMC ^{2,3} (±)	Comments
Micrometer (Flatness)	Up to 2 in	9.6 μin	Optical flats
Surface Plate, Fixed Points	18 in 60 in	30 μin 78 μin	Repeat-o-meter Planekator
Optical Comparator – X-Y Linearity (2D)	Up to 12 in	90 μin	Master reticule
Magnification (2D)	10x, 20x, 25x, 31.25x, 50x, 62.5x	430 μin	Magnification reticule
Length (2D) Angle	Up to 8 in Up to 90°	420 μin 0.084°	Optical comparator
Length (2D) Angle	Up to 2 in Up to 90°	150 μin 0.012°	Toolmaker's microscope

III. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage Level Flatness – 1 V (Into 50 Ω)	DC to 10 Hz (10 to 100) Hz 100 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 3) MHz (3 to 8) MHz (8 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 50) MHz (50 to 70) MHz (70 to 80) MHz (80 to 100) MHz	0.009 % 0.0069 % 0.0070 % 0.0070 % 0.0077 % 0.008 % 0.01 % 0.022 % 0.031 % 0.041 % 0.06 % 0.08 % 0.17 % 0.3 % 0.32 % 0.38 %	Ballantine 1395B-1 thermal converter



Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage Level Flatness (cont) – 3 V (Into 50 Ω)	DC to 10 Hz (10 to 100) Hz 100 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 3) MHz (3 to 8) MHz (8 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 50) MHz (50 to 70) MHz (70 to 80) MHz (80 to 100) MHz	0.009 % 0.0070 % 0.0070 % 0.0070 % 0.0076 % 0.009 % 0.010 % 0.024 % 0.031 % 0.041 % 0.06 % 0.08 % 0.18 % 0.29 % 0.32 % 0.38 %	Ballantine 1395B-3 thermal converter
AC Current – Measuring Equipment and Measure (0.02 to 0.22) mA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A (2.2 to 20) A (20 to 120) A	10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 10 kHz 10 Hz to 10 kHz (10 to 300) Hz	0.0072 % 0.0036 % 0.0034 % 0.0046 % 0.0044 % 0.0072 % 0.093 %	Fluke 5790A and A40 shunts Fluke 5700A, Fluke 52120A
Clamp-On Meter – (2 to 1000) A (1000 to 3000) A	10 Hz to 10 kHz (10 to 300) Hz	0.61 % 0.77 %	Fluke 52120A w/ 5500A/coil Fluke 52120A w/ 52120A/coil 3KA



Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Resistance – Measure and Generate	333 μΩ to 1 mΩ (1 to 10) mΩ (10 to 100) mΩ (0.1 to 1) Ω (1 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 (1 to 10) GΩ (10 to 100) GΩ	82 μΩ/Ω 71 μΩ/Ω 24 μΩ/Ω 11 μΩ/Ω 12 μΩ/Ω 8.3 μΩ/Ω 4.3 μΩ/Ω 3.0 μΩ/Ω 4.3 μΩ/Ω 8.1 μΩ/Ω 11 μΩ/Ω 11 μΩ/Ω 21 μΩ/Ω 210 μΩ/Ω 360 μΩ/Ω	Guildline 9211 Fluke 8508A with standard resistors
DC Resistance – Measure	(0.01 to 0.1) Ω (0.1 to 1) Ω (1 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	7.0 mΩ/Ω 0.72 mΩ/Ω 89 μΩ/Ω 28 μΩ/Ω 16 μΩ/Ω 15 μΩ/Ω 16 μΩ/Ω 24 μΩ/Ω 83 μΩ/Ω 0.65 mΩ/Ω 6.5 mΩ/Ω	Agilent 3458A-opt 2



Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Resistance – Generate Fixed Points	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	94 μΩ/Ω 93 μΩ/Ω 29 μΩ/Ω 30 μΩ/Ω 16 μΩ/Ω 17 μΩ/Ω 9.4 μΩ/Ω 11 μΩ/Ω 9.8 μΩ/Ω 11 μΩ/Ω 12 μΩ/Ω 13 μΩ/Ω 21 μΩ/Ω 22 μΩ/Ω 42 μΩ/Ω 51 μΩ/Ω 190 μΩ/Ω	Fluke 5700A/EP
DC Current – Measuring Equipment	(2 to 20) nA (20 to 200) nA (0.2 to 2) μA (2 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 20.5) A (0.1 to 2) A (2 to 120) A	0.0055 % 0.0044 % 0.0051 % 73 μA/A 40 μA/A 41 μA/A 52 μA/A 78 μA/A 450 μA/A 1.2 mA/A 0.016 % 0.015 %	ESR SR 1050 with voltage source Fluke 5700A/EP Fluke 5700A/EP with 5725A Fluke 5522A Fluke 52120A and 5700A/EP
Clamp-On Only	(10 to 16.5) A (16.5 to 150) A (150 to 1000) A (1000 to 2500) A	0.35 % 0.31 % 0.30 % 0.77 %	Fluke 5500A/coil Fluke 52120A/ coil 3KA



Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
DC Current – Measure	(2 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 10) A (10 to 100) A (100 to 300) A	0.0052 % 0.0015 % 0.0018 % 0.0017 % 0.0021 % 0.0025 % 0.0026 % 0.0070 % 0.013 %	Guidline 9211
DC Voltage – Measure and Generate	(0 to 0.1) V (0.1 to 100) V 100 V to 1 kV (1 to 60) kV	1.6 μ V/V 0.60 μ V/V 1.1 μ V/V 0.015 %	Ratio metric with zener reference Voltage divider with digital multimeter
DC Voltage – Generate	Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	12 μ V/V 4.9 μ V/V 3.9 μ V/V 3.8 μ V/V 6.8 μ V/V 6.3 μ V/V	Fluke 5700A/EP

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage – Measure (0 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	2.7 mV/V 1.6 mV/V 1.3 mV/V 2.2 mV/V 2.9 mV/V 5.1 mV/V 7.1 mV/V 8 mV/V	Fluke 5790A
(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	0.042 % 0.029 % 0.023 % 0.039 % 0.051 % 1.2 mV/V 1.5 mV/V 2.1 mV/V	



Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage – Measure (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	260 µV/V 120 µV/V 56 µV/V 95 µV/V 0.021 % 0.034 % 0.05 % 1.2 mV/V	Fluke 5790A
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	0.024 % 83 µV/V 29 µV/V 75 µV/V 0.011 % 0.019 % 0.032 % 1.1 mV/V	
(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	0.024 % 81 µV/V 31 µV/V 57 µV/V 95 µV/V 0.023 % 0.047 % 1.4 mV/V	
(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	0.024 % 82 µV/V 39 µV/V 81 µV/V 0.012 % 0.025 %	
(220 to 1000) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.024 % 0.012 % 50 µV/V 0.016 % 0.059 %	
(1 to 42) kV	60 Hz	0.72 %	HV divider with DMM

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
AC Voltage – Generate			
(0 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	0.062 % 0.044 % 0.038 % 0.058 % 0.095 % 2.0 mV/V 2.9 mV/V 4.7 mV/V	Fluke 5700A/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	0.042 % 0.018 % 0.014 % 0.027 % 0.063 % 1.1 mV/V 1.6 mV/V 3.4 mV/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	0.037 % 0.013 % 59 µV/V 0.012 % 0.018 % 0.049 % 1.2 mV/V 2.2 mV/V	
(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	0.037 % 0.014 % 59 µV/V 0.012 % 0.017 % 0.042 % 1.3 mV/V 2.3 mV/V	
(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	0.037 % 0.013 % 70 µV/V 0.013 % 0.021 %	
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.011 % 0.016 % 0.046 %	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.047 % 1.7 mV/V	

