SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

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CALIBRATION

Valid To: December 31, 2027 Certificate Number: 5825.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the organization's compliance with R205 – A2LA's Calibration Program Requirements), accreditation is granted to this laboratory to perform the following calibrations[1, 6]:

I. Dimensional

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Dial/Cylinder Gauge Testers	Up to 25 mm (25 to 100) mm	0.21 µm 0.25 µm	Gauge blocks, electronic micrometers
End Bars	Up to 500 mm (500 to 1000) mm	$\sqrt{(0.15\mu m)^2 + (1.9 \times 10^{-6} \times l_0)^2}$ $\sqrt{(0.16\mu m)^2 + (1.9 \times 10^{-6} \times l_0)^2}$	Gauge blocks, electronic micrometers
Extensometers, Linear Displacement Transducers[3]	Up to 50 mm (50 to 100) mm (100 to 1000) mm	$\sqrt{(0.14\mu m)^2 + (1.7 \times 10^{-6} \times l_0)^2}$ $\sqrt{(0.79\mu m)^2 + (1.8 \times 10^{-6} \times l_0)^2}$ $\sqrt{(7.9\mu m)^2 + (1.8 \times 10^{-6} \times l_0)^2}$	Gauge blocks
Filler Gauge[3]	(0.01 to 5) mm	0.34 µm	Universal length machine

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Gauge Blocks	(0.5 to 100) mm	$\sqrt{(71\text{nm})^2 + (1.2 \times 10^{-6} \times l_0)^2}$	Gauge block comparators, gauge blocks
Height Gauges / Linear Height Gauges[3]	Up to 1000 mm	$\sqrt{(1.2\mu\text{m})^2 + (3.0 \times 10^{-6} \times l_0)^2}$	Gauge blocks
Length – Measure[3]			
Universal Length Machine	Up to 500 mm	$\sqrt{(0.25\mu\text{m})^2 + (2.2 \times 10^{-6} \times l_0)^2}$	Gauge blocks, long gauge blocks
Electronic Micrometers	Up to 0.02 mm (0.02 to 0.2) mm (0.2 to 2) mm	0.08 µm 0.16 µm 0.78 µm	Gauge blocks
Height Micrometers –			
Blocks	Up to 610 mm	$\sqrt{(1.3\mu\text{m})^2 + (2.8 \times 10^{-6} \times l_0)^2}$	Gauge blocks, long gauge blocks, electronic micrometers, surface plate
Head	Up to 30 mm	$\sqrt{(1.4\mu\text{m})^2 + (2.8 \times 10^{-6} \times l_0)^2}$	
Riser Blocks	Up to 600 mm	$\sqrt{(1.3\mu\text{m})^2 + (2.8 \times 10^{-6} \times l_0)^2}$	
Laser Scan Micrometers[3]	(0.1 to 55) mm	0.75 µm	Standard pin gauge
Length – Measure			
Straight Rulers, Standard Tape Rules, Peripheral Gauges	Up to 3 m (3 to 10) m (10 to 20) m (20 to 30) m (30 to 40) m (40 to 50) m	0.33 mm 0.20 mm 0.24 mm 0.32 mm 0.42 mm 0.54 mm	Length calibration system

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Cylindrical Plug/Pin Gauges, Thread Measuring Wire Gauges	(0.1 to 100) mm	$\sqrt{(0.29\mu m)^2 + (3.4 \times 10^{-6} \times l_0)^2}$	Universal length machine
Radius Gauges	Up to 50 mm	3.0 µm	Profile projectors
Cylindrical Ring Gauges	(1 to 100) mm	$\sqrt{(0.77\mu m)^2 + (3.5 \times 10^{-6} \times l_0)^2}$	Universal length machine, standard ring gauges
Step Gauges	Up to 1000 mm	$\sqrt{(1.6\mu m)^2 + (4.2 \times 10^{-6} \times l_0)^2}$	Gauge blocks, electronic micrometers
Taper Thickness Gauges	(0.1 to 60) mm	0.03 mm	Profile projectors
Ultrasonic Thickness Gauges[3]	Up to 100 mm	2.5 µm	Ultrasonic thickness blocks
Thickness Specimens – Coating Ultrasonic	 Up to 8 mm Up to 100 mm	 1.4 µm $\sqrt{(1.4\mu m)^2 + (1.7 \times 10^{-6} \times l_0)^2}$	Gauge blocks, standard measuring machines, electronic micrometers
Coating Thickness Testers[3]	Up to 0.25 mm (0.25 to 1.05) mm (1.05 to 7.9) mm	1.5 µm 2.0 µm 6.9 µm	Coating thickness blocks

Parameter/Equipment	Range	CMC[2, 7, 9] (±)	Comments
Torque Arms –			
Torque Arm	Up to 500 mm	$\sqrt{(6.8\ \mu m)^2 + (7.8 \times 10^{-6} \times l_0)^2}$	Contact coordinate measuring machines
Torque Wire	Up to 5 mm	0.9 µm	Universal length machine
Angle – Measure			
Bevel Protractors	Up to 90° (90 to 360)°	1.3′ 2.0′	Angle gauge blocks, precision surface plates
Plate/Square/Electric Levels –			
Angle	± 200″ ± 1000″ ± 2000″	0.3″ 0.5″ 0.9″	Level & autocollimator calibrator, electronic micrometers, squareness testers, precision surface plates
Squareness	Up to 300 mm	2.3 µm	
Flatness	300 mm × 60 mm	1.1 µm	
Precisions Squares –			
Squareness	Up to 450 mm	$\sqrt{(2.0\mu m)^2 + (3.0 \times 10^{-6} \times l_0)^2}$	Electronic micrometer, squareness tester, surface plate
Parallelism	Up to 450 mm	1.2 µm	
Straightness	Up to 450 mm	2.9 µm	

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Surface Roughness / Contour Measuring System[3] –			
Z-Axis	Up to 60 mm	0.15 µm	Gauge blocks, optical flat
X-Axis	Up to 200 mm	$\sqrt{(0.57\mu m)^2 + (1.9 \times 10^{-6} \times l_0)^2}$	Standard scales
Angle	Up to 120°	1.3′	Angle gauge blocks
Optical Flats	⌀ (10 to 130) mm	0.06 µm	Optical flats, Monochromatic light sources
Optical Parallels –			
Flatness	⌀ (10 to 30) mm	0.060 µm	Optical flats, monochromatic light sources, gauge block comparators
Parallelism	⌀ (10 to 30) mm	0.080 µm	
Parallel blocks –			
Parallelism	Up to 1000 mm	1.3 µm	Electronic micrometers, surface plate
Flatness	Up to 1000 mm	1.2 µm	
Difference of Blocks	Up to 1000 mm	1.9 µm	

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Roundness Measurement Instruments[3] –			
Accuracy of Detector	Up to 1000 µm	0.23 µm	Standard roundness hemisphere, cylindrical squares, optical flats
Rotation Accuracy of Circumference Direction	Up to 360°	16 nm	
Rotation Accuracy of Shaft Direction	Up to 360°	16 nm	
Straightness	Up to 300 mm	1.3 µm	
Coordinate Measuring Machines[3] –			
Length Accuracy	Up to 600 mm	$\sqrt{(0.53\mu m)^2 + (2.0 \times 10^{-6} \times l_0)^2}$	Step gauges, precision squares, straight edges
Straightness	Up to 600 mm	2.1 µm	
Squareness (Deviation from 90°)	Up to 600 mm	1.1″	
Non-Contact Coordinate Measuring Machines[3] –			
Accuracy	Up to 1000 mm	$\sqrt{(0.43\mu m)^2 + (2.8 \times 10^{-6} \times l_0)^2}$	Standard scales

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Microscopes & Profile Projectors[3] –			
Length Accuracy	Up to 300 mm	$\sqrt{(0.45\mu m)^2 + (2.8 \times 10^{-6} \times l_0)^2}$	Standard scales, precision squares
Right Angle Accuracy	Up to 360°	1.7′	
Magnification Accuracy	×2 to ×100	3.3×10^{-4}	
Squareness Accuracy	Up to 300 mm	3.6 µm	
Micro Measuring Microscopes[3]	Up to 50 mm	2.7 µm	Standard scales
Thread Plug Gauges –			
External Diameter	Up to 100 mm	0.52 µm	Universal length machine, thread measuring wires, profile projectors
Effective Diameter	Up to 100 mm	1.6 µm	
Pitch	(0.2 to 6) mm	1.2 µm	
Half Angle	Up to 45°	1.8′	
V-Blocks & Box Blocks –			
Flatness	Up to 150 mm	1.0 µm	Pin gauges, test bars, precision surface plates, electronic micrometers, squareness tester
Parallelism	Up to 150 mm	1.2 µm	
Gradient	Up to 150 mm	0.6 µm	
Mutual Difference	Up to 150 mm	0.9 µm	
Squareness-Box Blocks	Up to 150 mm	$\sqrt{(2.0\mu m)^2 + (3.0 \times 10^{-6} \times l_0)^2}$	
Venier Calipers[3] –			
Inside/Outside/Gear Tooth	Up to 150 mm (150 to 1500) mm	$\sqrt{(3.8\mu m)^2 + (6.4 \times 10^{-6} \times l_0)^2}$ $\sqrt{(7.6\mu m)^2 + (6.8 \times 10^{-6} \times l_0)^2}$	Gauge blocks, caliper tester
Cylinder Gauges/Bore Gauges[3] –			
Cylinder Gauges	Up to 800 mm	0.85 µm	Dial gauge testers, gauge blocks
Bore Gauges	(0.5 to 18.5) mm	0.80 µm	

Parameter/Equipment	Range	CMC[2, 9] (±)	Comments
Depth Gauges & Depth Micrometers[3]	Up to 300 mm (300 to 1000) mm	$\sqrt{(1.0\ \mu m)^2 + (4.0 \times 10^{-6} \times l_0)^2}$ $\sqrt{(7.1\ \mu m)^2 + (4.1 \times 10^{-6} \times l_0)^2}$	Gauge blocks, precision surface plates
Dial/Digital Gauges[3]	Up to 50 mm (50 to 150) mm	$\sqrt{(1.6\mu m)^2 + (1.9 \times 10^{-6} \times l_0)^2}$ $\sqrt{(0.94\mu m)^2 + (2.0 \times 10^{-6} \times l_0)^2}$	Gauge blocks
Micro Indicators, Test Indicators[3]	Up to 2 mm	0.46 µm	Dial gauge testers
Micrometer Heads	Up to 50 mm	0.61 µm	Gauge blocks, electronic micrometers
3-Point Micrometers	(1 to 200) mm	3.2 µm	Standard ring gauges, precision surface plates
Inside Micrometers[3]	(5 to 300) mm (300 to 1500) mm	$\sqrt{(1.5\mu m)^2 + (4.9 \times 10^{-6} \times l_0)^2}$ $\sqrt{(2.2\mu m)^2 + (4.2 \times 10^{-6} \times l_0)^2}$	Gauge blocks
Outside Micrometers[3]	Up to 25 mm (25 to 500) mm (500 to 1500) mm	$\sqrt{(0.36\mu m)^2 + (4.2 \times 10^{-6} \times l_0)^2}$ $\sqrt{(1.6\mu m)^2 + (4.0 \times 10^{-6} \times l_0)^2}$ $\sqrt{(2.5\mu m)^2 + (4.1 \times 10^{-6} \times l_0)^2}$	Gauge blocks
Standard Sieves – Wire Rod Diameter Sieve Opening	 (0.01 to 8) mm (0.01 to 125) mm	 1.7 µm 2.6 µm	Profile projectors

Parameter/Equipment	Range	CMC[2] (±)	Comments
Welding Gauges –			
Height/Depth Measuring Scale	Up to 100 mm	0.009 mm	Profile projectors
Thick Measuring Scale	Up to 16 mm	0.009 mm	
Ruler Measuring Scale	Up to 50 mm	0.096 mm	
Angle Measuring Scale	Up to 90°	0.13°	
Taper Measuring Scale	Up to 7 mm	0.096 mm	

II. Dimensional Testing/Calibration[10]

Parameter/Equipment	Range	CMC[2, 9]	Comments
Length[10] – Measure	Up to 500 mm	$\sqrt{(2.1\ \mu m)^2 + (6.9 \times 10^{-6} \times l_0)^2}$	Contact coordinate measuring machines
Angle[10] – Measure	Up to 360°	2.2′	Profile projector

III. Mechanical

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electric Balances[3]	Up to 2 g (2 to 5) g (5 to 20) g (20 to 50) g (50 to 100) g (100 to 200) g (200 to 500) g (0.5 to 1) kg (1 to 2) kg (2 to 5) kg (5 to 10) kg (10 to 30) kg (30 to 50) kg (50 to 100) kg (100 to 200) kg (200 to 300) kg (300 to 600) kg	0.036 mg 0.051 mg 0.046 mg 0.12 mg 0.12 mg 0.15 mg 3.4 mg 3.5 mg 3.6 mg 2.9 mg 5.8 mg 22 mg 0.82 g 1.6 g 3.3 g 5.5 g 11 g	Standard weights
Platform Scale Balances[3]	Up to 20 kg (20 to 200) kg	1.2 g 58 g	Standard weights
Spring Scale Balances[3]	Up to 1 kg (1 to 2) kg (2 to 5) kg (5 to 10) kg (10 to 30) kg (30 to 50) kg	2.9 g 5.8 g 12 g 29 g 58 g 0.12 kg	Standard weights

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Weights, F1 Class	1 mg 2 mg 5 mg 10 mg 20 mg 50 mg 100 mg 200 mg 500 mg 1 g 2 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 5 kg 10 kg 20 kg	0.0030 mg 0.0022 mg 0.0022 mg 0.0029 mg 0.0047 mg 0.0041 mg 0.0055 mg 0.0079 mg 0.0084 mg 0.010 mg 0.013 mg 0.018 mg 0.025 mg 0.033 mg 0.061 mg 0.12 mg 0.22 mg 0.57 mg 1.2 mg 2.3 mg 6.1 mg 12 mg 26 mg	Standard weights, electric balance
Mass – Measure	Up to 50 mg (50 to 500) mg (0.5 to 5) g (5 to 50) g (50 to 100) g (100 to 200) g (200 g to 500) g (0.5 to 1) kg (1 to 2) kg (2 to 5) kg (5 to 10) kg (10 to 20) kg (20 to 26) kg (26 to 35) kg	0.006 mg 0.009 mg 0.017 mg 0.036 mg 0.055 mg 0.10 mg 0.29 mg 0.54 mg 1.0 mg 2.8 mg 5.4 mg 10 mg 13 mg 88 mg	Standard weights, electric balance
Force – Measuring Equipment	(10 to 500) N (0.5 to 5) kN (5 to 10) kN (10 to 20) kN (20 to 50) kN (50 to 100) kN	0.15 % 0.0031 % 0.028 % 0.046 % 0.039 % 0.034 %	Weight set, deadweight force standards, hydraulic force standards

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Force – Measure[3]			
Compression	10 N to 1000 kN	0.18 %	Electric force gauge
Tension	50 N to 100 kN	0.26 %	
Push-Pull Gauges	(0.2 to 50) N (50 to 1000) N (1000 to 2000) N (2000 to 5000) N	0.15 % 0.17 % 0.23 % 0.18 %	Deadweight force standards, weights
Torque – Measuring Equipment[3]	(0.005 to 100) N·m	0.71 %	Weights, torque arms
Torque – Measure[3]			
Clockwise	(0.06 to 0.6) N·m (0.6 to 1) N·m (1 to 2.5) N·m (2.5 to 5) N·m (5 to 10) N·m (10 to 25) N·m (25 to 50) N·m (50 to 100) N·m (100 to 250) N·m (250 to 500) N·m (500 to 1000) N·m (1000 to 2000) N·m	1.4 % 0.58 % 0.96 % 0.47 % 0.54 % 0.35 % 0.27 % 0.62 % 0.38 % 0.19 % 0.61 % 0.66 %	Torque testers
Counterclockwise	(0.06 to 0.6) N·m (0.6 to 1) N·m (1 to 2.5) N·m (2.5 to 5) N·m (5 to 10) N·m (10 to 25) N·m (25 to 50) N·m (50 to 100) N·m (100 to 250) N·m (250 to 500) N·m (500 to 1000) N·m (1000 to 2000) N·m	1.3 % 0.68 % 0.95 % 0.55 % 0.58 % 0.34 % 0.36 % 0.87 % 0.40 % 0.42 % 0.55 % 0.49 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Absolute Pressure Gauges	5 kPa abs to 7 MPa abs	0.054 %	Pressure controllers
Compound Pressure Gauges[3]	(-95 to 7000) kPa	|0.049 %| + 0.35 kPa	Pressure calibrators
Pneumatic Differential Pressure Gauges[3]	Up to 7 MPa	|0.052 %| + 0.36 kPa	Pressure calibrators
Gauge Pressure Gauges[3] –			
Gauge Pressure Gauges	Up to 500 kPa (0.5 to 10) MPa (10 to 40) MPa (40 to 200) MPa	|0.054 %| + 0.015 kPa 0.019 % 0.081 % 0.072 %	Pressure calibrators, pneumatic pressure balance, hydraulic pressure balance
Pressure Recorders	Up to 500 kPa (0.5 to 10) MPa (10 to 40) MPa (40 to 200) MPa	|3.0 %| + 1.0 kPa 1.2 % 1.5 % 0.59 %	
Pressure Transducers / Transmitters[3] –	(-95 to 0) kPa (0 to 500) kPa (0.5 to 10) MPa (10 to 100) MPa	|0.28 %| + 0.14 kPa |0.31 %| + 0.14 kPa 0.34 % 0.31 %	Pressure calibrators, dead weight testers
Pressure Transducers / Transmitters	(100 to 200) MPa 5 kPa abs to 7 MPa abs	0.26 % 0.30 %	
Dial Type Vacuum Gauges[3]	(-95 to 0) kPa	| 1 %| + 0.10 kPa	Pressure calibrators

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Pressure – Measure & Measuring Equipment			
Gauge Pressure[3]	Up to 500 kPa (0.5 to 10) MPa (10 to 40) MPa	|0.036 %| + 0.018 kPa 0.013 % 0.081 %	Pressure calibrators, dead weight testers
Gauge Pressure	(40 to 200) MPa	0.071 %	
Absolute Pressure	(5 to 200) kPa abs. (200 to 7000) kPa abs.	0.075 % 0.045 %	
Vacuum – Measure & Measuring Equipment[3]	(-95 to 0) kPa	|0.091 %| + 0.0091 kPa	Pressure calibrators

IV. Fluid Quantities

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Air Flow – Velocity Measurement	(0.1 to 2) m/s (2 to 55) m/s	8.1 % 0.53 %	ILA / LDV SONDE FP50US
Gas Flow Rate Meters	$(1.2 \cdot 10^{-5}$ to 0.12) m^3/h (0.12 to 260) m^3/h	0.19 % 0.25 %	Reference flowmeter, Sonic nozzle
Liquid Flow Rate Meters	(0.005 to 50) m^3/h	0.24 %	Reference flowmeter

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Air Particle Counter –			
Laser Reference Voltage	(0 to 10) V	5.4 mV	Agilent 34401A
Flow Rate	(1 to 100) L/min	2.5 %	TSI 4043H
Threshold Voltage	(0 to 10) V	5.4 mV	Agilent 34401A
Counting Efficiency[3]			
CPC	(0 to 1.0) µm	3.0 %	TSI 3068B
OPC	(0.1 to 1.0) µm	4.7 %	TSI 3772, PMS LASAIRII-110, CRM standard size particles
Liquid Particle Counter –			
Laser Reference Voltage	(0 to 10) V	5.4 mV	Agilent 34401A
Threshold Voltage	(0 to 10) V	5.4 mV	
Flow Rate	(10 to 25) mL/min (25 to 300) mL/min	8.1 % 5.0 %	Matheson FM-1050, Matheson FM1050S-V, PMS / FC-100CRM standard size particles
Particle Dilution Systems / PCRF (Particle Concentration Reduction Factor)			TSI 3776, 3772 AVL LIST GmbH AVL499 APG
Dilution Factor	Up to 20 000 DF	8.3 %	
Dynamic Viscometers	(2.5 to 200 000) mPa·s	1.5 %	Polyscience / AD29VB3S-A13K Wika / CTR2000 viscosity standard

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Volumetric Glass Wares	(0.1 to 2) ml (2 to 10) ml (10 to 25) ml (25 to 100) ml (100 to 250) ml (250 to 500) ml (500 to 1000) ml (1000 to 2000) ml (2000 to 5000) ml	3.0 µl 9.7 µl 0.024 ml 0.087 ml 0.21 ml 0.42 ml 0.84 ml 1.7 ml 4.2 ml	Standard weights, electric balance pure water, digital thermometer
Pycnometers	Up to 50 ml (50 to 100) ml (100 to 500) ml	0.042 ml 0.083 ml 0.41 ml	Standard weights, electric balance pure water, digital thermometer
Piston Type Volume Meters	(0.1 to 5) µl (5 to 10) µl (10 to 20) µl (20 to 50) µl (50 to 100) µl (0.1 to 0.2) ml (0.2 to 0.5) ml (0.5 to 1) ml (1 to 2) ml (2 to 5) ml (5 to 10) ml (10 to 20) ml	0.065 µl 0.067 µl 0.072 µl 0.096 µl 0.13 µl 0.24 µl 0.53 µl 1.2 µl 2.3 µl 5.3 µl 0.012 ml 0.023 ml	Standard weights, electric balance pure water, digital thermometer
Volume – Measure	(0.1 to 2) ml (2 to 10) ml (10 to 25) ml (25 to 100) ml (100 to 250) ml (250 to 500) ml (500 to 1000) ml (1000 to 2000) ml (2000 to 5000) ml	3.0 µl 9.7 µl 0.024 ml 0.087 ml 0.21 ml 0.42 ml 0.84 ml 1.7 ml 4.2 ml	Standard weights, electric balance pure water, digital thermometer

