

**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017  
AND ANSI/NCSL Z540-1-1994 (R2002)**

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**CALIBRATION AND DIMENSIONAL MEASUREMENT**

Valid to: **June 29, 2022**

Certificate Number: **AC-1647**

**CALIBRATION**

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source	Up to 330 $\mu$ A 330 $\mu$ A to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3.0) A (3.0 to 11) A (11 A to 20.5) A	150 $\mu$ A/A + 22 nA 100 $\mu$ A/A + 59 nA 100 $\mu$ A/A + 480 nA 100 $\mu$ A/A + 4.8 $\mu$ A 200 $\mu$ A/A + 51 $\mu$ A 380 $\mu$ A/A + 86 $\mu$ A 500 $\mu$ A/A + 980 $\mu$ A 1 mA/A + 1.8 mA	Fluke 5520A Multiproduct Calibrator
	(20.5 to 30) A	470 $\mu$ A/A + 2.2 mA	Transmille 4015 Multiproduct Calibrator
DC Current – Source (Clamp Meters Only)	(20 to 30) A (30 to 110) A (110 to 205) A	2.4 mA/A + 860 $\mu$ A 2.5 mA/A + 9.8 mA 3 mA/A + 18 mA	Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil
	(205 to 300) A	2.8 mA/A + 22 mA	Transmille 4015 Multiproduct Calibrator w/ 10 Turn Coil
DC Current – Source (Clamp Meters Only)	(205 to 550) A (550 to 1 025) A	2.5 mA/A + 49 mA 3 mA/A + 89 mA	Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil
	(1 025 to 1 500) A	2.8 mA/A + 110 mA	Transmille 4015 Multiproduct Calibrator w/ 50 Turn Coil