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
AC Voltage – Wideband Generate (0 to 1.1) mV (1.1 to 3) mV (3 to 11) mV (11 to 33) mV (33 to 110) mV (110 to 330) mV 330 mV to 1.1 V (1.1 to 3.5) V	30 Hz to 500 kHz 30 Hz to 500 kHz 30 Hz to 500 kHz 30 Hz to 500 kHz 30 Hz to 500 kHz 30 Hz to 500 kHz 30 Hz to 500 kHz 30 Hz to 500 kHz	6.4 mV/V 5.6 mV/V 4.5 mV/V 3.9 mV/V 3.9 mV/V 3.3 mV/V 3.3 mV/V 2.5 mV/V	Fluke 5700A/EP
AC Voltage – Wideband Amplifier Flatness (0 to 2.2) mV (2.2 to 7.0) mV (7.0 to 22) mV (22 to 70) mV (70 to 220) mV (220 to 700) mV 700 mV to 2.2 V (2.2 to 7.0) V	10 Hz to 30 MHz 10 Hz to 30 MHz 10 Hz to 30 MHz 10 Hz to 30 MHz 10 Hz to 30 MHz 10 Hz to 30 MHz 10 Hz to 30 MHz 10 Hz to 30 MHz	0.15 % 0.1 % 0.059 % 0.059 % 0.048 % 0.036 % 0.036 % 0.036 %	Fluke 5790A
Capacitance – Measure (0 to 10) pF (10 to 100) pF (100 to 1000) pF (1 to 10) nF (10 to 100) nF (100 to 1000) nF 0.1 pF to 1 nF (1 to 10) nF (10 to 100) nF 100 nF to 99.999 mF	1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 12 Hz to 1 kHz 12 Hz to 10 kHz 13 Hz to 10 kHz 12 Hz to 10 kHz	5.5 μF/F 5.0 μF/F 5.3 μF/F 13 μF/F 15 μF/F 50 μF/F 0.027 % 0.024 % 0.025 % 0.026 %	AH 2500A GenRad 1689M



Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
<p>Capacitance – Generate</p> <p>(0.19 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF 330 nF to 1.1 µF (1.1 to 3.3) µF (3.3 to 11) µF (11 to 33) µF (33 to 110) µF (110 to 330) µF 330 µF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF</p> <p>Fixed Cardinal Points</p> <p>(0.0001 to 1) µF 10 pF 100 pF 1000 pF</p> <p>10 nF 100 nF 1 µF 10 µF 10 µF 100 µF</p>	<p>Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz Up to 10 kHz</p> <p>1 kHz 1 kHz 1 kHz 1 kHz</p> <p>1 kHz 1 kHz 1 kHz 100 Hz 1 kHz 100 Hz</p>	<p>0.94 % 0.41 % 0.4 % 0.4 % 0.4 % 0.41 % 0.4 % 0.57 % 0.63 % 0.63 % 0.64 % 0.63 % 0.63 % 0.97 % 1.4 %</p> <p>2.0 mF/F 33 µF/F 35 µF/F 22 µF/F</p> <p>71 µF/F 76 µF/F 90 µF/F 280 µF/F 230 µF/F 410 µF/F</p>	<p>Fluke 5522A</p> <p>Arco SS32 GenRad 1404</p> <p>IET SCA GenRad 1409 Series</p> <p>IET SCA</p>
<p>Inductance – Generate, Fixed Points</p> <p>100 µH 1 mH 10 mH</p> <p>100 mH 1 H 10 H</p>	<p>100 Hz to 10 kHz</p> <p>100 Hz to 1 kHz</p>	<p>0.018 % 0.014 % 0.014 %</p> <p>0.014 % 0.016 % 0.017 %</p>	<p>GenRad 1482</p>
<p>Phase – Measure</p> <p>0° to 360°</p>	<p>10 Hz to 1 MHz</p>	<p>0.084°</p>	<p>Krohn-Hite 6620A</p>



Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
Power – Generate (0.1 to 4000) W	(50 to 400) Hz	0.082 %	Rotek 811A
(2 to 33) kW	20 Hz to 1 kHz	0.12 %	Fluke 5700A-EP, 5790A & 52120A. Krohn-Hite 6620A