V. Time & Frequency

Parameter/Equipment	Range	CMC[2, 7] (±)	Comments
Timebase Frequency	100 kHz to 10 MHz	1.1×10^{-12} Hz/Hz	Odetics 425-311 HP 53132A
Frequency – Measuring Equipment[3]	1 Hz to 46 GHz	9.7×10^{-10} Hz/Hz	Odetics 425-311 Agilent 33250A Agilent E8257D HP 83650B
Frequency – Measure[3]	1 Hz (1 to 100) Hz 100 Hz to 100 kHz 100 kHz to 3 GHz (3 to 46) GHz	72 µHz 7.9×10^{-6} Hz/Hz 6.7×10^{-7} Hz/Hz 6.7×10^{-9} Hz/Hz 1.7 Hz	Odetics 425-311 HP 53132A HP 53152A
Stopwatch	Day (86 400 s) Month (2 592 000 s)	6.6 ms 0.67 s	Witschi Analyser Q1
Timers[3]	(1 to 10 000) s	88 ms	HP 5334B, Agilent 33250A
Counter	(1 to 9000)	1	Odetics 425-311, Agilent 33210A, Autonics CT4S
Rotational Speed – Standard RPM Generators[3] Standard RPM	(1 to 1000) rpm (1000 to 100 000) rpm	0.088 rpm 0.90 rpm	Odetics 425-311, H.P 53132A, Kriss-P03A
Rotational Speed – Standard RPM Generators[3] Standard RPM	(1 to 60) rpm (60 to 900) rpm (900 to 99 000) rpm	0.089 rpm 0.15 rpm 1.5 rpm	TESTO 470

Parameter/Equipment	Range	CMC[2] (±)	Comments
Contact Type Tachometers –			
Contact RPM	(1 to 4000) rpm	0.11 rpm	Odetics 425-311, Kriss P01C
Photo Type Tachometers –			
Photo RPM	(1 to 600) rpm (600 to 100 000) rpm	0.090 rpm 0.90 rpm	Odetics 425-311, Keysight 33210A, Kriss-P02A
Speed Meter –			
Signal Generaor	(10 to 400) km/h	0.13 km/h	Odetics 425-311, Keysight 33210A, Racelogic VBTouch-V3
Non-Contact	(10 to 400) km/h	0.2 km/h	

VI. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Voltage – Generate[3]	0 mV (0.1 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 19) V (19 to 100) V (100 to 1000) V (1 to 2) kV (2 to 5) kV (5 to 100) kV	0.50 µV 1.4 µV/V 6.7 µV/V 45 µV/V 82 µV/V 0.63 mV 8.1 mV 0.082 % 0.072 % 0.069%	Fluke 5730A Spellman SL100P300 /SIC/220, Hipotronics KVM-200D, Fluke 8508A
DC Voltage – Measure[3]	0 mV (0 to 10) mV (10 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV (1 to 2) kV (2 to 4) kV (4 to 10) kV (10 to 20) kV (20 to 100) kV	0.12 µV 15 µV 49 µV 3.9 µV/V 3.7 µV/V 5.3 µV/V 5.5 µV/V 0.055 % 0.049 % 0.048 % 5.1 V 0.026 %	Fluke 8508A Hipotronics KVM-200D, Fluke 8508A
Meter Calibrators	100 mV 100 mV to 1 V 1 V to 1 kV	3.3 µV/V 2.5 µV/V 2.4 µV/V	Fluke 732B, Fluke 752A, Fluke 8508A
DC Standards	1.018 V 10 V	2.6 µV 26 µV	Fluke 732B, Fluke 8508A

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Voltage – Generate[3]			
1 mV	10 Hz 10 Hz to 100 kHz 100 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	3.5 µV 0.13 % 0.58 % 0.82 % 1.1 % 3.5 %	Fluke 5730A, Fluke 5725A, NI Pxi-5122
(1 to 10) mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz 100 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	7.7 µV 0.076 % 0.059 % 0.057 % 0.072 % 0.12 % 0.16 % 0.27 % 0.51 % 1.3 %	
(10 to 100) mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz 200 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	43 µV 0.043 % 0.019 % 0.016 % 0.023 % 0.057 % 0.11 % 0.13 % 0.24 % 0.48 % 1.2 %	
100 mV to 1 V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 2 MHz	0.33 mV 0.033 % 0.013 % 62 µV/V 94 µV/V 0.014 % 0.049 % 0.14 % 0.12 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Voltage – Generate (cont)[3]			
100 mV to 1 V	(2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.24 % 0.48 % 1.2 %	Fluke 5730A, Fluke 5725A, NI Pxi-5122
(1 to 3) V	10 Hz 10 Hz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	10 mV 0.12 % 0.24 % 0.48 % 1.2 %	
(3 to 10) V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	3.3 mV 0.033 % 0.013 % 58 µV/V 94 µV/V 0.013 % 0.039 % 0.14 % 0.22 %	
(10 to 100) V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	34 mV 0.033 % 0.013 % 72 µV/V 0.011 % 0.022 %	
(100 to 1000) V	40 Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.37 V 87 µV/V 0.021 % 0.073 %	
(1 to 2) kV (2 to 4) kV (4 to 8) kV (8 to 10) kV (10 to 20) kV (20 to 30) kV (30 to 60) kV (60 to 70) kV	(50 to 60) Hz	7.9 % 4.4 % 2.7 % 2.3 % 1.7 % 1.4 % 1.3 % 1.4 %	Phenix 6CP120/60-7.5

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Voltage – Measure[3]			
1 mV	10 Hz (10 to 20) Hz 20 Hz to 100 kHz 100 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 40) MHz (40 to 50) MHz	1.3 µV 0.13 % 0.065 % 0.20 % 0.32 % 0.59 % 1.1 % 1.5 % 1.5 %	Fluke 5790B
(1 to 10) mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz 50 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 40) MHz (40 to 50) MHz	4.9 µV 0.049 % 0.038 % 0.029 % 0.037 % 0.054 % 0.083 % 0.12 % 0.21 % 0.45 % 0.72 % 0.73 %	
(10 to 100) mV	10 Hz (10 to 20) Hz (20 to 40) Hz 40 to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 40) MHz (40 to 50) MHz	27 µV 0.027% 0.012 % 63 µV/V 64 µV/V 0.022 % 0.034 % 0.035 % 0.047 % 0.060 % 0.12 % 0.19 % 0.43 % 0.72 % 0.73 %	
100 mV to 1 V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	0.24 mV 0.024 % 77 µV/V 29 µV/V 54 µV/V	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Voltage – Measure (cont)[3]			
100 mV to 1 V	(50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 40) MHz (40 to 50) MHz	84 µV/V 0.019 % 0.031 % 0.060 % 0.12 % 0.19 % 0.43 % 0.71 % 0.72 %	Fluke 5790B
(1 to 3) V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 40) MHz (40 to 50) MHz	0.70 mV 0.024 % 80 µV/V 34 µV/V 57 µV/V 97 µV/V 0.023 % 0.047 % 0.060 % 0.12 % 0.19 % 0.44 % 0.74 % 0.74 %	
(3 to 10) V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	2.4 mV 0.024 % 78 µV/V 33 µV/V 57 µV/V 95 µV/V 0.023 % 0.047 % 0.15 %	
(10 to 100) V	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	24 mV 0.024 % 80 µV/V 37 µV/V 38 µV/V 81 µV/V 0.012 %	

Parameter/Range	Frequency	CMC[2, 4, 5, 8] (±)	Comments
AC Voltage – Measure (cont)[3]			
(100 to 700) V	40 Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	30 mV 45 µV/V 0.013 % 0.050 %	Fluke 5790B
(700 to 1000) V	40 Hz 40 Hz to 20 kHz (20 to 30) kHz	70 mV 47 µV/V 0.016 %	
1 kV (1 to 2) kV (2 to 4) kV (4 to 8) kV (8 to 10) kV (10 to 75) kV (75 to 100) kV	(50 to 60) Hz	6.0V 0.37 % 0.30 % 0.30 % 0.30 % 0.27 % 0.67 %	Vitrek 4700, HVL100/HVL150

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Current – Generate[3]	0 µA (0 to 10) µA (10 to 200) µA 200 µA to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 100) A (100 to 200) A (200 to 500) A (500 to 750) A 750 A to 1 kA (1 to 1.5) kA (1.5 to 2) kA (2 to 2.5) kA	7.0 nA 7.4 nA 17 nA 90 nA 44 µA/A 60 µA/A 0.21 mA 0.016 % 0.043 % 0.031 % 0.083 % 0.090 % 0.061 % 0.052 % 0.038 %	Fluke 5730A Fluke 52120A Fluke 25 Turn 3000A current coil

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Current – Measure[3] (Positive & Negative)	10 pA (10 to 100) pA (0.1 to 1) nA (1 to 100) nA (0.1 to 1) µA	0.12 pA 1.2 % 0.27 % 0.24 % 0.038 %	Keithley 6517A HP 3458A Fluke 8508A
	1 µA (1 to 10) µA (10 to 100) µA (100 to 200) µA (0.2 to 1) mA (1 to 2) mA (2 to 10) mA (10 to 20) mA (20 to 100) mA (100 to 200) mA (0.2 to 2) A (2 to 10) A (10 to 15) A (15 to 20) A (20 to 50) A (50 to 80) A (80 to 100) A (100 to 200) A (200 to 300) A (300 to 1500) A (1500 to 2000) A (2000 to 3000) A	76 pA 8.9 µA/A 8.5 µA/A 7.5 µA/A 11 µA/A 9.5 µA/A 50 µA/A 26 µA/A 11 µA/A 10 µA/A 25 µA/A 0.016 % 0.011 % 80 µA/A 0.050 % 0.045 % 0.043 % 0.036 % 0.028 % 0.024 % 0.041 % 0.044 %	Fluke 742A series, Guildline 9230A Series, Fluke 355

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Current – Generate[3]			
20 µA	1 kHz (1 to 10) kHz	13 nA 0.55 %	Fluke 5730A, Fluke 52120A
(20 to 200) µA	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	77 nA 77 nA 50 nA 34 nA 81 nA 0.17 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Current – Generate (cont)[3]			
200 µA to 2 mA	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.64 µA 0.63 µA 0.42 µA 0.29 µA 0.61 µA 0.17 %	Fluke 5730A, Fluke 52120A
(2 to 20) mA	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	6.4 µA 6.3 µA 4.2 µA 2.9 µA 5.5 µA 0.16 %	
(20 to 200) mA	10 Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	64 µA 64 µA 42 µA 28 µA 53 µA 0.14 %	
200 mA to 2 A	10 Hz 10 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.69 mA 0.69 mA 0.060 % 0.85 %	
(2 to 4) A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 5) kHz (5 to 10) kHz	3.6 mA 0.090 % 0.11 % 0.19 % 0.60 % 1.7 % 4.3 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Current – Generate (cont)[3]			
(4 to 10) A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 5) kHz (5 to 10) kHz	8.9 mA 0.089 % 0.11 % 0.19 % 0.58 % 1.7 % 4.2 %	Fluke 5730A, Fluke 52120A
(10 to 20) A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 5) kHz (5 to 10) kHz	18 mA 0.090 % 0.11 % 0.19 % 0.60 % 1.7 % 4.2 %	
(20 to 60) A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	27 mA 0.045 % 0.072 % 0.23 % 0.65 % 1.8 % 5.5 %	
(60 to 120) A	10 Hz (10 to 60) Hz (60 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	53 mA 0.044 % 0.072 % 0.23 % 0.64 % 1.8 % 5.4 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Current – Generate (cont)[3]			
(120 to 200) A (200 to 900) A (900 to 1000) A (1000 to 1500) A (1500 to 3000) A	(50 to 60) Hz (50 to 60) Hz (50 to 60) Hz (50 to 60) Hz (50 to 60) Hz	0.25 A 0.12 % 1.6 A 2.0 A 0.13 %	Fluke 25 turn 3000A current coil
AC Current – Measure[3]			
10 µA	10 Hz 10 Hz to 10 kHz	5.6 nA 0.035 %	Fluke 5790B, Fluke A40B series
(10 to 100) µA	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	29 nA 0.010 % 0.012 %	
(0.1 to 0.4) mA	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	0.11 µA 88 µA/A 0.011 %	
(0.4 to 0.8) mA	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	0.21 µA 84 µA/A 0.010 %	
(0.8 to 1) mA	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	0.24 µA 78 µA/A 98 µA/A	
(1 to 4) mA	10 Hz 10 Hz to 10 kHz	1.0 µA 60 µA/A	
(4 to 8) mA	10 Hz 10 Hz to 10 kHz	2.0 µA 68 µA/A	
(8 to 10) mA	10 Hz 10 Hz to 10 kHz	2.4 µA 61 µA/A	
(10 to 40) mA	10 Hz 10 Hz to 10 kHz	10 µA 69 µA/A	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Current – Measure (cont)[3]			
(40 to 80) mA	10 Hz 10 Hz to 10 kHz	20 µA 65 µA/A	Fluke 5790B, Fluke A40B series
(80 to 100) mA	10 Hz 10 Hz to 10 kHz	24 µA 58 µA/A	
(0.1 to 0.4) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	0.10 mA 74 µA/A 75 µA/A	
(0.4 to 0.8) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	0.20 mA 70 µA/A 71 µA/A	
(0.8 to 1) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	0.24 mA 62 µA/A 64 µA/A	
(1 to 4) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	1.1 mA 91 µA/A 0.013 %	
(4 to 8) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	2.1 mA 88 µA/A 0.014 %	
(8 to 10) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	2.5 mA 83 µA/A 0.013 %	
(10 to 15) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	4.0 mA 0.010 % 0.012 %	
(15 to 20) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	5.0 mA 0.010 % 0.012 %	
(20 to 40) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	11 mA 0.012 % 0.017 %	
(40 to 50) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	13 mA 0.012 % 0.017 %	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
AC Current – Measure (cont)[3]			
(50 to 80) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	23 mA 0.015 % 0.020 %	Fluke 5790B, Fluke A40B series
(80 to 100) A	10 Hz 10 Hz to 1 kHz (1 to 10) kHz	28 mA 0.014 % 0.020 %	
100 A (100 to 300) A (300 to 1000) A (1000 to 1400) A	(50 to 60) Hz	2.5 A 4.3 % 24 A 42 A	Fluke 355

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Power – Generate[3]	0.1 W (0.1 to 0.5) W (0.5 to 0.6) W (0.6 to 1) W (1 to 1.2) W (1.2 to 2.4) W (2.4 to 3) W (3 to 4.8) W (4.8 to 5) W (5 to 6) W (6 to 12) W (12 to 24) W (24 to 30) W (30 to 50) W (50 to 60) W (60 to 100) W (100 to 120) W (120 to 240) W (240 to 300) W (300 to 500) W (500 to 600) W (600 to 1000) W (1 to 1.2) kW (1.2 to 2.4) kW (2.4 to 4.8) kW (4.8 to 5) kW (5 to 6) kW	0.16 mW 0.038 % 0.029 % 0.017 % 0.014 % 0.0080 % 0.0097 % 0.0044 % 0.0083 % 0.0085 % 0.010 % 0.0080 % 0.0058 % 0.0068 % 0.0060 % 0.0073 % 0.0085 % 0.0060 % 0.0057 % 0.0066 % 0.0060 % 0.0068 % 0.0087 % 0.0067 % 0.0067 % 0.0048 % 0.0080 %	Fluke 5522A, Clarke-hess 8100

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Power – Generate (cont)[3]	(6 to 9.6) kW (9.6 to 10) kW (10 to 12) kW (12 to 24) kW (24 to 30) kW (30 to 60) kW (60 to 120) kW (120 to 240) kW (240 to 500) kW	0.0054 % 0.0070 % 0.011 % 0.0079 % 0.015 % 0.013 % 0.015 % 0.014 % 0.012 %	Fluke 5522A, Clarke-hess 8100 Fluke 25 turn 3000A current coil
AC Power – Generate[3]			
Power			
(50 to 60) Hz	0.06 W (0.06 to 0.12) W (0.12 to 0.24) W (0.24 to 0.48) W (0.48 to 0.6) W (0.6 to 1.2) W (1.2 to 6) W (6 to 12) W (12 to 60) W (60 to 120) W (120 to 600) W (600 to 1 200) W (1.2 to 9.6) kW (9.6 to 19.2) kW (19.2 to 60) kW (60 to 120) kW (120 to 240) kW	0.071 mW 0.060 % 0.035 % 0.028 % 0.017 % 0.024 % 0.015 % 0.015 % 0.013 % 0.015 % 0.013 % 0.015 % 0.024 % 0.024 % 0.014 % 0.015 % 0.015 %	Fluke 6105A, Fluke 25 turn 3000A current coil
Power Factor			
(50 to 60) Hz	(-1 to 1) PF	0.000 16 PF	Fluke 6105A
Harmonic			
(50 to 60) Hz	THD-V (0.5 to 20) % THD-I (0.5 to 20) %	0.024 % 0.022 %	Fluke 6105A

Parameter/Equipment	Range	CMC[2, 4, 5, 8] (±)	Comments
AC Power – Generate (cont)			
Flicker			
P_{st} (1 to 4000) cpm	1	0.39 %	Fluke 6105A N4L PPA5511
$P_{inst\cdot max}$			
Sinusoidal			
1	(0.5 to 25) Hz	0.38 %	
1	(25 to 33.333) Hz	0.39 %	
Square			
1	(0.5 to 28) Hz	0.40 %	
1	(28 to 30.5) Hz	1.1 %	
1	(30.5 to 33.333) Hz	0.40 %	
P_{st} Range			
1620 cpm	0.25	0.39 %	
	0.25 to 5	0.40 %	
AC Power – Measure[3]			
Power			
(50 to 60) Hz	(0.12) W	0.35 mW	ZES Zimmer LMG670
	(0.12 to 0.48) W	0.16 %	
	(0.48 to 2.4) W	0.075 %	
	(2.4 to 24) W	0.11 %	
	(24 to 240) W	0.092 %	
	(240 to 600) W	0.077 %	
	(600 to 1200) W	0.076 %	
	(1200 to 4800) W	0.080 %	
Power Factor			
(50 to 60) Hz	(-1 to 1) PF	0.000 70 PF	ZES Zimmer LMG670
Harmonic			
(50 to 60) Hz	THD-V (0.5 to 20) %	0.038 %	ZES Zimmer LMG670
	THD-I (0.5 to 20) %	0.038 %	

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
DC Resistance – Generate[3]	1 mΩ	0.28 µΩ	Yokogawa 2792 series
	10 mΩ	1.2 µΩ	Guildline 9330 series
	100 mΩ	0.71 µΩ	Tinsley 5685A
	1 Ω	3.3 µΩ	IET HARS-X-10-.001-K
	(1 to 2) Ω	0.19 mΩ	
	(2 to 3) Ω	0.27 mΩ	
	(3 to 4) Ω	0.33 mΩ	
	(4 to 5) Ω	0.40 mΩ	
	(5 to 6) Ω	0.47 mΩ	
	(6 to 7) Ω	0.54 mΩ	
	(7 to 8) Ω	0.61 mΩ	
	(8 to 9) Ω	0.68 mΩ	
	(9 to 10) Ω	0.75 mΩ	
	(10 to 20) Ω	0.78 mΩ	
	(20 to 30) Ω	1.2 mΩ	
	(30 to 40) Ω	1.5 mΩ	
	(40 to 50) Ω	1.9 mΩ	
	(50 to 60) Ω	2.2 mΩ	
	(60 to 70) Ω	2.6 mΩ	
	(70 to 80) Ω	2.9 mΩ	
	(80 to 90) Ω	3.3 mΩ	
	(90 to 100) Ω	3.6 mΩ	
	(100 to 200) Ω	7.0 mΩ	
	(200 to 300) Ω	11 mΩ	
	(300 to 400) Ω	14 mΩ	
	(400 to 500) Ω	17 mΩ	
	(500 to 600) Ω	21 mΩ	
	(600 to 700) Ω	24 mΩ	
	(700 to 800) Ω	27 mΩ	
	(800 to 900) Ω	31 mΩ	
	900 Ω to 1 kΩ	34 mΩ	
	(1 to 2) kΩ	78 mΩ	
	(2 to 3) kΩ	0.11 Ω	
	(3 to 4) kΩ	0.14 Ω	
	(4 to 5) kΩ	0.17 Ω	
	(5 to 6) kΩ	0.21 Ω	
	(6 to 7) kΩ	0.24 Ω	
	(7 to 8) kΩ	0.27 Ω	
	(8 to 9) kΩ	0.30 Ω	
	(9 to 10) kΩ	0.33 Ω	
	(10 to 20) kΩ	0.94 Ω	
	(20 to 30) kΩ	1.1 Ω	
	(30 to 40) kΩ	1.4 Ω	
	(40 to 50) kΩ	1.6 Ω	
	(50 to 60) kΩ	1.9 Ω	
	(60 to 70) kΩ	2.2 Ω	
	(70 to 80) kΩ	2.5 Ω	
	(80 to 90) kΩ	2.9 Ω	

Parameter/Equipment	Range	CMC[2, 8] (±)	Comments
DC Resistance – Generate[3] (cont)			
	(90 to 100) kΩ	3.1 Ω	Yokogawa 2792 series
	(100 to 200) kΩ	13 Ω	Guildline 9330 series
	(200 to 300) kΩ	14 Ω	Tinsley 5685A
	(300 to 400) kΩ	15 Ω	IET HARS-X-10-.001-K
	(400 to 500) kΩ	17 Ω	
	(500 to 600) kΩ	19 Ω	
	(600 to 700) kΩ	22 Ω	
	(700 to 800) kΩ	24 Ω	
	(800 to 900) kΩ	27 Ω	
	900 kΩ to 1 MΩ	29 Ω	
	(1 to 2) MΩ	0.20 kΩ	IET HRRS-B-8-100k-4kV
	(2 to 3) MΩ	0.21 kΩ	
	(3 to 4) MΩ	0.23 kΩ	
	(4 to 5) MΩ	0.25 kΩ	
	(5 to 6) MΩ	0.29 kΩ	
	(6 to 7) MΩ	0.34 kΩ	
	(7 to 8) MΩ	0.39 kΩ	
	(8 to 9) MΩ	0.43 kΩ	
	(9 to 10) MΩ	0.48 kΩ	
	(10 to 30) MΩ	11 kΩ	
	(30 to 40) MΩ	12 kΩ	
	(40 to 60) MΩ	13 kΩ	
	(60 to 70) MΩ	14 kΩ	
	(70 to 80) MΩ	15 kΩ	
	(80 to 90) MΩ	17 kΩ	
	(90 to 100) MΩ	18 kΩ	
	(100 to 200) MΩ	0.24 MΩ	
	(200 to 300) MΩ	0.26 MΩ	
	(300 to 500) MΩ	0.35 MΩ	
	(500 to 600) MΩ	0.44 MΩ	
	(600 to 700) MΩ	0.45 MΩ	
	(700 to 800) MΩ	0.54 MΩ	
	800 MΩ to 1 GΩ	0.64 MΩ	
	(1 to 2) GΩ	4.4 MΩ	
	(2 to 3) GΩ	5.6 MΩ	
	(3 to 4) GΩ	5.8 MΩ	
	(4 to 5) GΩ	6.9 MΩ	
	(5 to 6) GΩ	8.0 MΩ	
	(6 to 7) GΩ	9.2 MΩ	
	(7 to 8) GΩ	9.5 MΩ	
	(8 to 9) GΩ	11 MΩ	
	(9 to 10) GΩ	12 MΩ	
	(10 to 20) GΩ	78 MΩ	
	(20 to 30) GΩ	95 MΩ	
	(30 to 40) GΩ	0.12 GΩ	
	(40 to 50) GΩ	0.14 GΩ	

Parameter/Equipment	Range	CMC[2, 8] (±)	Comments
DC Resistance – Generate[3] (cont)			
	(50 to 60) GΩ	0.17 GΩ	Yokogawa 2792 series
	(60 to 70) GΩ	0.19 GΩ	Guildline 9330 series
	(70 to 80) GΩ	0.22 GΩ	Tinsley 5685A
	(80 to 90) GΩ	0.24 GΩ	IET HARS-X-10-.001-K
	(90 to 100) GΩ	0.27 GΩ	
	(100 to 200) GΩ	1.4 GΩ	
	(200 to 300) GΩ	2.0 GΩ	
	(300 to 400) GΩ	2.6 GΩ	
	(400 to 500) GΩ	3.2 GΩ	
	(500 to 600) GΩ	3.8 GΩ	
	(600 to 700) GΩ	4.5 GΩ	
	(700 to 800) GΩ	5.1 GΩ	
	(800 to 900) GΩ	5.7 GΩ	
	900 GΩ to 1 TΩ	6.3 GΩ	
	(1 to 2) TΩ	24 GΩ	
	(2 to 3) TΩ	26 GΩ	
	(3 to 4) TΩ	35 GΩ	
	(4 to 5) TΩ	36 GΩ	
	(5 to 6) TΩ	45 GΩ	
	(6 to 7) TΩ	46 GΩ	
	(7 to 8) TΩ	56 GΩ	
	(8 to 9) TΩ	57 GΩ	
	(9 to 10) TΩ	67 GΩ	
Fixed Points	1 Ω	0.12 mΩ	Fluke 5730A
	1.9 Ω	0.21 mΩ	
	10 Ω	0.27 mΩ	
	19 Ω	0.51 mΩ	
	100 Ω	1.2 mΩ	
	190 Ω	2.3 mΩ	
	1 kΩ	8.0 mΩ	
	1.9 kΩ	15 mΩ	
	10 kΩ	80 mΩ	
	19 kΩ	0.15 Ω	
	100 kΩ	1.1 Ω	
	190 kΩ	1.9 Ω	
	1 MΩ	5.0 Ω	
	1.9 MΩ	41 Ω	
	10 MΩ	0.47 kΩ	
	19 MΩ	1.1 kΩ	
	100 MΩ	12 kΩ	

Parameter/Range	Frequency	CMC[2, 8] (±)	Comments
AC Resistance – Generate[3]			
100 mΩ	(50 to 60) Hz	1.2 mΩ	Rara IRH300 series
(100 to 200) mΩ	(50 to 60) Hz	2.4 mΩ	
(200 to 300) mΩ	(50 to 60) Hz	3.5 mΩ	
(300 to 400) mΩ	(50 to 60) Hz	4.7 mΩ	
(400 to 500) mΩ	(50 to 60) Hz	5.9 mΩ	
Fixed Points			
1 Ω	1 kHz	1.2 mΩ	HP 16074A, Keysight 42030A
10 Ω	1 kHz	3.6 mΩ	
	1 kHz to 5 MHz	0.12 Ω	
	(5 to 10) MHz	0.13 Ω	
	(10 to 13) MHz	0.14 Ω	
100 Ω	1 kHz	36 mΩ	
	1 kHz to 13 MHz	1.2 Ω	
1 kΩ	1 kHz	0.36 Ω	
	1 kHz to 13 MHz	12 Ω	
10 kΩ	1 kHz	3.6 Ω	
	1 kHz to 1 MHz	0.12 kΩ	
100 kΩ	1 kHz	38 Ω	
	1 kHz to 1 MHz	1.2 kΩ	

Parameter/Equipment	Range	CMC[2, 8] (±)	Comments
DC Resistance – Measure[3]	1 mΩ (1 to 10) mΩ (10 to 80) mΩ (80 to 100) mΩ 100 mΩ to 1 Ω (1 to 2) Ω (2 to 3) Ω (3 to 4) Ω (4 to 5) Ω (5 to 6) Ω (6 to 7) Ω (7 to 8) Ω (8 to 9) Ω (9 to 10) Ω (10 to 40) Ω (40 to 50) Ω (50 to 60) Ω (60 to 70) Ω (70 to 80) Ω (80 to 90) Ω (90 to 100) Ω (100 to 200) Ω (200 to 300) Ω (300 to 400) Ω (400 to 500) Ω (500 to 600) Ω (600 to 700) Ω (700 to 800) Ω (800 to 900) Ω 900 Ω to 1 kΩ (1 to 2) kΩ (2 to 3) kΩ (3 to 4) kΩ (4 to 5) kΩ (5 to 6) kΩ (6 to 7) kΩ (7 to 8) kΩ (8 to 9) kΩ (9 to 10) kΩ (10 to 20) kΩ (20 to 30) kΩ (30 to 40) kΩ (40 to 50) kΩ (50 to 60) kΩ (60 to 70) kΩ (70 to 80) kΩ (80 to 90) kΩ	7.6 μΩ 8.7 μΩ 9.0 μΩ 11 μΩ 91 μΩ 0.13 mΩ 0.17 mΩ 0.21 mΩ 0.25 mΩ 0.30 mΩ 0.35 mΩ 0.39 mΩ 0.44 mΩ 0.48 mΩ 0.49 mΩ 0.56 mΩ 0.63 mΩ 0.70 mΩ 0.77 mΩ 0.85 mΩ 0.93 mΩ 3.7 mΩ 4.2 mΩ 4.9 mΩ 5.5 mΩ 6.1 mΩ 6.9 mΩ 7.7 mΩ 8.4 mΩ 9.2 mΩ 34 mΩ 42 mΩ 46 mΩ 54 mΩ 60 mΩ 69 mΩ 76 mΩ 84 mΩ 92 mΩ 0.39 Ω 0.43 Ω 0.50 Ω 0.57 Ω 0.63 Ω 0.70 Ω 0.78 Ω 0.85 Ω	Fluke 8508A, Fluke 5730A

Parameter/Equipment	Range	CMC[2, 8] (±)	Comments
DC Resistance – Measure[3] (cont)	(90 to 100) kΩ	0.93 Ω	Fluke 8508A, Fluke 5730A
	(100 to 200) kΩ	5.4 Ω	
	(200 to 300) kΩ	5.9 Ω	
	(300 to 400) kΩ	6.5 Ω	
	(400 to 500) kΩ	6.9 Ω	
	(500 to 600) kΩ	7.6 Ω	
	(600 to 700) kΩ	8.3 Ω	
	(700 to 800) kΩ	9.0 Ω	
	(800 to 900) kΩ	9.7 Ω	
	900 kΩ to 1 MΩ	11 Ω	
	(1 to 10) MΩ	72 kΩ	
	(10 to 100) MΩ	2.3 MΩ	
	100 MΩ to 1 GΩ	0.15 MΩ	Quadtech 1865
	(1 to 10) GΩ	15 MΩ	
	(10 to 100) GΩ	0.53 GΩ	
	100 GΩ to 1 TΩ	8 GΩ	
Fixed Points	1 Ω	4.1 μΩ	Fluke 8508A
	10 Ω	0.06 mΩ	Guildline 9330 series
	100 Ω	0.53 mΩ	Fluke 724A series
	1 kΩ	5.3 mΩ	Tinsley 5685A
	10 kΩ	53 mΩ	IET SRL-10G
	100 kΩ	0.77 Ω	
	1 MΩ	11 Ω	
	10 MΩ	0.14 Ω	
	100 MΩ	2.7 kΩ	
	1 GΩ	34 kΩ	
	10 GΩ	3.5 MΩ	

Parameter/Equipment	Frequency	CMC[2, 8] (±)	Comments
AC Resistance – Measure[3]			
100 mΩ	1 kHz	0.67 mΩ	Keysight E4980AL
(100 to 200) mΩ	1 kHz	0.79 mΩ	
(200 to 300) mΩ	1 kHz	1.3 mΩ	
(300 to 400) mΩ	1 kHz	1.5 mΩ	
(400 to 500) mΩ	1 kHz	1.9 mΩ	
(500 to 600) mΩ	1 kHz	2.2 mΩ	
(600 to 700) mΩ	1 kHz	2.5 mΩ	
(700 to 800) mΩ	1 kHz	2.9 mΩ	
(800 to 900) mΩ	1 kHz	3.2 mΩ	
900 mΩ to 1 Ω	1 kHz	3.5 mΩ	
(1 to 2) Ω	1 kHz	4.0 mΩ	
(2 to 3) Ω	1 kHz	4.7 mΩ	
(3 to 4) Ω	1 kHz	5.8 mΩ	
(4 to 5) Ω	1 kHz	6.7 mΩ	
(5 to 6) Ω	1 kHz	7.6 mΩ	
(6 to 7) Ω	1 kHz	8.7 mΩ	
(7 to 8) Ω	1 kHz	9.8 mΩ	
(8 to 9) Ω	1 kHz	11 mΩ	
(9 to 10) Ω	1 kHz	12 mΩ	
(10 to 20) Ω	1 kHz	38 mΩ	
(20 to 30) Ω	1 kHz	46 mΩ	
(30 to 40) Ω	1 kHz	57 mΩ	
(40 to 50) Ω	1 kHz	66 mΩ	
(50 to 60) Ω	1 kHz	78 mΩ	
(60 to 70) Ω	1 kHz	87 mΩ	
(70 to 80) Ω	1 kHz	98 mΩ	
(80 to 90) Ω	1 kHz	0.11 Ω	
(90 to 100) Ω	1 kHz	0.12 Ω	
(100 to 200) Ω	1 kHz	0.39 Ω	
(200 to 300) Ω	1 kHz	0.47 Ω	
(300 to 400) Ω	1 kHz	0.57 Ω	
(400 to 500) Ω	1 kHz	0.66 Ω	
(500 to 600) Ω	1 kHz	0.76 Ω	
(600 to 700) Ω	1 kHz	0.87 Ω	
(700 to 800) Ω	1 kHz	0.98 Ω	
(800 to 900) Ω	1 kHz	1.1 Ω	
900 Ω to 1 kΩ	1 kHz	1.2 Ω	

Parameter/Equipment	Frequency	CMC[2, 8] (±)	Comments
AC Resistance – Measure[3] (cont)			
(1 to 2) kΩ	1 kHz	3.9 Ω	Keysight E4980AL
(2 to 3) kΩ	1 kHz	4.7 Ω	
(3 to 4) kΩ	1 kHz	5.7 Ω	
(4 to 5) kΩ	1 kHz	6.6 Ω	
(5 to 6) kΩ	1 kHz	7.6 Ω	
(6 to 7) kΩ	1 kHz	8.8 Ω	
(7 to 8) kΩ	1 kHz	9.8 Ω	
(8 to 9) kΩ	1 kHz	11 Ω	
(9 to 10) kΩ	1 kHz	12 Ω	
(10 to 20) kΩ	1 kHz	39 Ω	
(20 to 30) kΩ	1 kHz	47 Ω	
(30 to 40) kΩ	1 kHz	56 Ω	
(40 to 50) kΩ	1 kHz	65 Ω	
(50 to 60) kΩ	1 kHz	76 Ω	
(60 to 70) kΩ	1 kHz	88 Ω	
(70 to 80) kΩ	1 kHz	98 Ω	
(80 to 90) kΩ	1 kHz	0.11 kΩ	
(90 to 100) kΩ	1 kHz	0.12 kΩ	
Fixed Points			HP 16074A, Keysight 42030A, Keysight E4980AL
1 Ω	1 kHz	1.2 mΩ	
10 Ω	1 kHz	6 mΩ	
	1 MHz	15 mΩ	
100 Ω	1 kHz	0.41 Ω	
	1 MHz	0.44 Ω	
1 kΩ	1 kHz	0.3 Ω	
	100 kHz	0.2 Ω	
	1 MHz	1.0 Ω	
10 kΩ	1 kHz	5 Ω	
	100 kHz to 1 MHz	11 Ω	
100 kΩ	1 kHz	0.41 kΩ	
	100 kHz	0.42 kΩ	
	1 MHz	0.15 kΩ	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Capacitance – Generate[3]			
1 pF	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	0.36 fF 0.37 fF 0.53 fF 0.59 fF 0.80 fF 1.0 fF 3.7 fF 4.7 fF	HP 16380A series, IET SCA series
(1 to 10) pF	1 kHz 1 kHz to 5 MHz (5 to 13) MHz	3.6 fF 3.6 fF 5.2 fF	
(10 to 100) pF	1 kHz 1 kHz to 5 MHz (5 to 10) MHz (10 to 13) MHz	36 fF 38 fF 49 fF 61 fF	
100 pF to 1 nF	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	0.36 pF 0.36 pF 0.39 pF 0.46 pF 0.57 pF 0.72 pF 2.1 pF 3.0 pF	
(1 to 10) nF	120 Hz 120 Hz to 1 kHz (1 to 100) kHz	0.91 pF 0.94 pF 0.91 pF	
(10 to 100) nF	120 Hz 120 Hz to 1 kHz (1 to 100) kHz	9.0 pF 8.7 pF 8.9 pF	
100 nF to 1 µF	120 Hz 120 Hz to 10 kHz (10 to 100) kHz	0.091 nF 0.086 nF 0.11 nF	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Capacitance – Generate (cont)[3]			
(1 to 10) µF	100 Hz 100 Hz to 1 kHz	4.7 nF 3.2 nF	HP 16380A series, IET SCA series
(10 to 100) µF	100 Hz 100 Hz to 1 kHz	77 nF 71 nF	
100 µF to 1 mF	100 Hz 100 Hz to 1 kHz	1.2 µF 2.3 µF	
Capacitance – Measure[3]			
1 pF	1 kHz 1 kHz to 1 MHz	0.021 fF 0.012 pF	Keysight E4980AL AH 2700A
(1 to 10) pF	50 Hz 50 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz 20 kHz to 1 MHz	0.21 fF 0.12 fF 0. 21 fF 0.51 fF 36 fF	
(10 to 100) pF	50 Hz (50 to 400) Hz 400 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 100) kHz 100 kHz to 1 MHz	2.1 fF 1.5 fF 1.1 fF 2.1 fF 3.1 fF 0.13 pF 0.36 pF	
100 pF to 1 nF	1 kHz (1 to 500) kHz 500 kHz to 1 MHz	0.051 pF 1.3 pF 3.6 pF	
(1 to 10) nF	1 kHz (1 to 12.5) kHz (12.5 to 100) kHz	0.21 pF 13 pF 35 pF	
(10 to 100) nF	1 kHz (1 to 12.5) kHz	5.1 pF 0.13 nF	
100 nF to 1 µF	1 kHz (1 to 12.5) kHz	0.11 nF 0.35 nF	
10 µF	1 kHz	35 nF	

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Capacitance – Measure (cont)[3]			
100 µF	120 Hz	0.35 µF	Keysight E4980AL AH 2700A
1 mF	120 Hz	12 µF	
Inductance – Generate[3]			
100 µH 100 µH to 1 mH 1 mH to 1 H	1 kHz	20 nH 0.14 µH 0.014%	Gen-rad 1482 Series
Inductance – Measure[3]			
100 µH	100 Hz (0.1 to 1) kHz (1 to 10) kHz	1.2 µH 0.35 µH 0.12 µH	Keysight E4980AL
100 µH to 1 mH	100 Hz (0.1 to 10) kHz	3.5 µH 1.2 µH	
(1 to 10) mH	100 Hz (0.1 to 10) kHz	35 µH 12 µH	
(10 to 100) mH	100 Hz (0.1 to 1) kHz	0.12 mH 0.12 mH	
100 mH to 1 H	100 Hz (0.1 to 1) kHz	1.2 mH 1.2 mH	
(1 to 10) H	100 Hz (0.1 to 1) kHz	12 mH 12 mH	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Temperature Calibrators –			
Type B	600 °C (600 to 1 000) °C (1000 to 1500) °C (1500 to 1820) °C	0.49 °C 0.32 °C 0.26 °C 0.26 °C	Fluke 8508A
Type E	-200 °C (-200 to 0) °C (0 to 250) °C (250 to 500) °C (500 to 1000) °C	0.12 °C 0.05 °C 0.04 °C 0.04 °C 0.04 °C	
Type J	-210 °C (-210 to 0) °C (0 to 250) °C (250 to 500) °C (500 to 1200) °C	0.15 °C 0.06 °C 0.06 °C 0.06 °C 0.06 °C	
Type K	-200 °C (-200 to 0) °C (0 to 500) °C (500 to 1000) °C (1000 to 1372) °C	0.19 °C 0.08 °C 0.07 °C 0.08 °C 0.09 °C	
Type N	-200 °C (-200 to 0) °C (0 to 500) °C (500 to 1000) °C (1000 to 1300) °C	0.29 °C 0.12 °C 0.08 °C 0.08 °C 0.09 °C	
Type R	-20 °C (-20 to 0) °C (0 to 500) °C (500 to 1000) °C (1000 to 1768) °C	0.62 °C 0.55 °C 0.27 °C 0.22 °C 0.24 °C	
Type S	-20 °C (-20 to 0) °C (0 to 500) °C (500 to 1000) °C (1000 to 1768) °C	0.60 °C 0.54 °C 0.30 °C 0.26 °C 0.29 °C	
Type T	-200 °C (-200 to 0) °C (0 to 100) °C (100 to 200) °C (200 to 400) °C	0.19 °C 0.08 °C 0.07 °C 0.06 °C 0.05 °C	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Electrical Conductivity Meters	14.36 MS/m 22.90 MS/m 34.26 MS/m 58.38 MS/m	0.12 MS/m 0.20 MS/m 0.29 MS/m 0.50 MS/m	Fischer calibration standards
Oscilloscope Calibrators –			
DC Voltage	0 mV (0 to 2.5) mV (2.5 to 5) mV (5 to 10) mV (10 to 25) mV (25 to 50) mV (50 to 100) mV (100 to 250) mV (250 to 500) mV (0.5 to 1) V (1 to 2.5) V (2.5 to 5) V (5 to 10) V (10 to 25) V (25 to 50) V (50 to 100) V (100 to 150) V (150 to 200) V	0.087 µV 0.012 % 62 µV/V 65 µV/V 26 µV/V 13 µV/V 60 µV/V 25 µV/V 13 µV/V 58 µV/V 24 µV/V 12 µV/V 61 µV/V 25 µV/V 13 µV/V 60 µV/V 41 µV/V 31 µV/V	Fluke 8508A
Square/Edge Wave Voltage			
1 kHz	5 mV (5 to 10) mV (10 to 25) mV (25 to 50) mV (50 to 100) mV (100 to 250) mV (250 to 500) mV (0.5 to 1) V (1 to 2.5) V (2.5 to 5) V (5 to 10) V	4.6 µV 0.097 % 0.042 % 0.026 % 0.018 % 0.017 % 0.0087 % 0.020 % 0.016 % 0.018 % 0.020 %	Fluke 8508A