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of RTD Devices Indicating Systems –			
Pt 385, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.059 °C 0.082 °C 0.11 °C 0.12 °C 0.14 °C 0.27 °C	Fluke 5522A
Pt 3926, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 630) °C	0.059 °C 0.082 °C 0.11 °C 0.14 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.29 °C 0.048 °C 0.059 °C 0.07 °C 0.082 °C 0.094 °C 0.11 °C 0.12 °C 0.27 °C	
Pt 385, 200 Ω	(-200 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.048 °C 0.059 °C 0.14 °C 0.16 °C 0.17 °C 0.19 °C	



Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of RTD Devices Indicating Systems – (cont)			
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 to 630) °C	0.048 °C 0.059 °C 0.071 °C 0.094 °C 0.11 °C 0.27 °C	Fluke 5522A
Pt 385, 1000 Ω	(-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.037 °C 0.048 °C 0.059 °C 0.071 °C 0.084 °C 0.27 °C	
PtNi 385, 120 Ω	(-80 to 100) °C (100 to 260) °C	0.093 °C 0.17 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.35 °C	
Electrical Calibration of Thermocouple Devices and Indicating Systems –			
Type B	(600 to 1820) °C	0.36 °C	Fluke 5522A
Type C	(0 to 2316) °C	0.32 °C	
Type E	(-250 to 1000) °C	0.19 °C	
Type J	(-210 to 1200) °C	0.19 °C	
Type K	(-200 to 1372) °C	0.21 °C	
Type N	(-200 to 1300) °C	0.23 °C	
Type R	(0 to 1767) °C	0.4 °C	
Type S	(0 to 1767) °C	0.43 °C	
Type T	(-250 to 400) °C	0.19 °C	
Type J, K, T, E, S, & R	(-250 to 1350) °C	0.086 °C	Ice point with standard mV source

IV. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
Square Wave Signal – Generate 1 mV to 10 V _(pk-pk) 1 mV to 210 V _(pk-pk)	50 Ω at 1 kHz 1 MΩ at 1 kHz	0.21 % 0.14 %	Fluke 9500B
Single Sideband Phase Noise – Measure	1 MHz to 3 GHz (3 to 6.6) GHz (6.6 to 22) GHz (22 to 26.5) GHz	1.4 dBc/Hz 2.2 dBc/Hz 2.7 dBc/Hz 3.2 dBc/Hz	Spectrum analyzer with phase noise measurement option
Residual FM – Measure	2.5 MHz to 26.5 GHz 1 MHz to 26.5 GHz	1.8 Hz/rms 3.4 Hz/rms	N5531S measuring receiver E4440A spectrum analyzer
Residual FM – Generate ≥ 3 kHz Bandwidth	100 kHz to 6 GHz	1.3 Hz/rms	SMA 100A signal generator
Phase Modulation – Measure 20 Hz to 20 kHz	150 kHz to 26.5 GHz	1.3 %	N5531S measuring receiver
Amplitude Modulation – Measure (Depth: 0 % to 100 %) 50 Hz to 100 kHz	100 kHz to 26.5 GHz	1.1 %	N5531S measuring receiver
Amplitude Modulation – Generate (Depth 0 % to 100 %) 1 Hz to 270 kHz DC to 10 kHz	<5 MHz 5 MHz to 31.8 GHz	1.8 % 2.6 %	MXG signal generator



Parameter/Equipment	Frequency	CMC ^{2,5} (±)	Comments
Frequency Modulation – Measure 20 Hz to 10 kHz (FM Deviation ≤40 kHz _{peak}) 20 Hz to 200 kHz (FM Deviation ≤400 kHz _{peak})	250 kHz to 10 MHz 10 MHz to 26.5 GHz	1.8 % 1.2 %	N5531S measuring receiver
Pulse Modulation – Measure On/Off Ratio Rise/Fall Time	1 MHz to 18 GHz 10 MHz to 18 GHz	1.2 dB 9 ns	E4440B spectrum analyzer HF oscilloscope, pulse generator & crystal detector
Pulse Modulation – Generate On/Off Ratio Rise/Fall Time	10 MHz to 31.8 GHz 10 MHz to 31.8 GHz	3.4 dB 12 ns	MXG signal generator
Harmonic Distortion Measure – (Distortion Range: 0.1% to 100%) 5 Hz to 600 kHz	Harmonics: 10 Hz to 3 MHz	0.21 dB	8903A audio analyzer



Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
RF Absolute Power – Generate (50 Ω Output)			
(+10 to -70) dBm	10 MHz to 26.5 GHz	0.32 dBm + <i>M</i>	MXG signal generator monitored by power sensors
(+23 to -53) dBm	0.01 Hz to 80 MHz	0.13 dBm + <i>M</i>	
(24 to -48) dBm	10 Hz to 100 kHz	0.04 dBm + <i>M</i>	9640A-LPNX signal generator
(24 to -48) dBm	100 kHz to 128 MHz	0.065 dBm + <i>M</i>	
(-48 to -74) dBm	100 kHz to 10 MHz	0.23 dBm + <i>M</i>	
(-74 to -94) dBm	100 kHz to 10 MHz	0.61 dBm + <i>M</i>	
(-48 to -84) dBm	(10 to 128) MHz	0.12 dBm + <i>M</i>	
(-84 to -94) dBm		0.37 dBm + <i>M</i>	
(-94 to -130) dBm		0.83 dBm + <i>M</i>	
(20 to -48) dBm	128 MHz to 0.3 GHz	0.09 dBm + <i>M</i>	
(-48 to -74) dBm		0.12 dBm + <i>M</i>	
(-74 to -84) dBm		0.35 dBm + <i>M</i>	
(-84 to -94) dBm		0.60 dBm + <i>M</i>	
(-94 to -130) dBm		1.7 dBm + <i>M</i>	
(20 to -48) dBm	(0.3 to 1.4) GHz	0.25 dBm + <i>M</i>	
(-48 to -74) dBm		0.49 dBm + <i>M</i>	
(-74 to -84) dBm		0.61 dBm + <i>M</i>	
(-84 to -94) dBm		1.2 dBm + <i>M</i>	
(-94 to -130) dBm		1.7 dBm + <i>M</i>	
(14 to -48) dBm	(1.4 to 3.0) GHz	0.36 dBm + <i>M</i>	
(-48 to -74) dBm		0.61 dBm + <i>M</i>	
(-74 to -94) dBm		1.1 dBm + <i>M</i>	
(14 to -130) dBm		1.7 dBm + <i>M</i>	
(14 to -17) dBm	(3.0 to 4.0) GHz	0.38 dBm + <i>M</i>	
(-17 to -74) dBm		0.61 dBm + <i>M</i>	
(-74 to -84) dBm		1.2 dBm + <i>M</i>	



Parameter/Range	Frequency	CMC ^{2, 5, 6} (\pm)	Comments
RF Absolute Power – Measure			
0 dBm	50 MHz	0.02 dBm + <i>M</i>	Power meter with thermistor mount and DMM
50 Ω (+20 to +35) dBm	100 kHz to 18 GHz	0.25 dBm + <i>M</i>	Power meter with power sensors
(-30 to +20) dBm	100 kHz to 26.5 GHz	0.056 dBm + <i>M</i>	
(-70 to -30) dBm	10 MHz to 26.5 GHz	0.065 dBm + <i>M</i>	
Flatness – (50 kHz Reference)			
10 mV to 5 V	50 kHz to 3.2 GHz	2.2 %	9500 B w/9530
Reflection Coefficient – (0.005 to 0.5)	5 MHz to 2 GHz	0.011	VSWR bridge and spectrum analyzer ρ is the reflection coefficient.