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscope Calibrators – (cont)			
Square/Edge Wave Voltage			
1 kHz	(10 to 25) V (25 to 50) V (50 to 100) V (100 to 130) V (130 to 200) V	0.037 % 0.028 % 0.020 % 0.015 % 0.012 %	Fluke 8508A
100 kHz	10 mV (10 to 25) mV (25 to 50) mV (50 to 100) mV (100 to 250) mV (250 to 500) mV (0.5 to 1) V (1 to 2.5) V	28 µV 0.27 % 0.18 % 0.13 % 0.14 % 0.16 % 0.11 % 0.096 %	
Square/Edge Wave Frequency	10 Hz 10 Hz to 1 MHz	8.7 µHz 0.087 µHz/Hz	HP 53132A
Edge TD Pulse Drive			
(10 to 100) Hz	11 V (11 to 100) V	3.7 mV 35 µV/V	HP 3458A
(0.1 to 1) kHz	11 V (11 to 100) V	2.9 mV 50 µV/V	
Edge Duty Cycle	50 %	0.078 %	Tektronix DPO 4102B
Edge Rise Time	300 ps (300 to 500) ps	0.64 ps 0.15 %	Tektronix DPO4102B
Leveled Sine Wave – Harmonic			
50 kHz to 6 GHz	-10 dBc (-10 to -80) dBc	0.64 dB 0.64 dB	Agilent E4440A

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscope Calibrators – (cont)			
HF Sine Output Voltage			
50 kHz to 600 MHz	60 mVpp (60 to 300) mVpp (300 to 600) mVpp (0.6 to 5.5) Vpp	0.9 mV 1.5 % 1.4 % 1.7 %	HP E4416A, Agilent E9340A
(0.6 to 1) GHz	60 mVpp (60 to 300) mVpp (300 to 600) mVpp (0.6 to 3.5) Vpp	0.9 mV 1.5 % 1.4 % 1.6 %	
(1 to 2) GHz	60 mVpp (60 to 300) mVpp (300 to 600) mVpp (0.6 to 3) Vpp	0.9 mV 1.5 % 1.4 % 1.5 %	
(2 to 6) GHz	60 mVpp (60 to 300) mVpp (300 to 600) mVpp (0.6 to 1.2) Vpp	0.9 mV 1.5 % 1.4 % 1.5 %	
Leveled Sine Wave – Frequency	500 MHz (0.5 to 6) GHz	1.4 Hz 0.033 µHz/Hz	HP 53132A
Leveled Sine Wave – Amplitude Peak to Peak			
10 Hz	5 mV (5 to 100) mV (0.1 to 1) V (1 to 5.5) V	4.4 µV 74 µV/V 0.14 % 0.017 %	Fluke 5790B
(0.01 to 50) kHz	5 mV (5 to 100) mV (0.1 to 1) V (1 to 5.5) V	4.8 µV 0.013% 0.12 % 0.024 %	

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscope Calibrators – (cont)			
Wave Generator – Square			
10 Hz	10 mV (10 to 900) mV (0.9 to 2.5) V (2.5 to 3.75) V (3.75 to 55) V	4.2 µV 0.026 % 0.053 % 0.066 % 72 µV/V	Fluke 5790B
(0.01 to 1) kHz	10 mV (10 to 900) mV (0.9 to 2.5) V (2.5 to 3.75) V (3.75 to 55) V	4.4 µV 55 µV/V 0.095 % 0.068 % 72 µV/V	
(1 to 10) kHz	2.5 V (2.5 to 3.75) V (3.75 to 55) V	1.3 mV 0.072 % 0.015 %	
Wave Generator – Sine			
10 Hz	10 mV (0.01 to 55) V	4.0 µV 73 µV/V	Fluke 5790B
(0.01 to 1) kHz	10 mV (0.01 to 55) V	4.0 µV 70 µV/V	
Wave Generator – Triangle			
10 Hz	10 mV (0.01 to 55) V	4.0 µV 73 µV/V	Fluke 5790B
(0.01 to 1) kHz	10 mV (0.01 to 55) V	4.1 µV 77 µV/V	
Pulse Generator – Period	10 ns (0.01 to 20) µs (20 to 100) µs	0.77 ps 0.0039 % 0.000 79 %	HP 53132A
Pulse Generator – Width	4 ns (4 to 100) ns	1.3 ps 0.10 %	Tektronix DPO4102B

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Oscilloscope Calibrators – (cont)			
Time Mark	1 ns (1 to 2) ns (2 to 5) ns (5 to 10) ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1) µs (1 to 2) µs (2 to 5) µs (5 to 10) µs (10 to 20) µs (20 to 50) µs (50 to 100) µs (100 to 200) µs (200 to 500) µs (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 50) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms (0.5 to 1) s (1 to 2) s (2 to 5) s (5 to 10) s (10 to 20) s	0.77 fs 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 004 % 0.000 015 % 0.000 077 % 0.000 038 % 0.000 015 % 0.000 077 % 0.000 038 %	HP 53132A

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Oscilloscope Calibrators – (cont)			
Frequency	50 mHz	7.7 nHz	HP 53132A
	(50 to 100) mHz	0.000 077 %	
	(100 to 200) mHz	0.000 038 %	
	(200 to 500) mHz	0.000 015 %	
	(0.5 to 1) Hz	0.000 077 %	
	(1 to 2) Hz	0.000 038 %	
	(2 to 5) Hz	0.000 015 %	
	(5 to 10) Hz	0.000 077 %	
	(10 to 20) Hz	0.000 038 %	
	(20 to 50) Hz	0.000 015 %	
	(50 to 100) Hz	0.000 077 %	
	(100 to 200) Hz	0.000 038 %	
	(200 to 500) Hz	0.000 015 %	
	(0.5 to 1) kHz	0.000 077 %	
	(1 to 2) kHz	0.000 038 %	
	(2 to 5) kHz	0.000 015 %	
	(5 to 10) kHz	0.000 077 %	
	(10 to 20) kHz	0.000 038 %	
	(20 to 50) kHz	0.000 015 %	
	(50 to 100) kHz	0.000 077 %	
	(100 to 200) kHz	0.000 038 %	
	(200 to 500) kHz	0.000 015 %	
	(0.5 to 1) MHz	0.000 077 %	
	(1 to 2) MHz	0.000 038 %	
	(2 to 5) MHz	0.000 015 %	
	(5 to 10) MHz	0.000 077 %	
	(10 to 20) MHz	0.000 038 %	
	(20 to 50) MHz	0.000 015 %	
	(50 to 100) MHz	0.000 077 %	
	(100 to 200) MHz	0.000 038 %	
	(200 to 500) MHz	0.000 015 %	
	(0.5 to 1.1) GHz	0.000 062 %	
MeasZ (Resistance)	40 Ω	16 mΩ	ESI DB62
	40 Ω to 1.5 MΩ	0.030 %	
MeasZ (Capacitance)	50 pF	0.36 pF	HP 4440B
	(50 to 100) pF	0.39 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Oscilloscopes –			
DC Voltage	0 mV (0 to 1) mV (1 to 2) mV (2 to 3) mV (3 to 4) mV (4 to 5) mV (5 to 6) mV (6 to 7) mV (7 to 8) mV (8 to 9) mV (9 to 10) mV (10 to 15) mV (15 to 25) mV (20 to 25) mV (25 to 30) mV (30 to 35) mV (35 to 40) mV (40 to 45) mV (45 to 50) mV (50 to 60) mV (60 to 70) mV (70 to 80) mV (80 to 90) mV (90 to 100) mV (100 to 150) mV (150 to 200) mV (200 to 250) mV (250 to 300) mV (300 to 350) mV (350 to 400) mV (400 to 450) mV (450 to 500) mV (0.5 to 0.6) V (0.6 to 0.7) V (0.7 to 0.8) V (0.8 to 0.9) V (0.9 to 1) V (1 to 2.5) V (2.5 to 5) V (5 to 10) V (10 to 25) V (25 to 30) V (30 to 35) V (35 to 40) V (40 to 45) V (45 to 50) V	4.6 µV 3.0 % 1.5 % 1.0 % 0.76 % 0.61 % 0.51 % 0.49 % 0.43 % 0.38 % 0.34 % 0.23 % 0.18 % 0.18 % 0.15 % 0.13 % 0.11 % 0.098 % 0.088 % 0.078 % 0.12 % 0.10 % 0.093 % 0.084 % 0.056 % 0.048 % 0.069 % 0.058 % 0.050 % 0.043 % 0.039 % 0.035 % 0.037 % 0.083 % 0.073 % 0.065 % 0.058 % 0.059 % 0.030 % 0.067 % 0.058 % 0.048 % 0.041 % 0.036 % 0.032 % 0.029 %	Fluke 9500B, Fluke 5522A (scope opt)

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Oscilloscopes – (cont)			
DC Voltage	(50 to 60) V (60 to 70) V (70 to 80) V (80 to 90) V (90 to 100) V (100 to 200) V	0.030 % 0.042 % 0.037 % 0.033 % 0.030 % 0.029 %	Fluke 9500B, Fluke 5522A (scope opt)
Square Wave			
1 kHz	1 mV (1 to 2) mV (2 to 3) mV (3 to 4) mV (4 to 5) mV (5 to 6) mV (6 to 7) mV (7 to 8) mV (8 to 9) mV (9 to 10) mV (10 to 15) mV (15 to 20) mV (20 to 25) mV (25 to 30) mV (30 to 35) mV (35 to 40) mV (40 to 45) mV (45 to 50) mV (50 to 100) mV (100 to 250) mV (250 to 500) mV (0.5 to 1) V (1 to 2.5) V (2.5 to 5) V (5 to 10) V (10 to 25) V (25 to 50) V (50 to 60) V (60 to 70) V (70 to 80) V (80 to 90) V (90 to 100) V (100 to 150) V (150 to 200) V	19 µV 0.94 % 0.62 % 0.47 % 0.38 % 0.31 % 1.2 % 1.0 % 0.90 % 0.81 % 0.54 % 0.41 % 0.32 % 0.27 % 0.23 % 0.20 % 0.18 % 0.16 % 0.71 % 0.28 % 0.14 % 0.70 % 0.28 % 0.14 % 0.70 % 0.28 % 0.14 % 0.12 % 0.17 % 0.15 % 0.13 % 0.12 % 0.16 % 0.12 %	Fluke 9500B

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscopes – (cont)			
Bandwidth			
50 kHz to 1 MHz	60 mV (0.06 to 3) V	2.4 mV 2.5 %	Fluke 9500B Keysight N5173B HP E4416A
(1 to 550) MHz	60 mV (0.06 to 3) V	2.9 mV 2.9 %	Agilent E9300A HP 11667C
(0.55 to 40) GHz	60 mV (60 to 600) mV (0.6 to 3) V	1.6 mV 2.7 % 3.1 %	
Time Marker	1 ns (1 to 2) ns (2 to 5) ns (5 to 10) ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1) µs (1 to 2) µs (2 to 5) µs (5 to 10) µs (10 to 20) µs (20 to 50) µs (50 to 100) µs (100 to 200) µs (200 to 500) µs (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 50) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms (0.5 to 1) s (1 to 2) s (2 to 5) s (5 to 10) s (10 to 20) s	7.9 fs 0.000 40 % 0.000 16 % 0.000 69 % 0.000 35 % 0.000 14 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 79 % 0.000 39 % 0.000 75 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 79 % 0.000 39 % 0.000 16 % 0.000 78 % 0.000 39 %	Fluke 9500B

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscopes – (cont)			
Frequency	100 mHz	0.99 µHz	Fluke 9500B
	(100 to 200) mHz	0.000 50 %	
	(200 to 500) mHz	0.000 20 %	
	(0.5 to 1) Hz	0.000 72 %	
	(1 to 2) Hz	0.000 36 %	
	(2 to 5) Hz	0.000 15 %	
	(5 to 10) Hz	0.000 71 %	
	(10 to 20) Hz	0.000 35 %	
	(20 to 50) Hz	0.000 15 %	
	(50 to 100) Hz	0.000 72 %	
	(100 to 200) Hz	0.000 36 %	
	(200 to 500) Hz	0.000 15 %	
	(0.5 to 1) kHz	0.000 72 %	
	(1 to 2) kHz	0.000 36 %	
	(2 to 5) kHz	0.000 15 %	
	(5 to 10) kHz	0.000 71 %	
	(10 to 20) kHz	0.000 36 %	
	(20 to 50) kHz	0.000 15 %	
	(50 to 100) kHz	0.000 71 %	
	(100 to 200) kHz	0.000 36 %	
	(200 to 500) kHz	0.000 15 %	
	(0.5 to 1) MHz	0.000 71 %	
	(1 to 2) MHz	0.000 36 %	
	(2 to 5) MHz	0.000 15 %	
	(5 to 10) MHz	0.000 72 %	
	(10 to 20) MHz	0.000 36 %	
	(20 to 50) MHz	0.000 15 %	
	(50 to 100) MHz	0.000 72 %	
	(100 to 200) MHz	0.000 36 %	
	(200 to 500) MHz	0.000 15 %	
	(0.5 to 1) GHz	0.000 71 %	
AC Voltage			
50 Hz to 10 kHz	10 mV	5.8 µV	Fluke 5370A
	(10 to 15) mV	0.042 %	
	(15 to 20) mV	0.034 %	
	(20 to 25) mV	0.044 %	
	(25 to 30) mV	0.037 %	
	(30 to 35) mV	0.034 %	
	(35 to 40) mV	0.030 %	
	(40 to 45) mV	0.027 %	
	(45 to 50) mV	0.024 %	
	(50 to 60) mV	0.028 %	
	(60 to 70) mV	0.022 %	
	(70 to 80) mV	0.020 %	
	(80 to 90) mV	0.021 %	
	(90 to 100) mV	0.017 %	

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscopes – (cont)			
AC Voltage			
50 Hz to 10 kHz	(100 to 150) mV (150 to 200) mV (200 to 250) mV (250 to 300) mV (300 to 350) mV (350 to 400) mV (400 to 450) mV (450 to 500) mV (500 to 600) mV (600 to 700) mV (700 to 800) mV (800 to 900) mV (0.9 to 1) V (1 to 1.5) V (1.5 to 2) V (2 to 2.5) V (2.5 to 3) V (3 to 3.5) V (3.5 to 4) V (4 to 4.5) V (4.5 to 5) V (5 to 6) V (6 to 7) V (7 to 8) V (8 to 9) V (9 to 10) V (10 to 15) V (15 to 20) V (20 to 25) V (25 to 30) V (30 to 35) V (35 to 40) V (40 to 45) V (45 to 50) V (50 to 60) V (60 to 70) V (70 to 80) V (80 to 90) V (90 to 100) V	0.013 % 0.012 % 0.020 % 0.018 % 0.016 % 0.016 % 0.015 % 0.014 % 0.018 % 0.017 % 0.016 % 0.015 % 0.017 % 0.013 % 0.013 % 0.012 % 0.010 % 0.0093 % 0.0082 % 0.0077 % 0.0075 % 0.014 % 0.013 % 0.011 % 0.015 % 0.0097 % 0.0098 % 0.0081 % 0.014 % 0.012 % 0.011 % 0.010 % 0.0094 % 0.0092 % 0.015 % 0.019 % 0.017 % 0.016 % 0.011 %	Fluke 5370A
Input Resistance	50 Ω 75 Ω 1 MΩ	5.9 mΩ 5.9 mΩ 0.45 kΩ	Fluke 8508A
10 MHz Reference	10 MHz	0.078 µHz/Hz	HP 53132A

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Oscilloscopes – (cont)			
CAL OUT Voltage			
DC	100 mV (0.1 to 1) V (1 to 2) V (2 to 3) V (3 to 4) V (4 to 5) V (5 to 6) V (6 to 7) V (7 to 8) V (8 to 9) V (9 to 10) V (10 to 11) V (11 to 12) V	75 µV 75 µV/V 42 µV/V 28 µV/V 21 µV/V 17 µV/V 14 µV/V 12 µV/V 10 µV/V 9.3 µV/V 8.3 µV/V 48 µV/V 44 µV/V	Fluke 8508A
1 kHz	100 mV (0.1 to 1) V (1 to 2) V (2 to 3) V (3 to 4) V (4 to 5) V (5 to 6) V (6 to 7) V (7 to 8) V (8 to 9) V (9 to 10) V (10 to 11) V (11 to 12) V	63 µV 0.011 % 0.046 % 0.031 % 0.023 % 0.019 % 0.015 % 0.013 % 0.012 % 0.010 % 0.0093 % 0.086 % 0.079 %	
CAL OUT Frequency	100 Hz 100 Hz to 10 MHz	88 µHz 0.77 µHz/Hz	HP 53132A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Multifunction Calibrator – Voltage			
DC Voltage			
(Positive & Negative)	0 mV	0.12 µV	Fluke 8508A
	(0.1 to 100) mV	1.6 µV/V	Fluke 732B
	(0.1 to 1) V	0.81 µV/V	Fluke 752A
	(1 to 10) V	0.9 µV/V	
	(10 to 100) V	0.9 µV/V	
	(100 to 1 000) V	0.9 µV/V	
AC Voltage			
(100 µV)	10 Hz	20 nV	Fluke 5790B
	(10 to 40) Hz	0.020 %	Fluke 5730A
	(40 to 100) Hz	0.020 %	
	(100 to 500) Hz	0.020 %	
	(0.5 to 1) kHz	0.020 %	
	(1 to 10) kHz	0.020 %	
	(10 to 20) kHz	0.020 %	
	(20 to 30) kHz	0.020 %	
	(30 to 50) kHz	0.020 %	
	(50 to 100) kHz	0.021 %	
	(100 to 200) kHz	0.025 %	
	(200 to 300) kHz	0.025 %	
	(300 to 500) kHz	0.045 %	
	(0.5 to 1) MHz	0.13 %	
	(1 to 2) MHz	0.032 %	
	(2 to 5) MHz	0.050 %	
	(5 to 10) MHz	0.20 %	
	(10 to 20) MHz	0.075 %	
	(20 to 30) MHz	0.16 %	
(0.1 to 1) mV	10 Hz	0.21 µV	
	(10 to 40) Hz	0.021 %	
	(40 to 100) Hz	0.021 %	
	(100 to 500) Hz	0.021 %	
	(0.5 to 1) kHz	0.021 %	
	(1 to 10) kHz	0.021 %	
	(10 to 20) kHz	0.021 %	
	(20 to 30) kHz	0.021 %	
	(30 to 50) kHz	0.022 %	
	(50 to 100) kHz	0.021 %	
	(100 to 200) kHz	0.026 %	
	(200 to 300) kHz	0.026 %	
	(300 to 500) kHz	0.046 %	
	(0.5 to 1) MHz	0.13 %	
	(1 to 2) MHz	0.030 %	
	(2 to 5) MHz	0.050 %	
	(5 to 10) MHz	0.20 %	
	(10 to 20) MHz	0.075 %	
	(20 to 30) MHz	0.17 %	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Multifunction Calibrator – Voltage (cont)			
AC Voltage			
(1 to 100) mV	10 Hz	3.6 µV	Fluke 5790B
	(10 to 40) Hz	15 µV/V	Fluke 5730A
	(40 to 100) Hz	13 µV/V	
	(100 to 500) Hz	13 µV/V	
	(0.5 to 1) kHz	13 µV/V	
	(1 to 10) kHz	16 µV/V	
	(10 to 20) kHz	16 µV/V	
	(20 to 30) kHz	24 µV/V	
	(30 to 50) kHz	24 µV/V	
	(50 to 100) kHz	48 µV/V	
	(100 to 200) kHz	85 µV/V	
	(200 to 300) kHz	85 µV/V	
	(300 to 500) kHz	0.013 %	
	(0.5 to 1) MHz	0.024 %	
	(1 to 2) MHz	0.017 %	
	(2 to 5) MHz	0.028 %	
	(5 to 10) MHz	0.032 %	
	(10 to 20) MHz	0.062 %	
	(20 to 30) MHz	0.13 %	
(0.1 to 1) V	10 Hz	30 µV	
	(10 to 40) Hz	8.2 µV/V	
	(40 to 100) Hz	8.6 µV/V	
	(100 to 500) Hz	8.6 µV/V	
	(0.5 to 1) kHz	8.6 µV/V	
	(1 to 10) kHz	8.5 µV/V	
	(10 to 20) kHz	8.5 µV/V	
	(20 to 30) kHz	11 µV/V	
	(30 to 50) kHz	11 µV/V	
	(50 to 100) kHz	21 µV/V	
	(100 to 200) kHz	40 µV/V	
	(200 to 300) kHz	40 µV/V	
	(300 to 500) kHz	67 µV/V	
	(0.5 to 1) MHz	0.026 %	
	(1 to 2) MHz	0.016 %	
	(2 to 5) MHz	0.029 %	
	(5 to 10) MHz	0.037 %	
	(10 to 20) MHz	0.059 %	
	(20 to 30) MHz	0.13 %	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Multifunction Calibrator – Voltage (cont)			
AC Voltage			
(1 to 3) V	10 Hz	92 µV	Fluke 5790B, Fluke 5730A
	(10 to 40) Hz	7.0 µV/V	
	(40 to 100) Hz	6.5 µV/V	
	(100 to 500) Hz	6.5 µV/V	
	(0.5 to 1) kHz	6.5 µV/V	
	(1 to 10) kHz	6.8 µV/V	
	(10 to 20) kHz	6.8 µV/V	
	(20 to 30) kHz	7.6 µV/V	
	(30 to 50) kHz	7.6 µV/V	
	(50 to 100) kHz	8.1 µV/V	
	(100 to 200) kHz	26 µV/V	
	(200 to 300) kHz	26 µV/V	
	(300 to 500) kHz	32 µV/V	
	(0.5 to 1) MHz	0.024 %	
	(1 to 2) MHz	0.010 %	
	(2 to 5) MHz	0.024 %	
	(5 to 10) MHz	0.033 %	
	(10 to 20) MHz	0.057 %	
	(20 to 30) MHz	0.12 %	
(3 to 10) V	10 Hz	0.34 mV	
	(10 to 40) Hz	7.8 µV/V	
	(40 to 100) Hz	7.6 µV/V	
	(100 to 500) Hz	7.6 µV/V	
	(0.5 to 1) kHz	7.6 µV/V	
	(1 to 10) kHz	7.8 µV/V	
	(10 to 20) kHz	7.8 µV/V	
	(20 to 30) kHz	8.6 µV/V	
	(30 to 50) kHz	8.5 µV/V	
	(50 to 100) kHz	13 µV/V	
	(100 to 200) kHz	23 µV/V	
	(200 to 300) kHz	23 µV/V	
	(300 to 500) kHz	29 µV/V	
	(0.5 to 1) MHz	0.024 %	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Multifunction Calibrator – Voltage (cont)			
AC Voltage			
(10 to 20) V	10 Hz	0.58 mV	Fluke 5790B, Fluke 5730A
	(10 to 40) Hz	7.4 µV/V	
	(40 to 100) Hz	7.4 µV/V	
	(100 to 500) Hz	7.4 µV/V	
	(0.5 to 1) kHz	7.4 µV/V	
	(1 to 10) kHz	7.6 µV/V	
	(10 to 20) kHz	7.6 µV/V	
	(20 to 30) kHz	8.5 µV/V	
	(30 to 50) kHz	8.5 µV/V	
	(50 to 100) kHz	13 µV/V	
	(100 to 200) kHz	23 µV/V	
	(200 to 300) kHz	23 µV/V	
	(300 to 500) kHz	29 µV/V	
	(0.5 to 1) MHz	0.024 %	
(20 to 60) V	10 Hz	2.1 mV	
	(10 to 40) Hz	9.9 µV/V	
	(40 to 100) Hz	8.7 µV/V	
	(100 to 500) Hz	8.7 µV/V	
	(0.5 to 1) kHz	8.7 µV/V	
	(1 to 10) kHz	8.5 µV/V	
	(10 to 20) kHz	8.5 µV/V	
	(20 to 30) kHz	10 µV/V	
	(30 to 50) kHz	10 µV/V	
	(50 to 100) kHz	12 µV/V	
	(100 to 200) kHz	33 µV/V	
	(200 to 300) kHz	33 µV/V	
(60 to 100) V	10 Hz	4.4 mV	
	(10 to 40) Hz	11 µV/V	
	(40 to 100) Hz	9.3 µV/V	
	(100 to 500) Hz	9.3 µV/V	
	(0.5 to 1) kHz	9.3 µV/V	
	(1 to 10) kHz	9.8 µV/V	
	(10 to 20) kHz	9.8 µV/V	
	(20 to 30) kHz	12 µV/V	
	(30 to 50) kHz	12 µV/V	
	(50 to 100) kHz	21 µV/V	

Parameter/Range	Frequency	CMC[2] (±)	Comments
Multifunction Calibrator – Voltage (cont)			
AC Voltage			
(100 to 600) V	40 Hz (40 to 100) Hz (100 to 500) Hz (0.5 to 1) kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	9.3 mV 15 µV/V 15 µV/V 15 µV/V 16 µV/V 16 µV/V 24 µV/V 47 µV/V	Fluke 5790B, Fluke 5730A
(600 to 1000) V	40 Hz (40 to 100) Hz (100 to 500) Hz (0.5 to 1) kHz (1 to 10) kHz (10 to 20) kHz (20 to 30) kHz	16 mV 16 µV/V 15 µV/V 15 µV/V 17 µV/V 17 µV/V 30 µV/V	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Multifunction Calibrator – Current			
DC Current			
(Positive & Negative)	0 µA (0 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 20) A (20 to 30) A	0.36 nA 0.59 µA/A 0.84 µA/A 0.92 µA/A 0.58 µA/A 9.4 µA/A 8.5 µA/A 36 µA/A 31 µA/A	Fluke 8508A, Fluke 742A series, Guildline 9230A-30

Parameter/Range	Frequency	CMC[2] (±)	Comments
Multifunction Calibrator – Current (cont)			
AC Current			
(10 µA)	10 Hz	0.77 nA	Fluke 5790B
	(10 to 40) Hz	54 µA/A	Fluke A40B series
	(40 to 45) Hz	71 µA/A	
	(45 to 100) Hz	68 µA/A	
	(100 to 200) Hz	67 µA/A	
	(200 to 500) Hz	61 µA/A	
	(0.5 to 1) kHz	67 µA/A	
	(1 to 2) kHz	65 µA/A	
	(2 to 5) kHz	63 µA/A	
	(5 to 10) kHz	69 µA/A	
	(10 to 30) kHz	77 µA/A	
(10 to 100) µA	10 Hz	5.2 nA	
	(10 to 40) Hz	23 µA/A	
	(40 to 45) Hz	58 µA/A	
	(45 to 100) Hz	55 µA/A	
	(100 to 200) Hz	53 µA/A	
	(200 to 500) Hz	46 µA/A	
	(0.5 to 1) kHz	54 µA/A	
	(1 to 2) kHz	54 µA/A	
	(2 to 5) kHz	52 µA/A	
	(5 to 10) kHz	59 µA/A	
	(10 to 30) kHz	62 µA/A	
(0.1 to 1) mA	10 Hz	42 nA	
	(10 to 40) Hz	21 µA/A	
	(40 to 45) Hz	22 µA/A	
	(45 to 100) Hz	25 µA/A	
	(100 to 200) Hz	37 µA/A	
	(200 to 500) Hz	28 µA/A	
	(0.5 to 1) kHz	28 µA/A	
	(1 to 2) kHz	30 µA/A	
	(2 to 5) kHz	8.6 µA/A	
	(5 to 10) kHz	26 µA/A	
	(10 to 30) kHz	27 µA/A	

Parameter/Range	Frequency	CMC[2] (±)	Comments
Multifunction Calibrator – Current (cont)			
AC Current			
(1 to 10) mA	10 Hz	0.33 µA	Fluke 5790B, Fluke A40B series
	(10 to 40) Hz	21 µA/A	
	(40 to 45) Hz	14 µA/A	
	(45 to 100) Hz	13 µA/A	
	(100 to 200) Hz	12 µA/A	
	(200 to 500) Hz	13 µA/A	
	(0.5 to 1) kHz	12 µA/A	
	(1 to 2) kHz	14 µA/A	
	(2 to 5) kHz	12 µA/A	
	(5 to 10) kHz	14 µA/A	
	(10 to 30) kHz	16 µA/A	
(10 to 100) mA	10 Hz	3.3 µA	
	(10 to 40) Hz	15 µA/A	
	(40 to 45) Hz	16 µA/A	
	(45 to 100) Hz	15 µA/A	
	(100 to 200) Hz	18 µA/A	
	(200 to 500) Hz	17 µA/A	
	(0.5 to 1) kHz	18 µA/A	
	(1 to 2) kHz	14 µA/A	
	(2 to 5) kHz	23 µA/A	
	(5 to 10) kHz	19 µA/A	
	(10 to 30) kHz	21 µA/A	
(100 to 330) mA	10 Hz	46 µA	
	(10 to 40) Hz	98 µA/A	
	(40 to 45) Hz	98 µA/A	
	(45 to 100) Hz	98 µA/A	
	(100 to 200) Hz	98 µA/A	
	(200 to 500) Hz	99 µA/A	
	(0.5 to 1) kHz	98 µA/A	
	(1 to 2) kHz	97 µA/A	
	(2 to 5) kHz	98 µA/A	
	(5 to 10) kHz	98 µA/A	
	(10 to 30) kHz	0.010 %	
(0.33 to 1) A	10 Hz	30 µA	
	(10 to 40) Hz	38 µA/A	
	(40 to 45) Hz	43 µA/A	
	(45 to 100) Hz	53 µA/A	
	(100 to 200) Hz	53 µA/A	
	(200 to 500) Hz	36 µA/A	
	(0.5 to 1) kHz	8.7 µA/A	
	(1 to 2) kHz	35 µA/A	
	(2 to 5) kHz	39 µA/A	
	(5 to 10) kHz	73 µA/A	

Parameter/Range	Frequency	CMC[2] (±)	Comments
Multifunction Calibrator – Current (cont)			
AC Current			
(1 to 3) A	10 Hz	0.38 mA	Fluke 5790B
	(10 to 40) Hz	81 µA/A	Fluke A40B series
	(40 to 45) Hz	83 µA/A	
	(45 to 100) Hz	81 µA/A	
	(100 to 200) Hz	81 µA/A	
	(200 to 500) Hz	82 µA/A	
	(0.5 to 1) kHz	81 µA/A	
	(1 to 2) kHz	81 µA/A	
	(2 to 5) kHz	81 µA/A	
	(5 to 10) kHz	81 µA/A	
(3 to 10) A	45 Hz	0.22 mA	
	(45 to 100) Hz	26 µA/A	
	(100 to 200) Hz	26 µA/A	
	(200 to 500) Hz	26 µA/A	
	(0.5 to 1) kHz	26 µA/A	
	(1 to 2) kHz	26 µA/A	
	(2 to 5) kHz	27 µA/A	
(10 to 20) A	45 Hz	0.52 mA	
	(45 to 100) Hz	24 µA/A	
	(100 to 200) Hz	23 µA/A	
	(200 to 500) Hz	26 µA/A	
	(0.5 to 1) kHz	25 µA/A	
	(1 to 2) kHz	26 µA/A	
	(2 to 5) kHz	26 µA/A	
(20 to 30) A	45 Hz	1.3 mA	
	(45 to 100) Hz	40 µA/A	
	(100 to 200) Hz	42 µA/A	
	(200 to 500) Hz	42 µA/A	
	(0.5 to 1) kHz	40 µA/A	
	(1 to 2) kHz	43 µA/A	
	(2 to 5) kHz	43 µA/A	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Multifunction Calibrator – Resistance	0 Ω (0 to 1) Ω (1 to 1.9) Ω (1.9 to 10) Ω (10 to 19) Ω (19 to 100) Ω (100 to 190) Ω (0.19 to 1) kΩ (1 to 1.9) kΩ (1.9 to 10) kΩ (10 to 19) kΩ (19 to 100) kΩ (100 to 190) kΩ (0.19 to 1) MΩ (1 to 1.9) MΩ (1.9 to 10) MΩ (10 to 19) MΩ (19 to 100) MΩ (0.1 to 1) GΩ	2.1 μΩ 3.8 μΩ/Ω 3.8 μΩ/Ω 9.4 μΩ/Ω 5.0 μΩ/Ω 3.6 μΩ/Ω 1.9 μΩ/Ω 2.5 μΩ/Ω 1.3 μΩ/Ω 2.3 μΩ/Ω 2.3 μΩ/Ω 2.4 μΩ/Ω 1.3 μΩ/Ω 3.2 μΩ/Ω 1.7 μΩ/Ω 7.1 μΩ/Ω 8.0 μΩ/Ω 17 μΩ/Ω 17 μΩ/Ω	Fluke 8508A, Fluke 742A series, IET SRL-100M Guildline 9334A-1G
Multifunction Calibrator – Frequency	10 Hz to 30 MHz	0.059 μHz/Hz	HP 53132A

Parameter/Frequency	Range	CMC[2] (±)	Comments
Analog & Digital Multimeter – DC Voltage Positive & Negative	0 mV (0 to 100) mV (100 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	0.24 μV 3.5 μV/V 1.6 μV/V 4.5 μV/V 1.9 μV/V 1.8 μV/V	Fluke 5730A

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
Analog & Digital Multimeter – DC (cont)			
Current Positive & Negative	100 nA 0 µA (0 to 1) µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 20) A (20 to 30) A	2.7 pA 0.31 nA 0.039 % 0.0039 % 0.0021 % 0.0016 % 0.0083 % 0.0018 % 0.0033 % 0.0078 % 0.0077 % 0.0065 %	Fluke 5730A, Fluke 52120A, IET SRL-100M
Resistance	0 Ω (0 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ (10 to 100) MΩ (0.1 to 1) GΩ (1 to 10) GΩ	2.1 µΩ 2.9 µΩ/Ω 0.72 µΩ/Ω 9.9 µΩ/Ω 0.49 µΩ/Ω 2.0 µΩ/Ω 6.2 µΩ/Ω 13 µΩ/Ω 18 µΩ/Ω 0.015%	Fluke 5730A, Fluke 742A series, IET SRL series, Guildline 9330 series

Parameter/Range	Frequency	CMC[2] (±)	Comments
Analog & Digital Multimeter – AC			
Voltage 1 mv	10 Hz (10 to 40) Hz (40 to 500) Hz (0.5 to 1) kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz (0.5 to 1) MHz	0.84 µV 0.69 µV 0.68 µV 0.68 µV 0.70 µV 0.70 µV 0.88 µV 1.7 µV 1.6 µV 2.2 µV 6.2 µV	Fluke 5730A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Analog & Digital Multimeter – AC (cont)			
Voltage			
(1 to 100) mV	10 Hz	88 µV	Fluke 5730A
	(10 to 40) Hz	44 µV/V	
	(40 to 500) Hz	41 µV/V	
	(0.5 to 1) kHz	41µV/V	
	(1 to 10) kHz	45 µV/V	
	(10 to 20) kHz	46 µV/V	
	(20 to 50) kHz	64 µV/V	
	(50 to 100) kHz	0.010 %	
	(100 to 200) kHz	0.021 %	
	(200 to 500) kHz	0.035 %	
	(0.5 to 1) MHz	0.076 %	
(0.1 to 1) V	10 Hz	74 µV/V	
	(10 to 40) Hz	39 µV/V	
	(40 to 500) Hz	22 µV/V	
	(0.5 to 1) kHz	22 µV/V	
	(1 to 10) kHz	23 µV/V	
	(10 to 20) kHz	23 µV/V	
	(20 to 50) kHz	32 µV/V	
	(50 to 100) kHz	50 µV/V	
	(100 to 200) kHz	0.019 %	
	(200 to 500) kHz	0.054 %	
	(0.5 to 1) MHz	0.22 %	
(1 to 10) V	10 Hz	69 µV/V	
	(10 to 40) Hz	35 µV/V	
	(40 to 500) Hz	22 µV/V	
	(0.5 to 1) kHz	94 µV/V	
	(1 to 10) kHz	22 µV/V	
	(10 to 20) kHz	22 µV/V	
	(20 to 50) kHz	33 µV/V	
	(50 to 100) kHz	59 µV/V	
	(100 to 200) kHz	0.030 %	
	(200 to 500) kHz	0.070 %	
	(0.5 to 1) MHz	0.21 %	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Analog & Digital Multimeter – AC (cont)			
Voltage			
(10 to 100) V	10 Hz	87 µV/V	Fluke 5730A
	(10 to 40) Hz	43 µV/V	
	(40 to 500) Hz	28 µV/V	
	(0.5 to 1) kHz	28 µV/V	
	(1 to 10) kHz	28 µV/V	
	(10 to 20) kHz	28 µV/V	
	(20 to 50) kHz	35 µV/V	
	(50 to 100) kHz	86 µV/V	
(100 to 1000) V	40 Hz	26 µV/V	
	(40 to 500) Hz	20 µV/V	
	(0.5 to 1) kHz	20 µV/V	
	(1 to 10) kHz	59 µV/V	
	(10 to 20) kHz	59 µV/V	
	(20 to 30) kHz	0.017 %	
Current			
10 µA	10 Hz	11 nA	Fluke 5730A, Fluke 5725A, Fluke 52120A
	(10 to 40) Hz	7.9 nA	
	(40 to 500) Hz	1.6 nA	
	(0.5 to 1) kHz	3.9 nA	
	(1 to 5) kHz	11 nA	
	(5 to 10) kHz	17 nA	
(10 to 100) µA	10 Hz	0.011 %	
	(10 to 40) Hz	79 µA/A	
	(40 to 500) Hz	72 µA/A	
	(0.5 to 1) kHz	72 µA/A	
	(1 to 5) kHz	0.018 %	
	(5 to 10) kHz	0.043 %	
(0.1 to 1) mA	10 Hz	0.011 %	
	(10 to 40) Hz	67 µA/A	
	(40 to 500) Hz	64 µA/A	
	(0.5 to 1) kHz	64 µA/A	
	(1 to 5) kHz	0.012 %	
	(5 to 10) kHz	0.040 %	
(1 to 10) mA	10 Hz	0.015 %	
	(10 to 40) Hz	69 µA/A	
	(40 to 500) Hz	61 µA/A	
	(0.5 to 1) kHz	61 µA/A	
	(1 to 5) kHz	0.016 %	
	(5 to 10) kHz	0.060 %	

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
Analog & Digital Multimeter – AC (cont)			
Current			
(10 to 100) mA	10 Hz (10 to 40) Hz (40 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.015 % 71 µA/A 62 µA/A 62 µA/A 0.017 % 0.061 %	Fluke 5730A, Fluke 5725A, Fluke 52120A
(0.1 to 1) A	10 Hz (10 to 40) Hz (40 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.017 % 0.013 % 0.010 % 0.010 % 0.027 % 0.10 %	
(1 to 10) A	40 Hz (40 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.027 % 55 µA/A 56 µA/A 0.18 % 0.16 %	
(10 to 20) A	40 Hz (40 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.017 % 0.016 % 0.023 % 0.050 % 0.15 %	
(20 to 30) A	40 Hz (40 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.017 % 0.016 % 0.016 % 0.061 % 0.18 %	
Frequency	10 Hz (10 to 100) Hz 100 Hz to 10 MHz	0.08 mHz 0.77 µHz/Hz 0.077 µHz/Hz	HP 33120A, 425-311

VII. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
RF Power Sensors[3, 11] –			
Calibration Factor:	9 kHz to 1 GHz	1.5 %	Keysight N5173B, R&S NRP-Z55, HP 83650B, Agilent E4417A, Keysight 8487A
Type N	(1 to 10) GHz	1.5 %	
3.5 mm	(10 to 18) GHz	1.9 %	
2.92 mm	(18 to 26) GHz	1.9 %	
2.4 mm	(26 to 34) GHz	2.3 %	
	(34 to 38) GHz	2.4 %	
	(38 to 43) GHz	3.5 %	
	(43 to 50) GHz	4.2 %	
RF Power – Measure[3, 11]			
(-10 to 20) dBm	5 Hz to 100 MHz	0.05 dB	Agilent N1911A, Agilent E9304A-H18, Keysight 8487A, R&S NRP-Z55, Keysight V8486A, Keysight W8486A Keysight N8486DD
	100 MHz to 1 GHz	0.05 dB	
	(1 to 8) GHz	0.06 dB	
	(8 to 18) GHz	0.08 dB	
	(18 to 26.5) GHz	0.07 dB	
	(26.5 to 33) GHz	0.09 dB	
	(33 to 40) GHz	0.09 dB	
	(40 to 50) GHz	0.16 dB	
	(50 to 75) GHz	0.26 dB	
	(75 to 110) GHz	0.30 dB	
	(110 to 170) GHz	0.34 dB	
(-20 to -10) dBm	5 Hz to 100 MHz	0.05 dB	
	100 MHz to 1 GHz	0.05 dB	
	(1 to 8) GHz	0.06 dB	
	(8 to 18) GHz	0.08 dB	
	(18 to 26.5) GHz	0.07 dB	
	(26.5 to 33) GHz	0.09 dB	
	(33 to 40) GHz	0.09 dB	
	(40 to 50) GHz	0.16 dB	
	(50 to 75) GHz	0.24 dB	
	(75 to 110) GHz	0.30 dB	
	(110 to 170) GHz	0.32 dB	
(-30 to -20) dBm	5 Hz to 100 MHz	0.05 dB	
	100 MHz to 1 GHz	0.05 dB	
	(1 to 8) GHz	0.06 dB	
	(8 to 18) GHz	0.08 dB	
	(18 to 26.5) GHz	0.07 dB	
	(26.5 to 33) GHz	0.09 dB	
	(33 to 40) GHz	0.09 dB	
	(40 to 50) GHz	0.16 dB	
	(50 to 75) GHz	0.24 dB	
	(75 to 110) GHz	0.30 dB	
	(110 to 170) GHz	0.32 dB	