Parameter/Range	Frequency	CMC ^{2,3} (±)	Comments
Relative Power – Measure (0 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB (-70 to -80) dB (-80 to -90) dB (-90 to -100) dB (-100 to -110) dB (-110 to -120) dB (-120 to -127) dB	10 MHz to 26.5 GHz 10 MHz to 19.2 GHz 10 MHz to 13.2 GHz	0.026 dB + <i>M</i> 0.032 dB + <i>M</i> 0.037 dB + <i>M</i> 0.043 dB + <i>M</i> 0.052 dB + <i>M</i> 0.069 dB + <i>M</i> 0.073 dB + <i>M</i> 0.09 dB + <i>M</i> 0.11 dB + <i>M</i> 0.14 dB + <i>M</i> 0.11 dB + <i>M</i> 0.37 dB + <i>M</i> 0.45 dB + <i>M</i>	N5531S measuring receiver
RF Attenuation (10 dB Step) – Generate (10 to 110) dB 120 dB	DC to 18 GHz DC to 1 GHz	0.011 dB 0.32 dB	10 dB step attenuator
RF Attenuation (1 dB Step) – Generate (1 to 11) dB 12 dB	DC to 18 GHz DC to 1 GHz	0.019 dB 0.14 dB	1 dB step attenuator



Parameter/Range	Frequency	CMC ² (±)	Comments
RF Attenuation – Measure (0 to -100) dB	10 Hz to 3 GHz (3 to 13) GHz (13 to 22) GHz (22 to 26.5) GHz	0.61 dB 1.8 dB 2.5 dB 3.2 dB	Spectrum analyzer
(0 to -40) dB	100 kHz to 4.2 GHz	0.027 dB	Power meter with sensor

V. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Air Velocity	(30 to 250) ft/min (250 to 1500) ft/min (1500 to 9000) ft/min	1.3 % 1.6 % 1.4 %	Wind tunnel, MKS differential pressure transducer
Flow – Measuring Equipment Gas	1 sccm to 120 slpm	0.39 %	DHI molbloc system
Volume – Fixed Points	(10 to 100) mL (100 to 2000) mL (2000 to 4000) mL (1 to 5) gal 5 gal 25 gal	0.028 mL 0.069 mL 0.85 mL 0.56 in ³ 0.0098 gal 0.013 gal	Gravimetric Prover volumetric transfer

VI. Mechanical

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Force – Compression and Tension	(0 to 50) lbf (50 to 500) lbf (500 to 3000) lbf (3000 to 10 000) lbf (10 000 to 25 000) lbf (25 000 to 50 000) lbf (50 000 to 100 000) lbf	0.34 % 0.32 % 0.94 lbf 1.4 lbf 3.3 lbf 9.5 lbf 8.5 lbf	Class F weights, proving rings
Durometer Calibration – Spring Force	Type A Type D Type M	0.59 N or 0.47 duro 0.2 N or 0.45 duro 0.33 N or 0.4 duro	Scale
Mass – Measure, Fixed Points	25 kg 10 kg 5 kg 2 kg 1 kg 500 g 200 g 100 g 50 g 20 g 10 g 5 g 2 g 1 g 500 mg 200 mg 100 mg 50 mg 20 mg 10 mg 5 mg 1 mg	61 mg 3.3 mg 1.9 mg 1.6 mg 0.34 mg 0.17 mg 34 µg 29 µg 32 µg 19 µg 18 µg 4.4 µg 4.4 µg 4.4 µg 2.8 µg 2.8 µg 2.8 µg 2.9 µg 2.9 µg 2.9 µg 2.9 µg 2.9 µg	Double substitution with Class E1 weights
Shock	(20 to 10 000) g	1.3 %	Standard accelerometer



Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Acceleration	(5 to 10) Hz (10 to 99) Hz 100 Hz (101 to 920) Hz 921 Hz to 5 kHz (5 to 10) kHz (10 to 15) kHz	1.2 % 0.75 % 0.53 % 0.71 % 0.98 % 1.9 % 0.8 %	Accelerometer
Torque – Measure	(5 to 50) in·ozf (20 to 200) in·ozf (5 to 50) in·lbf (40 to 400) in·lbf (100 to 1000) in·lbf (25 to 250) ft·lbf (60 to 600) ft·lbf	0.38 % 0.38 % 0.30 % 0.30 % 0.32 % 0.30 % 0.34 %	Torque tester
Torque – Measuring Equipment	(5 to 50) in·ozf (20 to 200) in·ozf (5 to 50) in·lbf (40 to 400) in·lbf (100 to 1000) in·lbf (25 to 250) ft·lbf (60 to 600) ft·lbf (100 to 1000) ft·lbf	0.25 % 0.22 % 0.17 % 0.17 % 0.20 % 0.16 % 0.17 % 0.16 %	Wheels/weights



Parameter/Equipment	Range	CMC ² (±)	Comments
Durocalibrators	A Scale	0.095 duro units	ASTM Class 1 weights
	D Scale	0.016 duro units	
Duro Test Blocks	A and D Scale	1.0 duro units	Durometer

VII. Thermodynamics

Parameter/Equipment	Range	CMC ² (±)	Comments
Relative Humidity – Measure	Up to 100 % RH	1.9 % RH	Vaisala HM70/ HMP77B
Relative Humidity – Measuring Equipment	(10 to 95) % RH	0.6 % RH	Thunder Scientific 2500
Dew Point	(-10 to 70) °C	0.26 °C	Thunder Scientific 2500 with Hum-Cal software
Temperature – Measure	(-196 to 661) °C (660 to 1000) °C (1000 to 1100) °C (1100 to 1450) °C	0.0052 °C 0.77 °C 0.98 °C 2.3 °C	SPRT Type S TC
Temperature – Measuring Equipment	(-80 to 550) °C (-10 to 122) °C (150 to 1000) °C (1000 to 1100) °C (1100 to 1200) °C	0.013 °C 0.4 °C 1.2 °C 1.3 °C 1.7 °C	SPRT with Hart 6055 bath RTD with drywell Type S TC with drywell
Surface Probe	(35 to 400) °C	0.35 °C	RTD with surface calibrator

Parameter/Equipment	Range	CMC ² (±)	Comments
Infrared Thermometers	(-15 to 120) °C (35 to 500) °C	0.21 °C 0.22 °C	RTD with Fluke IR calibrator

VIII. Time & Frequency

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Time Marker & Period	500 ps to 10 s	9 μs/s	Fluke 9500B
RPM – Photo Generate – Strobe Tachometer Tester	Up to 150 000 RPM	0.008 RPM	Frequency counter with light pickup
Optical Measure – Tachometer	Up to 150 000 RPM	0.016 RPM	Signal generator with strobe
Contact Measure – Tachometer	(10 to 190) RPM (200 to 50 000) RPM	0.14 % 0.0088 %	Ideal Aerosmith 1921 tachometer tester
Frequency – Measuring Equipment			
Fixed	10 MHz	9.1 parts in 10 ¹² Hz	Fluke 910R GPS
Variable	1 μHz to 80 MHz	1.3 part in 10 ¹¹ Hz	Signal generator locked to Fluke 910R
	10 MHz to 32 GHz	2.8 parts in 10 ¹¹ Hz	Signal generator locked to Fluke 910R
Frequency – Measure	10 nHz to 6 GHz	9.1 parts in 10 ¹² Hz	Frequency counter locked to Fluke 910R
	(6 to 26.5) GHz	2.8 parts in 10 ¹¹ Hz	Measuring receiver locked to Fluke 910R
Stopwatch/Timer	15 s to 24 hr	0.6 s	Fluke 910R GPS

Parameter/Equipment	Range	CMC ² (±)	Comments
Time – Measure ≤17.5 ps	<200 kHz	26 ps	Tektronix 11801C with SD 24
Rise Time – Measuring Equipment ≤150 ps	1 kHz to 10 MHz	180 ps	Fluke 9500B
17.9 ps	<200 kHz	2.3 ps	Tektronix 067-1338-00

¹ This laboratory offers commercial calibration services.

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 In the statement of CMC, L is the numerical value of the nominal length of the device measured in inches.

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 are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.

⁵ In the statement of CMC the values listed with percent (%) are percent of reading or generated value unless otherwise noted.

⁶ In the statement of CMC, M is the mismatch uncertainty for the unit under test.