Parameter/Frequency	Range	CMC[2, 8] (±)	Comments
Reflection Coefficients S_{11}/S_{22} (mag) – Measure[3]			
5 Hz to 3 GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.0060 (lin) 0.0063 (lin) 0.0067 (lin) 0.0073 (lin) 0.0081 (lin) 0.0091 (lin) 0.011 (lin) 0.012 (lin) 0.014 (lin) 0.016 (lin)	Agilent E5061B, Agilent E8363B, Agilent N5230C, Keysight 85054D, Keysight 85056D, Maury 8770F, Keysight V11644A, Keysight W11644A, OML V05VNA2-T/R, OML V08VNA2-T/R, OML V15VNA2-T/R, OML V10VNA2-T/R, Eravant STQ-TO-05-S1-CKIT1-CF-NIST, Eravant STQ-TO-06-S1-CKIT1-CF-NIST
(3 to 20) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.0093 (lin) 0.0093 (lin) 0.0095 (lin) 0.0097 (lin) 0.010 (lin) 0.011 (lin) 0.012 (lin) 0.013 (lin) 0.014 (lin) 0.016 (lin)	
(20 to 40) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.012 (lin) 0.012 (lin) 0.013 (lin) 0.013 (lin) 0.014 (lin) 0.016 (lin) 0.017 (lin) 0.020 (lin) 0.023 (lin) 0.026 (lin)	
(40 to 50) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.020 (lin) 0.021 (lin) 0.023 (lin) 0.025 (lin) 0.029 (lin) 0.033 (lin) 0.037 (lin) 0.043 (lin) 0.049 (lin) 0.055 (lin)	

Parameter/Frequency	Range	CMC[2, 7] (±)	Comments
Reflection Coefficients S_{11}/S_{22} (mag) – Measure[3] (cont)			
(50 to 75) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.033 (lin) 0.035 (lin) 0.038 (lin) 0.040 (lin) 0.044 (lin) 0.048 (lin) 0.052 (lin) 0.057 (lin) 0.063 (lin) 0.069 (lin)	Agilent E5061B, Agilent E8363B, Agilent N5230C, Keysight 85054D, Keysight 85056D, Maury 8770F, Keysight V11644A, Keysight W11644A, OML V05VNA2-T/R, OML V08VNA2-T/R, OML V15VNA2-T/R,
(75 to 110) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.033 (lin) 0.035 (lin) 0.038 (lin) 0.040 (lin) 0.044 (lin) 0.048 (lin) 0.052 (lin) 0.057 (lin) 0.063 (lin) 0.069 (lin)	OML V10VNA2-T/R, Eravant STQ-TO-05-S1-CKIT1-CF-NIST, Eravant STQ-TO-06-S1-CKIT1-CF-NIST
(110 to 140) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.047 (lin) 0.049 (lin) 0.052 (lin) 0.056 (lin) 0.060 (lin) 0.065 (lin) 0.071 (lin) 0.076 (lin) 0.083 (lin) 0.090 (lin)	
(140 to 170) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	0.059 (lin) 0.061 (lin) 0.065 (lin) 0.069 (lin) 0.074 (lin) 0.079 (lin) 0.085 (lin) 0.092 (lin) 0.099 (lin) 0.11 (lin)	

Parameter/Frequency	Range	CMC[2, 7] (±)	Comments
Reflection Coefficients S_{11}/S_{22} (phase) – Measure[3]			
5 Hz to 3 GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	3.5 (deg) 1.8 (deg) 1.3 (deg) 1.1 (deg) 0.92 (deg) 0.86 (deg) 0.83 (deg) 0.84 (deg) 0.85 (deg) 0.88 (deg)	Agilent E5061B, Agilent E8363B, Agilent N5230C, Keysight 85054D, Keysight 85056D, MAURY 8770F, Keysight V11644A, Keysight W11644A, OML V05VNA2-T/R, OML V08VNA2-T/R, OML V15VNA2-T/R, OML V10VNA2-T/R, ERAVANT STQ-TO-05-S1-CKIT1-CF-NIST, ERAVANT STQ-TO-06-S1-CKIT1-CF-NIST
(3 to 20) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	5.3 (deg) 2.7 (deg) 1.8 (deg) 1.4 (deg) 1.2 (deg) 1.1 (deg) 0.92 (deg) 0.89 (deg) 0.87 (deg) 0.88 (deg)	
(20 to 40) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	6.7 (deg) 3.5 (deg) 2.4 (deg) 1.9 (deg) 1.7 (deg) 1.5 (deg) 1.4 (deg) 1.4 (deg) 1.5 (deg) 1.5 (deg)	
(40 to 50) GHz	(0 to 0.1) lin (0.1 to 0.2) lin (0.2 to 0.3) lin (0.3 to 0.4) lin (0.4 to 0.5) lin (0.5 to 0.6) lin (0.6 to 0.7) lin (0.7 to 0.8) lin (0.8 to 0.9) lin (0.9 to 1) lin	11 (deg) 5.9 (deg) 4.3 (deg) 3.6 (deg) 3.3 (deg) 3.1 (deg) 3.1 (deg) 3.1 (deg) 3.1 (deg) 3.2 (deg)	

Parameter/Frequency	Range	CMC[2, 7] (±)	Comments
Reflection Coefficients S_{11}/S_{22} (phase) – Measure[3] (cont)			Agilent E5061B, Agilent E8363B, Agilent N5230C, Keysight 85054D, Keysight 85056D, MAURY 8770F, Keysight V11644A, Keysight W11644A, OML V05VNA2-T/R, OML V08VNA2-T/R, OML V15VNA2-T/R, OML V10VNA2-T/R, ERAVANT STQ-TO-05-S1-CKIT1-CF-NIST, ERAVANT STQ-TO-06-S1-CKIT1-CF-NIST
(50 to 75) GHz	(0 to 0.1) lin	19 (deg)	
	(0.1 to 0.2) lin	9.9 (deg)	
	(0.2 to 0.3) lin	7.1 (deg)	
	(0.3 to 0.4) lin	5.8 (deg)	
	(0.4 to 0.5) lin	5.0 (deg)	
	(0.5 to 0.6) lin	4.6 (deg)	
	(0.6 to 0.7) lin	4.3 (deg)	
	(0.7 to 0.8) lin	4.1 (deg)	
	(0.8 to 0.9) lin	4.0 (deg)	
	(0.9 to 1) lin	4.0 (deg)	
(75 to 110) GHz	(0 to 0.1) lin	19 (deg)	
	(0.1 to 0.2) lin	9.9 (deg)	
	(0.2 to 0.3) lin	7.1 (deg)	
	(0.3 to 0.4) lin	5.8 (deg)	
	(0.4 to 0.5) lin	5.0 (deg)	
	(0.5 to 0.6) lin	4.6 (deg)	
	(0.6 to 0.7) lin	4.3 (deg)	
	(0.7 to 0.8) lin	4.1 (deg)	
	(0.8 to 0.9) lin	4.0 (deg)	
	(0.9 to 1) lin	4.0 (deg)	
(110 to 140) GHz	(0 to 0.1) lin	27 (deg)	
	(0.1 to 0.2) lin	15 (deg)	
	(0.2 to 0.3) lin	10 (deg)	
	(0.3 to 0.4) lin	8.0 (deg)	
	(0.4 to 0.5) lin	6.9 (deg)	
	(0.5 to 0.6) lin	6.2 (deg)	
	(0.6 to 0.7) lin	5.8 (deg)	
	(0.7 to 0.8) lin	5.5 (deg)	
	(0.8 to 0.9) lin	5.3 (deg)	
	(0.9 to 1) lin	5.2 (deg)	
(140 to 170) GHz	(0 to 0.1) lin	34 (deg)	
	(0.1 to 0.2) lin	18 (deg)	
	(0.2 to 0.3) lin	13 (deg)	
	(0.3 to 0.4) lin	9.9 (deg)	
	(0.4 to 0.5) lin	8.4 (deg)	
	(0.5 to 0.6) lin	7.6 (deg)	
	(0.6 to 0.7) lin	7.0 (deg)	
	(0.7 to 0.8) lin	6.6 (deg)	
	(0.8 to 0.9) lin	6.3 (deg)	
	(0.9 to 1) lin	6.2 (deg)	

Parameter/Frequency	Range	CMC[2, 7] (±)	Comments
Transmission Coefficients S_{21}/S_{12} –Measure[3]			
5 Hz to 3 GHz	(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	0.09 dB 0.10 dB 0.12 dB 0.14 dB 0.18 dB 0.26 dB 0.49 dB 1.2 dB 3.2 dB	Agilent E5061B, Agilent N5230C, Agilent E8363B, Keysight 85054D, Keysight 85056D, Maury 8770F, OML V15VNA2-T/R, OML V10VNA2-T/R, Keysight W11644A, Keysight V11644A
(3 to 20) GHz	(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	0.07 dB 0.08 dB 0.09 dB 0.10 dB 0.14 dB 0.24 dB 0.46 dB 1.1 dB 2.8 dB	Eravant STQ-TO-06-S1-CKIT1-CF-NIST Eravant STQ-TO-05-S1-CKIT1-CF-NIST OML V08VNA2-T/R OML V05VNA2-T/R
(20 to 40) GHz	(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	0.15 dB 0.15 dB 0.16 dB 0.17 dB 0.21 dB 0.30 dB 0.56 dB 1.3 dB 3.3 dB	
(40 to 50) GHz	(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	0.66 dB 0.66 dB 0.67 dB 0.67 dB 0.68 dB 0.72 dB 0.92 dB 1.8 dB 4.4 dB	
(50 to 75) GHz	(0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB	0.34 dB 0.34 dB 0.34 dB 0.34 dB 0.35 dB 0.36 dB	

Parameter/Frequency	Range	CMC[2, 7] (±)	Comments
Transmission Coefficients S_{21}/S_{12} –Measure[3] (cont)			Agilent E5061B, Agilent N5230C,
(75 to 110) GHz	(0 to 10) dB	0.34 dB	Agilent E8363B,
	(10 to 20) dB	0.34 dB	Keysight 85054D,
	(20 to 30) dB	0.34 dB	Keysight 85056D,
	(30 to 40) dB	0.34 dB	Maury 8770F,
	(40 to 50) dB	0.35 dB	OML V15VNA2-T/R,
	(50 to 60) dB	0.36 dB	OML V10VNA2-T/R, Keysight W11644A,
(110 to 140) GHz	(0 to 10) dB	0.50 dB	Keysight V11644A
	(10 to 20) dB	0.50 dB	Eravant STQ-TO-06-
	(20 to 30) dB	0.50 dB	S1-CKIT1-CF-NIST
	(30 to 40) dB	0.50 dB	Eravant STQ-TO-05-
	(40 to 50) dB	0.51 dB	S1-CKIT1-CF-NIST
	(50 to 60) dB	0.54 dB	OML V08VNA2-T/R
			OML V05VNA2-T/R
(140 to 170) GHz	(0 to 10) dB	0.66 dB	
	(10 to 20) dB	0.66 dB	
	(20 to 30) dB	0.66 dB	
	(30 to 40) dB	0.67 dB	
	(40 to 50) dB	0.70 dB	
	(50 to 60) dB	0.78 dB	
Tuned RF Level – Measure[3, 11]			
9 kHz to 8 GHz	(0 to 30) dBm	0.15 dB	R&S FSMR
	(-40 to 0) dBm	0.16 dB	R&S NRP-Z37
	(-80 to -40) dBm	0.18 dB	
	(-120 to -80) dBm	0.20 dB	
	(-140 to -120) dBm	0.21 dB	
(8 to 18) GHz	(0 to 30) dBm	0.20 dB	
	(-40 to 0) dBm	0.20 dB	
	(-80 to -40) dBm	0.22 dB	
	(-120 to -80) dBm	0.24 dB	
	(-140 to -120) dBm	0.25 dB	
(18 to 26.5) GHz	(0 to 30) dBm	0.27 dB	
	(-40 to 0) dBm	0.27 dB	
	(-80 to -40) dBm	0.29 dB	
	(-120 to -80) dBm	0.31 dB	
	(-140 to -120) dBm	0.32 dB	

Parameter/Frequency	Range	CMC[2, 4, 7] (±)	Comments
Amplitude Modulation – Measure[3]			HP 8902A measuring receiver, R&S FSMR3026 measuring receiver
AM Depth CW: 150 kHz to 1.3 GHz, Rate: 50 Hz to 10 kHz	(1 to 5) %	6.0 %	
CW: 150 kHz to 26.5 GHz Rate: 50 Hz to 10 kHz	(5 to 99) %	1.6 %	
Frequency Modulation – Measure[3]			HP 8902A measuring receiver, R&S FSMR3026 measuring receiver
FM Deviation CW: 150 kHz to 26.5 GHz, Rate: 50 Hz to 10 kHz	(1 to 400) kHz	2.6 %	
Pulse Modulation – Measure[3]			R&S FSW43 signal & spectrum analyzer
CW: 9 kHz to 40 GHz, Period	200 ns to 10 s	0.12 %	
Width	200 ns to 10 s	0.12 %	
Phase Modulation – Measure[3]			
Phase Deviation CW: 150 kHz to 26.5 GHz, Rate: 200 Hz to 10 kHz	(1 to 400) rad	2.0 %	HP 8902A measuring receiver, R&S FSW43 signal & spectrum analyzer
2nd/3rd Harmonics & Spurious – Measure[3]	20 Hz to 20 GHz (20 to 40) GHz	1.4 dB 1.6 dB	R&S FSMR measuring receiver, R&S FSW43 signal & spectrum analyzer, N9030A

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
EFT / Burst Generators[3] – Electrical Fast Transient Damped Oscillatory Burst Simulator			IEC-61000-4-4, IEC-61000-4-18, ISO 7637-2, ISO 7637-3, Mil-Std-461G
Peak Voltage (50 Ω)	(10 to 20) V (20 to 50) V (50 to 200) V (200 to 500) V (0.5 to 1) kV (1 to 2) kV (2 to 2.5) kV (2.5 to 3) kV (3 to 4) kV	3.4 % 3.0 % 3.4 % 3.0 % 3.4 % 2.9 % 2.7 % 2.5 % 3.3 %	Tektronix DPO4102B Haefely PAT 50A
Peak Voltage (1 kΩ)	(10 to 40) V (40 to 100) V (100 to 400) V (0.4 to 1) kV (1 to 2) kV (2 to 4) kV (4 to 5) kV (5 to 6) kV (6 to 8) kV	3.9 % 3.6 % 3.9 % 3.6 % 3.9 % 3.5 % 3.3 % 3.2 % 3.1 %	Tektronix DPO4102B Haefely PAT 1000

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
EFT / Burst Generators[3] – (cont)			
Rise Time / Fall Time / Duration / Burst Period / Repetition Rate / Burst Duration	(1.0 to 2.0) ns (2.0 to 5.0) ns (5.0 to 10.0) ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1.0) µs (1.0 to 2.0) µs (2.0 to 5.0) µs (5.0 to 10.0) µs (10 to 20) µs (20 to 50) µs (50 to 100) µs (100 to 200) µs (200 to 500) µs (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 50) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms (0.5 to 1.0) s (1.0 to 2.0) s (2.0 to 5.0) s	0.082 % 0.061 % 0.14 % 0.083 % 0.033 % 0.13 % 0.061 % 0.025 % 0.12 % 0.059 % 0.024 % 0.13 % 0.061 % 0.025 % 0.13 % 0.061 % 0.025 % 0.12 % 0.060 % 0.024 % 0.13 % 0.061 % 0.025 % 0.13 % 0.061 % 0.025 % 0.12 % 0.060 % 0.025 %	Tektronix MSO54B
Frequency	(2.5 to 5) kHz (5 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 3) MHz (3 to 10) MHz (10 to 30) MHz (30 to 100) MHz	0.052 % 0.12 % 0.068 % 0.067 % 0.030 % 0.12 % 0.037 % 0.13 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
ESD Simulators –			IEC 61000-4-2, IEC 61340-3-1, ISO 10605
ESD Discharge Current (Ip, Ip2, I30 ns, I60 ns, I130 ns, I180 ns, I360 ns, I400 ns, I800 ns)	(0.10 to 0.30) A (0.30 to 0.50) A (0.50 to 1.0) A (1.0 to 10.0) A (10.0 to 30.0) A (30.0 to 100.0) A (100.0 to 125.0) A (125.0 to 150.0) A	0.55 % 0.51 % 0.43 % 0.34 % 2.1 % 3.2 % 2.6 % 2.1 %	R&S RTO1022, MWF MESD-T04G
Rise / Fall Time	(0.5 to 1.0) ns	0.037 ns	R&S RTO1022
ESD Voltage	(0.1 to 0.5) kV (0.5 to 1) kV (1 to 2) kV (2 to 4) kV (4 to 6) kV (6 to 8) kV (8 to 10) kV (10 to 12) kV (12 to 14) kV (14 to 16) kV (16 to 18) kV (18 to 20) kV (20 to 25) kV (25 to 30) kV	6.5 V 0.68 % 1.4 % 0.75 % 0.61 % 0.48 % 0.40 % 0.40 % 0.36 % 0.32 % 0.30 % 0.28 % 0.29 % 0.26 %	Brandenbuge 149-04 and probe
ESD Peak Current (HBM)	(0.15 to 0.17) A (0.17 to 0.33) A (0.33 to 0.67) A (0.67 to 1.33) A (1.33 to 2.67) A (2.67 to 5.33) A	14 mA 8.2 % 8.2 % 8.2 % 9.0 % 7.2 %	R&S RTO1022, Tektronix CT-1/P6041, Weinschel 24-20-34-LIM
ESD Peak Current (MM)	(1.5 to 1.75) A (1.75 to 3.5) A (3.5 to 7.0) A (7 to 16) A	8.6 % 9.3 % 8.8 % 8.1 %	
Rise / Fall Time (MM or HBM)	(1 to 11) ns	0.037 ns	R&S RTO1022
Delay Time (MM or HBM)	(100 to 200) ns	0.58 ns	
Peak voltage (MM or HBM)	(10 to 100) V (0.1 to 8) kV	3.5 V 3.8 %	R&S RTO1022, Tektronix P6015A

Parameter/Equipment	Range	CMC[2] (±)	Comments
RF Power Meter Calibrators[3] –			
Power Range: (Volage Measurement, Resistance Measurement)	3 µW 10 µW 30 µW 100 µW 300 µW 1 mW 3 mW 10 mW 30 mW 100 mW	0.27 nW 0.44 nW 1.8 nW 2.9 nW 15 nW 0.02 µW 0.10 µW 0.18 µW 0.45 µW 2.5 µW	HP 3458A
EMC Transducers[3] –			
Transfer Impedance			
5 Hz to 3 GHz	(-86 to -46) dBΩ (-46 to -16) dBΩ (-16 to 34) dBΩ	3.6 dB 1.4 dB 0.18 dB	CISPR 16-1-2, IEC 61000-4-6; Agilent E5061B Agilent 85032F
Absorbing Clamps –			
Clamp Factor	30 MHz to 1 GHz	2.1 dB	CISPR 16-1-3, CISPR 16-1-4; Agilent E5061B Agilent 85032F

Parameter/Equipment	Frequency	CMC[2, 8] (±)	Comments
EMI Test Receivers[3] –			CISPR 16-1-1, ANSI C63.2
Sine-Wave Voltage Accuracy	10 Hz to 2 GHz (2 to 12) GHz (12 to 40) GHz (40 to 50) GHz	0.04 dB 0.06 dB 0.08 dB 0.15 dB	HP 83650B; Agilent 33250A; Keysight N8487A; Rohde & Schwarz NRP-Z55; Agilent E4417A
CISPR Pulse Response	9 kHz to 1 GHz (1 to 5) GHz (5 to 18) GHz (18 to 26) GHz (26 to 40) GHz	0.30 dB 0.27 dB 0.37 dB 0.36 dB 0.40 dB	Schwarzbeck IGUU 2916; Keysight N5173B
CISPR Pulse Repetition Frequency Response	9 kHz to 1 GHz (1 to 40) GHz	0.10 dB 0.37 dB	
Overall Selectivity	9 kHz to 44 GHz	0.08 dB	
IF Rejection Ratio	9 kHz to 44 GHz	0.31 dB	
Image Frequency Rejection Ratio	9 kHz to 44 GHz	0.31 dB	
Other Spurious Response	9 kHz to 44 GHz	0.31 dB	
Random Noise	9 kHz to 1 GHz (1 to 15) GHz (15 to 44) GHz	0.08 dB 0.12 dB 0.22 dB	
EMI Bandwidth	10 Hz to 20 MHz	0.074 %	
RF Impulse Generators[3] –			
Impulse Level	9 kHz to 1 GHz	0.28 dB	R&S ESU26

Parameter/Equipment	Frequency/Range	CMC[2, 4] (±)	Comments
LISNs[3] –			
Impedance	10 Hz to 1 GHz	0.5 Ω	ANSI C63.4, CISPR 25, CISPR 16-1-2, MIL-STD-461G, ISO 7637-2; Agilent E5061B Keysight 85054B
Phase Angle	10 Hz to 15 kHz 15 kHz to 1 GHz	1.2° 0.5°	
Voltage Division Factor	10 Hz to 1 GHz	0.14 dB	
Isolation			
9 kHz to 200 MHz	(0 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 110) dB	0.2 dB 0.3 dB 0.5 dB 1.0 dB 2.7 dB 2.7 dB	
Insertion Loss	150 kHz to 30 MHz	0.14 dB	
CDNs[3] –			
Impedance	15 Hz to 300 MHz	3.4 Ω	IEC 61000-4-6, CISPR 16-1-2, Agilent E5061B, Keysight 85054D
Phase Angle	15 Hz to 300 MHz	1.3°	
Voltage Division Factor	15 Hz to 300 MHz	0.15 dB	
ISNs[3] –			
Impedance	9 kHz to 1 GHz	3.3 Ω	CISPR 22, CISPR 32, CISPR 16-1-2, Agilent E5061B, Keysight 85054D
Phase Angle	9 kHz to 1 GHz	1.0°	
Voltage Division Factor	150 kHz to 30 MHz	0.15 dB	
Isolation: 150 kHz to 30 MHz	Up to 70 dB (70 to 80) dB (80 to 110) dB	0.45 dB 1.1 dB 2.5 dB	
Longitudinal Conversion Loss: 150 kHz to 30 MHz	Up to 50 dB (50 to 60) dB (60 to 70) dB (70 to 80) dB	0.22 dB 0.28 dB 0.47 dB 0.70 dB	
Insertion Loss	150 kHz to 30 MHz	0.14 dB	

Parameter/Equipment	Frequency/Range	CMC[2, 4] (±)	Comments
EM Clamps[3] –			
Coupling Factor	100 kHz to 1 GHz	0.15 dB	IEC 61000-4-6, Agilent E5061B, Keysight 85054D
Decoupling Factor	100 kHz to 100 MHz	0.52 dB	
Impedance	100 kHz to 16 MHz (16 to 100) MHz	8 % 3 %	
Insertion Loss	100 kHz to 1 GHz	0.14 dB	CISPR 16-1-4
Network Analyzers[3] –			
Magnitude Dynamic Accuracy @ 1 GHz & 2 GHz	(0 to 10) dB (10 to 50) dB (50 to 100) dB	0.028 dB 0.031 dB 0.065 dB	Keysight 8494B, Keysight 8496B Keysight 85054D HP 85054B
Impedance	9 kHz to 1 GHz (1 to 18) GHz	0.6 Ω 1.1 Ω	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Noise Figure Meters[3, 11] –			
Noise Figure	10 MHz to 18 GHz	0.4 dB	HP 346B
Noise Impulse Simulators[3] –			
Peak Voltage	(10 to 20) V (20 to 50) V (50 to 200) V (200 to 250) V (250 to 500) V (0.5 to 1) kV (1 to 2) kV (2 to 2.5) kV (2.5 to 3) kV (3 to 4) kV	3.4 % 3.1 % 3.4 % 3.2 % 3.1 % 3.4 % 2.9 % 2.7 % 2.7 % 3.4 %	Tektronix MSO54B, Haefely PAT 50A

Parameter/Equipment	Range	CMC[2, 4,] (±)	Comments
Noise Impulse Simulators[3] – (cont)			
Rise/Fall/Duration/Period/ Repetition Rate/Burst Duration	(0.1 to 1.0) ns (1.0 to 2.0) ns (2.0 to 5.0) ns (5.0 to 10.0) ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1.0) µs (1.0 to 2.0) µs (2.0 to 5.0) µs (5.0 to 10.0) µs (10 to 20) µs (20 to 50) µs (50 to 100) µs (100 to 200) µs (200 to 500) µs (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 50) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms (0.5 to 1.0) s (1.0 to 2.0) s (2.0 to 5.0) s	0.16 % 0.081 % 0.060 % 0.13 % 0.085 % 0.034 % 0.12 % 0.060 % 0.024 % 0.063 % 0.032 % 0.014 % 0.071 % 0.035 % 0.014 % 0.12 % 0.061 % 0.025 % 0.068 % 0.050 % 0.014 % 0.071 % 0.040 % 0.014 % 0.071 % 0.036 % 0.014 % 0.066 % 0.034 % 0.014 %	Tektronix MS054B
RF Power Meters[3] –			
Instrument Accuracy	3 µW to 100 mW	0.43 %	HP 11683A
CAL. Out Accuracy			
(10 to 300) MHz	1 µW to 100 mW	0.56 %	HP 432A, HP 8478B, Agilent 8478B

Parameter/Equipment	Range	CMC[2, 4,] (±)	Comments
RF High Power Meters[3, 11] – Calibration Factor			
10 kHz to 1 GHz	(1 to 10) W (10 to 50) W (50 to 100) W (100 to 200) W	7.5 % 1.7 % 1.5 % 1.5 %	Bird 6091, Agilent E4433B, Amplifier Research 250W1000B Amplifier Research AR1000L

Parameter/Equipment	Frequency	CMC[2, 4,] (±)	Comments
RF Spectrum Analyzers[3, 11] –			
Frequency Readout	5 Hz to 110 GHz	0.96 mHz/Hz	SRS FS725, Keysight 33210A, Keysight N5173B, HP 83650B, R&S NRP-Z55, Agilent N8487A, Keysight V8486A, Keysight W8486A, C&K MS4060LP-19AS1, C&K MS5075LP-15AS1, C&K MS6090LP-12AS1, C&K MS90140LP-08AS1, Keysight 8494B, Keysight 8496B, Keysight 85056D, Keysight 85054D, Keysight 85052D, Maury 8770F
Marker Frequency Counter	5 Hz to 110 GHz	0.06 Hz	
Frequency Span	5 Hz to 110 GHz	1.4 mHz/Hz	
Resolution Bandwidth	1 Hz to 100 MHz	2.2 mHz/Hz	
Resolution Bandwidth Selectivity	1 Hz to 100 MHz	4.2 %	
Resolution Bandwidth Switching Error	1 Hz to 100 MHz	0.002 dB	
Input Attenuator Accuracy	(0 to 100) dB	0.08 dB	
Scale Fidelity	(0 to 100) dB	0.08 dB	
Reference Level Accuracy	(0 to 100) dB	0.06 dB	

Parameter/Equipment	Frequency	CMC[2] (±)	Comments
RF Spectrum Analyzers[3, 11] – (cont)			
Frequency Response	5 Hz to 50 MHz 50 MHz to 8 GHz (8 to 13) GHz (13 to 18) GHz (18 to 20) GHz (20 to 40) GHz (40 to 50) GHz (50 to 75) GHz (75 to 110) GHz	0.11 dB 0.12 dB 0.15 dB 0.19 dB 0.21 dB 0.23 dB 0.37 dB 0.33 dB 0.34 dB	SRS FS725, Keysight 33210A, Keysight N5173B, HP 83650B, R&S NRP-Z55, Agilent N8487A, Keysight V8486A, Keysight W8486A, C&K MS4060LP-9AS1, C&K MS5075LP-5AS1, C&K MS6090LP-2AS1, C&K MS90140LP-08AS1, Keysight 8494B, Keysight 8496B, Keysight 85056D, Keysight 85054D, Keysight 85052D, Maury 8770F
Average Noise Level	5 Hz to 3 GHz (3 to 12) GHz (12 to 18) GHz (18 to 40) GHz (40 to 50) GHz	0.6 dB 1.0 dB 1.4 dB 1.7 dB 2.1 dB	
Noise Side Band	(-10 to 10) MHz	1.7 dB	
Harmonic Mixer –			R&S FSMR, R&S FSW43, N9030A, C&K MS4060LP-19AS1, C&K MS4060LP-15AS1,C&k MS4060LP-12AS1, C&K MS4060LP-8AS1, C&K MS140220-05AS1, Agilent E9304A-H18, Keysight 8487A, R&S NRP-Z55, Keysight V8486A, Keysight W8486A, Keysight N8486DD
Conversion Loss (-20 to 60) dB	(40 to 75) GHz (75 to 110) GHz (110 to 170) GHz	0.70 dB 0.74 dB 0.75 dB	
Waveguide Detector –			Agilent E8257D, C&K MS4060LP-19AS1, C&K MS5075LP-15AS1, C&K MS6090LP-12AS1, C&K MS90140LP-08AS1, Keysight V8486A, Keysight W8486A, Agilent E4419B, Keysight 3458A
Sensitivity	(40 to 75) GHz (75 to 110) GHz	2.4 mV/mW 2.4 mV/mW	

Parameter/Equipment	Range	CMC[2] (±)	Comments
RF Speed Guns – Speed	(5 to 1000) m/s	0.09 m/s	Agilent 33210A, HP 53152A, NSI-MI Technologies MI-210-26A
Surge Generators[3] –			IEC 61000-4-5, IEC 61000-4-9, IEC 61000-4-10, IEC 61000-4-12, IEC 61000-4-18, ISO 7637-2, ISO 7637-3, ISO 16750-2, MIL-STD-461G, MIL-STD-1275E
Voltage	(2 to 10) V (10 to 20) V (20 to 50) V (50 to 100) V (100 to 200) V (200 to 500) V (500 to 1000) V (1 to 2) kV (2 to 4) kV (4 to 6) kV (6 to 8) kV (8 to 10) kV (10 to 12) kV (12 to 15) kV (15 to 18) kV (18 to 20) kV	0.93 % 0.71 % 0.39 % 0.36 % 0.39 % 0.17 % 0.36 % 1.5 % 0.84 % 0.87 % 0.73 % 0.76 % 0.63 % 0.69 % 0.61 % 0.55 %	Tektronix DPO4102B, Tektronix P6015A
Current	(1 to 2) A (2 to 5) A (5 to 10) A (10 to 20) A (20 to 50) A (50 to 100) A (100 to 200) A (200 to 500) A (500 to 1000) A (1000 to 2000) A (2000 to 3000) A (3000 to 5000) A (5000 to 7000) A (7000 to 10 000) A (10 000 to 20 000) A (20 000 to 50 000) A (50 000 to 100 000) A	1.3 % 0.70 % 0.59 % 0.58 % 0.53 % 0.43 % 0.58 % 0.53 % 0.037 % 0.58 % 0.86 % 0.52 % 0.61 % 0.43 % 0.59 % 0.24 % 0.13 %	Tektronix DPO4102B, Pearson 110, Pearson 4997, Pearson 4418, Weinschel 24-20-34-LIM, Weinschel 24-40-34-LIM

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
Surge Generators[3] (cont) –			
Rise Time / Fall Time / Duration	(0.2 to 1) ns (1 to 2) ns (2 to 5) ns (5 to 10) ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1) µs (1 to 2) µs (2 to 5) µs (5 to 10) µs (10 to 20) µs (20 to 50) µs (50 to 100) µs (100 to 200) µs (200 to 500) µs (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 50) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms (0.5 to 1) s (1 to 2) s (2 to 5) s (5 to 10) s	0.14 % 0.085 % 0.062 % 0.14 % 0.085 % 0.034 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 % 0.065 % 0.026 % 0.13 %	Tektronix MSO54B
Frequency	(0.1 to 1) Hz 1 Hz to 10 MHz	0.59 % 0.12 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Dip Simulators[3] –			IEC 61000-4-11, IEC 61000-4-29, IEC 61000-4-34, ISO 7637-2, ISO 16750-2
Output Voltage			
DC	(1 to 10) V (10 to 50) V (50 to 100) V (100 to 150) V (150 to 200) V (200 to 250) V (250 to 300) V (300 to 400) V	0.071 % 0.014 % 0.0084 % 0.014 % 0.016 % 0.014 % 0.012 % 0.0097 %	HP 34401A
(50 to 60) Hz	(50 to 100) V (100 to 150) V (150 to 200) V (200 to 250) V (250 to 300) V (300 to 400) V	0.59 % 0.26 % 0.21 % 0.18 % 0.16 % 0.14 %	
Output Frequency	(50 to 60) Hz	0.035 %	
Dip & Up Voltage			
DC			
(0 to 12) V			
0 %	0 V	0.19 V	Tektronix MSO54B, Teseq MD200A
(0 to 40) %	Up to 4.8 V	4.8 %	
(40 to 70) %	(4.8 to 8.4) V	3.3 %	
(70 to 80) %	(8.4 to 9.6) V	3.1 %	
(80 to 120) %	(9.6 to 14.4) V	2.7 %	
(12 to 25) V			
0 %	0 V	0.19 V	
(0 to 40) %	Up to 10 V	3.1 %	
(40 to 70) %	(10 to 17.5) V	2.6 %	
(70 to 80) %	(17.5 to 20) V	2.5 %	
(80 to 120) %	(20 to 30) V	2.4 %	
(25 to 50) V			
0 %	0 V	0.19 V	
(0 to 40) %	Up to 20 V	2.5 %	
(40 to 70) %	(20 to 35) V	2.4 %	
(70 to 80) %	(35 to 40) V	2.4 %	
(80 to 120) %	(40 to 60) V	2.3 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Dip Simulators[3] – (cont)			
Dip & Up Voltage			
DC			
(50 to 100) V			
0 %	0 V	0.21 V	Tektronix MSO54B, Teseq MD200A
(0 to 40) %	Up to 40 V	2.5 %	
(40 to 70) %	(40 to 70) V	2.4 %	
(70 to 80) %	(70 to 80) V	2.4 %	
(80 to 120) %	(80 to 120) V	2.3 %	
(100 to 200) V			
0 %	0 V	0.21 V	
(0 to 40) %	Up to 80 V	2.5 %	
(40 to 70) %	(80 to 140) V	2.4 %	
(70 to 80) %	(140 to 160) V	2.4 %	
(80 to 120) %	(160 to 240) V	2.3 %	
(200 to 300) V			
0 %	0 V	0.23 V	
(0 to 40) %	Up to 120 V	2.6 %	
(40 to 70) %	(120 to 210) V	2.4 %	
(70 to 80) %	(210 to 240) V	2.4 %	
(80 to 120) %	(240 to 360) V	2.4 %	
(300 to 400) V			
0 %	0 V	0.23 V	
0 % to 40 %	Up to 160 V	2.5 %	
40 % to 70 %	(160 to 280) V	2.4 %	
70 % to 80 %	(280 to 320) V	2.4 %	
80 % to 120 %	(320 to 480) V	2.3 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Dip Simulators[3] – (cont)			
Dip & Up Voltage			
AC (50 Hz to 60 Hz)			Tektronix MSO54B Teseq MD200A
(100 to 110) V			
0 %	0 V	0.21 V	
0 % to 40 %	Up to 160 V	2.9 %	
40 % to 70 %	(160 to 280) V	2.5 %	
70 % to 80 %	(280 to 320) V	2.5 %	
80 % to 120 %	(320 to 480) V	2.4 %	
(110 to 120) V			
0 %	0 V	0.21 V	
0 % to 40 %	Up to 160 V	2.8 %	
40 % to 70 %	(160 to 280) V	2.5 %	
70 % to 80 %	(280 to 320) V	2.4 %	
80 % to 120 %	(320 to 480) V	2.4 %	
(120 to 220) V			
0 %	0 V	0.21 V	
0 % to 40 %	Up to 160 V	2.9 %	
40 % to 70 %	(160 to 280) V	2.5 %	
70 % to 80 %	(280 to 320) V	2.5 %	
80 % to 120 %	(320 to 480) V	2.4 %	
(220 to 230) V			
0 %	0 V	0.21 V	
0 % to 40 %	Up to 160 V	2.8 %	
40 % to 70 %	(160 to 280) V	2.5 %	
70 % to 80 %	(280 to 320) V	2.5 %	
80 % to 120 %	(320 to 480) V	2.4 %	
(230 to 380) V			
0 %	0 V	0.24 V	
0 % to 40 %	Up to 160 V	3.0 %	
40 % to 70 %	(160 to 280) V	2.5 %	
70 % to 80 %	(280 to 320) V	2.5 %	
80 % to 120 %	(320 to 480) V	2.4 %	
(380 to 400) V			
0 %	0 V	0.24 V	
0 % to 40 %	Up to 160 V	2.9 %	
40 % to 70 %	(160 to 280) V	2.5 %	
70 % to 80 %	(280 to 320) V	2.5 %	
80 % to 120 %	(320 to 480) V	2.4 %	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Dip Simulators[3] – (cont)			
Delta Time	0.2 ns (0.2 to 1) ns (1 to 2) ns (2 to 5) ns (5 to 10 ns (10 to 20) ns (20 to 50) ns (50 to 100) ns (100 to 200) ns (200 to 500) ns (0.5 to 1) µs (1 to 2) µs (2 to 5) µs (5 to 10) µs (10 to 20) µs (20 to 50) µs (50 to 100) µs (100 to 200) µs (200 to 500) µs (0.5 to 1) ms (1 to 2) ms (2 to 5) ms (5 to 10) ms (10 to 20) ms (20 to 50) ms (50 to 100) ms (100 to 200) ms (200 to 500) ms (0.5 to 1) s (1 to 2) s (2 to 5) s (5 to 10) s	0.0014 ns 0.14 % 0.083 % 0.061 % 0.14 % 0.083 % 0.034 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 % 0.062 % 0.025 % 0.13 %	Tektronix MSO54B
Inrush Current	50 A (50 to 100) A (100 to 500) A (500 to 1000) A	0.24 A 0.36 % 0.39 % 0.33 %	Tektronix MSO54B, Pearson 110, Weinschel 24-40-34-LIM
Frequency	10 Hz to 1 kHz	0.12 %	Tektronix MSO54B

Parameter/Frequency	Range	CMC[2, 4] (±)	Comments
E-field Probes[3] – Correction Factor: 5 kHz to 18 GHz (18 to 40) GHz	 (1 to 200) V/m (1 to 200) V/m	 13 % 14%	IEEE Std.1309, IEC 61000-4-3; reference E-field probes, power amplifiers, TEM/GTEM cell, FAC (open-ended chamber)
H-field Probes – Frequency Response: 10 Hz to 400 kHz 400 kHz to 220 MHz 220 MHz to 1 GHz Linearity: 50 Hz 60 Hz	 (0.16 to 40) A/m (0.02 to 2.97) A/m (0.02 to 1.48) A/m (0.16 to 400) A/m (0.16 to 400) A/m	 6 % 14 % 16 % 4 % 4 %	IEEE Std. 1309, reference H-field probes, TEM cell, Schwarzbeck HHS5204-12 Helmholz coil

Parameter/Equipment	Frequency	CMC[2] (±)	Comments
Antenna VSWR – Up to 60	20 MHz to 18 GHz (18 to 40) GHz (40 to 110) GHz (110 to 140) GHz (140 to 220) GHz	0.02 (lin mag) 0.02 (lin mag) 0.02 (lin mag) 0.03 (lin mag) 0.03 (lin mag)	ANSI C63.5, CISPR 16-1-6; Keysight N5234A, Keysight 85054D, Maury 85056KE02, Keysight 85056D, Keysight V11644A, Keysight W11644A, Eravant STQ-TO-06-S1, Eravant STQ-TO-05-S1, OML V15VNA2-T/R, OML V12VNA2-T/R, OML V08VNA2-T/R, OML V05VNA2-T/R
Antenna Symmetry/Balance – Up to 20 dB	30 MHz to 18 GHz (18 to 40) GHz	1.0 dB 1.2 dB	ANSI C63.5, CISPR 16-1-6; Keysight N5234A, Keysight 85054D, Maury 85056KE02, Keysight 85056D

Parameter/Equipment	Frequency	CMC[2] (±)	Comments
Antenna Radiation Pattern – Up to 70 dB	700 MHz to 18 GHz (18 to 40) GHz	1.4 dB 1.4 dB	CISPR 16-1-6; Keysight N5234A, Keysight 85054D, Maury 85056KE02, Keysight 85056D
Dipole Antennas – Antenna Factor Up to 80 dB(1/m)	20 MHz to 18 GHz	1.1 dB	ANSI C63.5, SAE ARP958, CISPR 16-1-6; Keysight N5234A, Keysight 85054D
Biconical Antennas – Antenna Factor Up to 80 dB(1/m)	20 MHz to 18 GHz (18 to 40) GHz	1.2 dB 1.5 dB	ANSI C63.5, SAE ARP958, CISPR 16-1-6; Keysight N5234A, Keysight 85054D, Maury 85056KE02
Log Periodic Antennas – Antenna Factor Up to 80 dB(1/m)	20 MHz to 18 GHz (18 to 40) GHz	1.2 dB 1.4 dB	ANSI C63.5, SAE ARP958, CISPR 16-1-6; Keysight N5234A, Keysight 85054D, Maury 85056KE02
Loop Antennas – Antenna Factor Up to 110 dB(1/m)	10 Hz to 30 MHz	1.3 dB	ANSI C63.5, SAE ARP958, CISPR 16-1-6; Standard loop antenna, HP 3458A
Monopole Antennas – Antenna Factor Up to 110 dB(1/m)	1 kHz to 30 MHz	1.4 dB	ANSI C63.5, SAE ARP958, CISPR 16-1-6, ECSM; Keysight E5061B, Keysight 85054D

Parameter/Equipment	Frequency	CMC[2] (±)	Comments
Horn Antennas – Antenna Factor Up to 70 dB(1/m)	 200 MHz to 18 GHz (18 to 40) GHz (40 to 110) GHz (140 to 220) GHz	 0.9 dB 1.4 dB 0.7 dB 0.8 dB	ANSI C63.5, SAE ARP958, CISPR 16-1-6; Keysight N5234A, Keysight 85054D, Maury 85056KE02, Keysight 85056D, Keysight V11644A, Keysight W11644A, Eravant STQ-TO-06-S1, Eravant STQ-TO-05-S1, OML M05RH

VIII. Magnetic Quantities

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Flux Meters	0.1 mWb (0.1 to 1) mWb 1 mWb to 10 Wb	0.59 µWb 0.082 % 0.080 %	Walker MTC-1, HP 34401A
Flux Sources	0.1 mWb (0.1 to 100) mWb (0.1 to 10) Wb	6.7 nWb 67 µWb/Wb 11 µWb/Wb	Fluke 8508A, HP 53131A, Rohde & Schwarz RTO1022
Magnetometers	0 mT (0 to 1) mT (1 to 25) mT (40 to 1000) mT (1 to 1.9) T	2.3 µT 0.64 % 0.29 % 0.074 % 0.080 %	Walker FGM-3D1, KRISS KMS-1003, Ohm-labs CS-10, H.P 34401A, Lakeshore FC-EM7, Metrolab PT-2026
Reference/Standard Magnets	5 mT (5 to 25) mT (0.05 to 1.9) T	16 µT 0.29 % 0.16 %	Walker FGM-3D1, KRISS KMS-1003, Ohm-labs CS-10, HP 34401A, Lakeshore 475, Lakeshore FC-EM7, Metrolab PT-206

IX. Thermodynamics

Parameter/Equipment	Range	CMC[2, 7] (±)	Comments
Temperature – Measuring Equipment[3]	(-196 to 500) ℃ (500 to 1100) ℃	0.04 ℃ 0.9 ℃	Accumac AM1960, Fluke 1594A, ASL F650-B-Y, Kambic OB-22/2 ULT, & OB-22/2, Fluke 6055, Heto CB208, KRISS S-Type, WOO JIN BT-003, Nova Nova-high-fur, HART 9101, HP 3458A
Without Sensor	(-196 to 500) ℃ (500 to 1600) ℃	0.03 ℃ 0.09 ℃	IET HARS-X-10-.001-K Fluke 5730A, HART 9101
Temperature – Measure[3]	(-196 to -80) °C (-80 to 500) °C (500 to 1100) °C (1100 to 1600) °C	0.06 °C 0.02 °C 1.0 °C 2.6 °C	Accumae AM1960, Fluke 1594A, KRISS S-type, AST Eng. B-type, Hart 9101, HP 34401A
Infrared Radiation Temperature – Measuring Equipment			
Ɛ = 0.995, λ = (8 to 14) µm	(-20 to 0) °C (0 to 200) °C	0.8 °C 0.9 °C	Heitronics TRTII, Isotech 982, 976, Sensor Therm CS1500, Developments IR574, Kambic OB-15/2 BBLT, Heitronics KT19.82II
Ɛ = 0.995, λ = 3.9 µm	(200 to 500) °C (500 to 800) °C (800 to 1000) °C	1.2 °C 1.6 °C 1.8 °C	
Relative Humidity – Measuring Equipment[3]	(5 to 98) % RH	1.5 % RH	Michell S8000 remote, Hart 1529-R, KRISS H2 humidity generator, Espec PL-3J, Espec PSL-2KP, Shinyei SRH-1R135ADR

Parameter/Equipment	Range	CMC[2, 7] (±)	Comments
Relative Humidity – Measure[3]	(5 to 98) % RH	1.5 % RH	Michell S8000 remote, Hart 1529-R
Dew Point Temperature – Measuring Equipment	(-20 to 47) °C DP	0.6 °C DP	Michell S8000 remote, Shinyei SRH-1R135ADR

X. Acoustics & Vibration

Parameter/Equipment	Frequency	CMC[2] (±)	Comments
Sound – Measuring Equipment			
Multifunction Acoustic Calibrator			
(94, 104, & 114) dB	31.5 Hz (31.5 to 63) Hz (63 to 8000) Hz (8000 to 12 500) Hz	0.12 dB 0.10 dB 0.09 dB 0.10 dB	B&K 4190, Zoontech ZT601, Agilent 34401A, HP 53131A,
Pistonphone, Sound Source			
(114 to 134) dB (94 to 134) dB	250 Hz 1000 Hz	0.09 dB 0.09 dB	G.R.A.S 40AG, Zoontch ZT601, Agilent 34401A, HP 53131A

Parameter/Equipment	Frequency	CMC[2, 4] (±)	Comments
Microphone Sensitivity – Measure (-50.00 to -20.00) dB	20 Hz (20 to 25) Hz (25 to 31.5) Hz (31.5 to 50) Hz (50 to 63) Hz (63 to 8 000) Hz (8 000 to 10 000) Hz (10 000 to 12 500) Hz (12 500 to 16 000) Hz (16 000 to 20 000) Hz	0.16 dB 0.14 dB 0.13 dB 0.12 dB 0.11 dB 0.10 dB 0.11 dB 0.12 dB 0.18 dB 0.25 dB	B&K 4190, Zoontech ZT601 & ZT602, HP 34401A, HP 53131A, HP 33120A
Sound[3] – Measure (84.0 to 104.0) dB	20 Hz (20 to 50) Hz (50 to 125) Hz (125 to 2500) Hz (2500 to 8000) Hz (8000 to 12 500) Hz (12 500 to 16 000) Hz (16 000 to 20 000) Hz	0.5 dB 0.4 dB 0.3 dB 0.2 dB 0.3 dB 0.4 dB 0.5 dB 0.6 dB	B&K 4190, Zoontech ZT601 & ZT602, HP 34401A, HP 53131A, HP 33120A
Vibration Calibrators[3] (0.1 to 1000) m/s^2	(10 to 5000) Hz	1.6 %	B&K 8305, Agilent 34401A, HP 53131A, Tektronix DPO4102B

Parameter/Equipment	Frequency	CMC[2, 4] (±)	Comments
Vibration Transducer[3] –			
Sensitivity (Normal) (0.001 to 1000) mV/(m/s^2) (0.001 to 1000) pC/(m/s^2)	0.5 Hz (0.5 to 8) Hz (8 to 40) Hz (40 to 630) Hz (630 to 1250) Hz (1250 to 2500) Hz (2500 to 5000) Hz (5000 to 10 000) Hz (10 000 to 15 000) Hz (15 000 to 20 000) Hz	2.2 % 2.1 % 1.2 % 1.1 % 1.2 % 1.7 % 2.1 % 2.8 % 3.7 % 4.5 %	B&K 8305, Keysight 34461A, Tektronix TDS2012C, Agilent 33210A, Ni PXI-5122, B&K 4809, B&K 2718, APS APS-113,APS APS-125
Sensitivity (Shock) @ Pulse Duration (0.1 – 5) ms	200 m/s^2 (200 to 500) m/s^2 (500 to 1000) m/s^2 (1000 to 20 000) m/s^2 (20 000 to 100 000) m/s^2	3.0 % 2.5 % 2.4 % 3.0 % 3.8 %	PCB 301A12, Tektronix TDS540A, PCB 482C, Spektra SE-201
Vibration Measuring Instruments –			
Acceleration (0.1 to 1000) m/s^2	10 Hz (10 to 40) Hz (40 to 160) Hz (160 to 630) Hz (630 to 1250) Hz (1250 to 2500) Hz	1.7 % 1.8 % 1.7 % 1.8 % 1.9 % 2.1 %	B&K 8305, Keysight 34461A, Agilent 33210A, B&K 4809, B&K 2718
Velocity (0.01 to 1000) m/s	(10 to 20) Hz (20 to 160) Hz (160 to 630) Hz (630 to 1250) Hz (1250 to 2500) Hz	1.8 % 1.7 % 1.8 % 2.1 % 2.7 %	
Displacement (0.001 to 50) mm	(10 to 160) Hz (160 to 315) Hz	1.6 % 2.2 %	
Shock	200 m/s^2 (200 to 500) m/s^2 (500 to 1000) m/s^2 (1000 to 1500) m/s^2 (1500 to 2000) m/s^2	4.6 % 3.0 % 2.7 % 2.6 % 3.2 %	PCB 301A12, Tektronix TDS540A, PCB 482C, Spectra SE-201

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Vibration Tester[3] –			
Acceleration (0.1 to 1000) m/s^2	(3 to 10) Hz (10 to 3000) Hz	3.4 % 3.1 %	B&K 8305, PCB 301A12, B&K 2692-0S4
Frequency	(3 to 8) Hz (8 to 3000) Hz	0.59 mHz 5.8 mHz	
Displacement 0.1 µm to 100 mm	(3 to 5) Hz (5 to 80) Hz (80 to 100) Hz (100 to 160) Hz (160 to 315) Hz	3.0 % 3.1 % 3.2 % 3.8 % 9.1 %	
Shock	200 m/s^2 (200 to 500) m/s^2 (500 to 2000) m/s^2 (2000 to 20 000) m/s^2 (20 000 to 100 000) m/s^2	5.1 % 3.7 % 3.5 % 3.9 % 4.4 %	PCB 482C, Keysight 34461A, H.P 53131A, NI PXI-5122, Tektronix TDS540A

XI. Optical Quantities

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Illuminance Meters	0.5 lx (0.5 to 12 000) lx	3.4 % 3.1 %	Fluke Y5020, Optronic OL83A, Optronic OL730C, Optronic P-854, standard lamp 2856 K, Pimac 50 W, Agilent 34401A, HP 34401A
UV Irradiance Meters –			
365 nm	60 µW/cm^2 to 200 mW/cm^2	4.8 %	Optronic OL730A-5A Keithlet 485
405 nm	60 µW/cm^2 to 69 mW/cm^2	5.4 %	
Luminance Meters[3] –			
Luminance	(1 to 10) cd/m^2 (10 to 100) cd/m^2 (100 to 3000) cd/m^2 (3000 to 13 000) cd/m^2	2.6 % 1.8 % 1.6 % 1.9 %	Optronic OL455-125A-1

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Total Luminous Flux Meters[3] – Total Luminous Flux	(56.9 to 20 973) lm	2.3 %	Kriss C70215-0, halogen lamp 5 W, Ohm-labs CS-20, Keysight N8741A, Keysight 34461A, Instrument Systems ISP1000
Luminous Intensity Meters[3] – Luminous Intensity	(7.59 to 2809) cd	2.5 %	FEL lamp 1 kW, Ohm-labs CS-20, Keysight N8741A, Keysight 34461A
Color Temperature Meters – Color Temperature Color Temperature[3] Color Temperature	 (2836 to 2876) K (2750 to 2790) K (3127 to 3167) K	. 22 K 22 K 22 K	Ohm-labs CS-20, Keysight N8741A, Keysight 34461A 2856 K 1 kW 2770 K 150 W 3147 K 1 kW
Color Temperature Standard Lamps – Color Temperature	2856 K	22 K	Instrument Systems CAD140D, Keysight 34461A, Ohm-labs CS-20, 2 856 K 1 kW

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
Colorimeter; Source Color[3] –			
Color Coordinates (CIE 1931 x, y)			
CIE-A	X: 0.448 to 0.454 Y: 0.411 to 0.417	0.003 x 0.003 y	Fluke Y5020, Optronic OL83A, 2 856 K 400 W, 2 856 K 50 W, HP 34401A, Optronic OL455-125A-1, Instrument Systems CAS140D153U31
Red	X: 0.671 to 0.677 Y: 0.321 to 0.327	0.004 x 0.004 y	
Green	X: 0.375 to 0.381 Y: 0.537 to 0.543	0.004 x 0.004 y	
Blue	X: 0.146 to 0.152 Y: 0.090 to 0.096	0.004 x 0.004 y	
White	X: 0.394 to 0.400 Y: 0.389 to 0.395	0.004 x 0.004 y	
Total Luminous Flux Standard Lamps –			
Total Luminous Flux	(56.9 to 20 937) lm	3.3 %	Halogen lamp 5 W, Ohm-labs CS-20, Keysight N8741A, Keysight 34461A, Instrument Systems ISP1000
Luminous Intensity Lamps –			
Luminous Intensity	(7.59 to 2896) cd	2.9 %	Optronic P-854, KEITHLEY 6485, Ohm-labs CS-20, Keysight N8741A, Keysight 34461A,

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Spectral Irradiance Lamps –			
Spectral Irradiance	250 nm (250 to 255) nm (255 to 265) nm (265 to 275) nm (275 to 285) nm (285 to 295) nm (295 to 305) nm (305 to 330) nm (330 to 370) nm (370 to 390) nm (390 to 475) nm (475 to 1020) nm	7.7 % 6.8 % 6.4 % 5.9 % 5.4 % 5.2 % 4.5 % 4.1 % 3.6 % 3.0 % 2.6 % 2.2 %	Spectral irradiance standard lamp, Instrument Systems CAS140D(LED25), Ohm-labs CS-20, Keysight N8741A, Keysight 34461A
Total Spectral Radiant Flux Lamps[3] –			
Total Spectral Radiant Flux	350 nm (350 to 365) nm (365 to 380) nm (380 to 410) nm (410 to 490) nm (490 to 850) nm	5.8 % 5.2 % 4.4 % 3.6 % 3.0 % 2.6 %	Total spectral radiant flux standard lamp, Instrument Systems CAS140D(ISP1000), Ohm-labs CS-20, Keysight N8741A, Keysight 34461A

Parameter/Equipment	Range	CMC[2, 4, 5] (±)	Comments
Luminance Standard Lamps –			
Luminance	(1 to 10) cd/m² (10 to 100) cd/m² (100 to 1000) cd/m² (1000 to 13 000) cd/m²	2.4 % 1.7 % 1.6 % 1.9 %	Optronic OL455-125A-1, Instrument Systems CAS140D153U31
Color Coordinates (CIE 1931 x, y)			
CIE-A	X: 0.448 to 0.454 Y: 0.411 to 0.417	0.003 x 0.003 y	
Red	X: 0.671 to 0.677 Y: 0.321 to 0.327	0.004 x 0.004 y	
Green	X: 0.375 to 0.381 Y: 0.538 to 0.544	0.004 x 0.004 y	
Blue	X: 0.146 to 0.152 Y: 0.091 to 0.097	0.004 x 0.004 y	
White	X: 0.394 to 0.400 Y: 0.389 to 0.395	0.004 x 0.004 y	
Spectral Radiance Standard Sources –			
Spectral Radiance	380 nm (380 to 390) nm (390 to 410) nm (410 to 425) nm (425 to 450) nm (450 to 1040) nm	4.1 % 3.9 % 3.5 % 3.1 % 2.8 % 2.5 %	Optronic OL455-125A-1 Instrument Systems CAS140D153U31

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Spectral Irradiance Meters –			
Wavelength	(350 to 850) nm	0.51 nm	Oriel #6035, (HgAr), Thorlabs CP532
Spectral Irradiance (0.124 to 211) $mW \cdot m^{-2} \cdot nm^{-1}$	250 nm (250 to 255) nm (255 to 275) nm (275 to 295) nm (295 to 340) nm (340 to 405) nm (405 to 590) nm (590 to 1020) nm	7.9 % 7.6 % 6.1 % 5.0 % 4.0 % 3.1 % 2.5 % 2.0 %	Spectral irradiance standard lamps, Keysight N8741A, Ohm-labs CS-20, Keysight 34461A
Total Spectral Radiant Flux Meters[3] –			
Wavelength	(350 to 850) nm	0.51 nm	Oriel #6035, (HgAr), Thorlabs CP532
Total Spectral Radiant Flux (1.2 to 90) $mW \cdot nm^{-1}$	350 nm (350 to 355) nm (355 to 370) nm (370 to 390) nm (390 to 425) nm (425 to 455) nm (455 to 850) nm	4.4 % 4.2 % 3.7 % 3.3 % 2.5 % 2.1 % 2.0 %	Total spectral radiant flux lamp, Keysight N8741A, Ohm-labs CS-20 Keysight 34461A
Spectral Radiance Meters –			
Wavelength	(350 to 850) nm	0.51 nm	Oriel #6035, (HgAr), Thorlabs CP532
Spectral Radiance (0.9 to 36.5) $mW \cdot m^{-2} nm^{-1} sr^{-1}$	380 nm (380 to 390) nm (390 to 410) nm (410 to 425) nm (425 to 440) nm (440 to 460) nm (460 to 1040) nm	3.9 % 3.7 % 3.4 % 2.9 % 2.6 % 2.4 % 2.2 %	Optronic OL455-125A-1

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Optical Sources –			
Wavelength	1310 nm 1550 nm	8.5×10^{-7} nm 8.2×10^{-7} nm	ADCMT 8471, wavelength CMC is a relative value
Optical output	1310 nm, 1550 nm (-60 to 0) dBm	0.09 dB	Expo IQS-1500
Optical Meters –			
Wavelength	1310 nm, 1550 nm	0.058 nm	EXFO IQS-1500 optical calibration system
Optical input	1310 nm, 1550 nm (-60 to 0) dBm	0.09 dB	
Linearity	1310 nm, 1550 nm (-60 to 0) dB	0.07 dB	
Resolution	1310 nm, 1550 nm RBW (0.1 to 1) nm	0.058 nm	
Optical Attenuators –			
Attenuation	1310 nm, 1550 nm (0 to 60) dB	0.07 dB	EXFO IQS-1500 optical calibration system

Parameter/Equipment	Range	CMC[2] (±)	Comments
Optical Time Domain Reflectometers –			
Wavelength	1310 nm, 1550 nm	0.36 nm	Optical fiber spectrum analyzer
Length			
1310 nm	3 km 13 km	0.1 m 0.34 m	KRISS 3 km/ 13 km optical fiber standard length
1550 nm	3 km 13 km	0.1 m 0.34 m	
Return Loss			
1310 nm	3 km (2.79 dB) 13 km (7.26 dB)	0.11 dB 0.10 dB	KRISS 3 km/ 13 km optical fiber standard loss
1550 nm	3 km (1.56 dB) 13 km (4.07 dB)	0.09 dB 0.10 dB	

XII. Chemical Quantities

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Gas Analyzers[3] –			
Oxygen (O_2)	Up to 22 cmol/mol	2.2 %	Standard gas: O_2
Carbon monoxide (CO)	Up to 105 µmol/mol	2.0 %	Standard gas: CO
Methane (CH_4)	Up to 2.2 cmol/mol	3.6 %	Standard gas: CH_4
Carbon Dioxide (CO_2)	Up to 10.5 cmol/mol	2.0 %	Standard gas: CO_2
Hydrogen Sulfide (H_2S)	Up to 53 µmol/mol	4.9 %	Standard Gas: H_2S
Sulfur dioxide(SO_2)	Up to 105 µmol/mol	2.1 %	Standard gas: SO_2
Hydrogen chloride(HCl)	Up to 53 µmol/mol	5.0 %	Standard gas: HCl
Nitrogen monoxide(NO)	Up to 105 µmol/mol	2.1 %	Standard gas: NO
Hydrogen(H_2)	Up to 2.2 cmol/mol	2.2 %	Standard gas: H_2

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Breath Alcohol Analyzers –			
Dry Process	0 to 0.080 % BAC	2.0 %	Standard gas: C_2H_5OH
Wet Process	0 to 0.080 % BAC	1.4 %	Alcohol reference solutions
Electrical conductivity Meters[3] –			
Liquid	100 µS/cm 1 413 µS/cm 10 mS/cm	2.2 µS/cm 5.9 µS/cm 0.055 mS/cm	Conductivity soutions
pH Meters[3]	(4 to 10) pH	0.017 pH	pH buffer solutions

[1] This laboratory offers commercial and field calibration & dimension testing 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] 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, percentages are percentage of reading, unless otherwise indicated.

[5] In the statement of CMC, the unitless CMC was calculated as a relative standard uncertainty of measurement.

[6] This scope meets A2LA's *P112 Flexible Scope Policy*.

[7] 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.

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

[9] In the statement of CMC, l_o is the nominal value of the length, including numerical value and unit for a quantitative-based mathematical equation.

[10] This laboratory meets R205 – Specific Requirements: Calibration Laboratory Accreditation Program for the types of dimensional tests listed and is considered equivalent to that of a calibration.

[11] Mismatch uncertainty is not included in the CMC values.