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage - Source	Up to 330 mV 330 mV to 3.3 V (3.3 to 33) V (33 to 330) V (330 to 1.0) kV	20 $\mu$ V/V + 1.4 $\mu$ V 11 $\mu$ V/V + 8.7 $\mu$ V 12 $\mu$ V/V + 83 $\mu$ V 18 $\mu$ V/V + 830 $\mu$ V 18 $\mu$ V/V + 3.3 mV	Fluke 5520A Multiproduct Calibrator
DC Resistance - Source	Up to 11 $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ 330 $\Omega$ to 1.1 k $\Omega$ (1.1 to 3.3) k $\Omega$ (3.3 to 11) k $\Omega$ (11 to 33) k $\Omega$ (33 to 110) k $\Omega$ (110 to 330) k $\Omega$ 330 k $\Omega$ to 1.1 M $\Omega$ (1.1 to 3.3) M $\Omega$ (3.3 to 11) M $\Omega$ (11 to 33) M $\Omega$ (33 to 110) M $\Omega$ (110 to 330) M $\Omega$ 330 M $\Omega$ to 1.1 G $\Omega$	40 $\mu\Omega/\Omega$ + 1.1 m $\Omega$ 30 $\mu\Omega/\Omega$ + 1.6 m $\Omega$ 28 $\mu\Omega/\Omega$ + 1.7 m $\Omega$ 28 $\mu\Omega/\Omega$ + 2.8 m $\Omega$ 28 $\mu\Omega/\Omega$ + 4.3 m $\Omega$ 28 $\mu\Omega/\Omega$ + 26 m $\Omega$ 28 $\mu\Omega/\Omega$ + 33 m $\Omega$ 28 $\mu\Omega/\Omega$ + 340 m $\Omega$ 28 $\mu\Omega/\Omega$ + 710 m $\Omega$ 32 $\mu\Omega/\Omega$ + 3.6 $\Omega$ 32 $\mu\Omega/\Omega$ + 12 $\Omega$ 60 $\mu\Omega/\Omega$ + 120 $\Omega$ 130 $\mu\Omega/\Omega$ + 230 $\Omega$ 250 $\mu\Omega/\Omega$ + 3.1 k $\Omega$ 500 $\mu\Omega/\Omega$ + 12 k $\Omega$ 3 m $\Omega/\Omega$ + 200 k $\Omega$ 15 m $\Omega/\Omega$ + 4.2 M $\Omega$	Fluke 5520A Multiproduct Calibrator
Conductance - Source	910 pS to 3.0 nS (3.0 to 9.1) nS (9.1 to 30) nS (30 to 91) nS (91 to 300) nS (300 to 910) nS 910 ns to 3.0 $\mu$ S (3.0 to 9.1) $\mu$ S (9.1 to 30) $\mu$ S (30 to 91) $\mu$ S (91 to 300) $\mu$ S (300 to 910) $\mu$ S 910 $\mu$ $\mu$ S to 3.0 mS (3.0 to 9.1) mS (9.1 to 30) mS (30 to 91) mS (91 to 300) mS (300 to 910) mS 910 mS to 3.0 S (3.0 to 9.1) S	40 $\mu$ S/S + 12 pS 4.2 mS/S + 12 pS 620 $\mu$ S/S + 3.5 pS 620 $\mu$ S/S + 3.5 pS 150 $\mu$ S/S + 17 pS 95 $\mu$ S/S + 17 pS 39 $\mu$ S/S + 34 pS 55 $\mu$ S/S + 57 pS 35 $\mu$ S/S + 300 pS 51 $\mu$ S/S + 300 pS 35 $\mu$ S/S + 1.9 nS 51 $\mu$ S/S + 3.2 nS 35 $\mu$ S/S + 20 nS 51 $\mu$ S/S + 68 nS 80 $\mu$ S/S + 380 nS 210 $\mu$ S/S + 2.5 $\mu$ S 420 $\mu$ S/S + 26 $\mu$ S 1.2 mS/S + 210 $\mu$ S 3.8 mS/S + 2.3 mS 12 mS/S + 21 mS	Fluke 5520A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source	(29 to 330) $\mu$ A (10 Hz to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	2 mA/A + 150 nA 1.5 mA/A + 140 nA 1.3 mA/A + 140 nA 3 mA/A + 180 nA 8 mA/A + 220 nA 16 mA/A + 420 nA	Fluke 5520A Multiproduct Calibrator
AC Current – Source	330 $\mu$ A to 3.3 mA (10 Hz to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (3.3 to 33) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (33 to 330) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz 330 mA to 1.1 A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (1.1 to 3.0) A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	2 mA/A + 730 nA 1.3 mA/A + 540 nA 1 mA/A + 560 nA 2 mA/A + 590 nA 5 mA/A + 700 nA 10 mA/A + 930 nA 1.8 mA/A + 6.7 $\mu$ A 900 $\mu$ A/A + 6.7 $\mu$ A 400 $\mu$ A/A + 6.7 $\mu$ A 800 $\mu$ A/A + 4 $\mu$ A 2 mA/A + 8.8 $\mu$ A 4 mA/A + 8.8 $\mu$ A 1.8 mA/A + 89 $\mu$ A 900 $\mu$ A/A + 89 $\mu$ A 400 $\mu$ A/A + 38 $\mu$ A 1 mA/A + 57 $\mu$ A 2 mA/A + 110 $\mu$ A 4 mA/A + 220 $\mu$ A 1.8 mA/A + 270 $\mu$ A 500 $\mu$ A/A + 160 $\mu$ A 6 mA/A + 1.1 mA 25 mA/A + 5.1 mA 1.8 mA/A + 730 $\mu$ A 600 $\mu$ A/A + 400 $\mu$ A 6 mA/A + 1.2 mA 25 mA/A + 5.1 mA	Fluke 5520A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source	(3.0 to 11) A (45 Hz to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	600 $\mu$ A/A + 2.5 mA 1 mA/A + 2.7 mA 30 mA/A + 4.5 mA	Fluke 5520A Multiproduct Calibrator
	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	1.2 mA/A + 6.4 mA 1.5 mA/A + 6.4 mA 30 mA/A + 12 mA	
	(20.5 to 30) A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	2.3 mA/A + 16 mA 2.3 mA/A + 16 mA 1 mA/A + 5.4 mA 6.9 mA/A + 8 mA	Transmille 4015 Multiproduct Calibrator
AC Current – Source	(20 to 30) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	2.6 mA/A + 25 mA 3 mA/A + 27 mA 32 mA/A + 45 mA	Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil
	(30 to 110) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	3.2 mA/A + 64 mA 3.5 mA/A + 64 mA 32 mA/A + 120 mA	
	(205 to 300) A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	4.6 mA/A + 1.6 A 4.6 mA/A + 160 mA 3.3 mA/A + 54 mA 9.2 mA/A + 80 mA	Transmille 4015 Multiproduct Calibrator w/ 10 Turn Coil
AC Current – Source (Clamp Meters Only)	(205 to 550) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	2.6 mA/A + 130 mA 3 mA/A + 140 mA 32 mA/A + 230 mA	Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil
	(550 to 1 025) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	3.2 mA/A + 320 mA 3.5 mA/A + 320 mA 32 mA/A + 560 mA	
	(1 025 to 1 500) A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	4.6 mA/A + 800 mA 4.6 mA/A + 800 mA 3.3 mA/A + 270 mA 9.2 mA/A + 400 mA	Transmille 4015 Multiproduct Calibrator w/ 50 Turn Coil



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Electrical – DC/Low Frequency

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AC Voltage - Source	(1 to 33) mV		Fluke 5520A Multiproduct Calibrator
	(10 to 45) Hz	800 $\mu\text{V/V} + 6.7 \mu\text{V}$	
	45 Hz to 10 kHz	150 $\mu\text{V/V} + 6.7 \mu\text{V}$	
	(10 to 20) kHz	200 $\mu\text{V/V} + 6.7 \mu\text{V}$	
	(20 to 50) kHz	1 mV/V + 7.4 $\mu\text{V}$	
	(50 to 100) kHz	3.5 mV/V + 15 $\mu\text{V}$	
	(100 to 500) kHz	8 mV/V + 56 $\mu\text{V}$	
	(33 to 330) mV		
	(10 to 45) Hz	300 $\mu\text{V/V} + 21 \mu\text{V}$	
	45 Hz to 10 kHz	150 $\mu\text{V/V} + 13 \mu\text{V}$	
	(10 to 20) kHz	160 $\mu\text{V/V} + 14 \mu\text{V}$	
	(20 to 50) kHz	350 $\mu\text{V/V} + 20 \mu\text{V}$	
	(50 to 100) kHz	800 $\mu\text{V/V} + 42 \mu\text{V}$	
	(100 to 500) kHz	2 mV/V + 120 $\mu\text{V}$	
	330 mV to 3.3 V		
	(10 to 45) Hz	300 $\mu\text{V/V} + 110 \mu\text{V}$	
	45 Hz to 10 kHz	150 $\mu\text{V/V} + 95 \mu\text{V}$	
	(10 to 20) kHz	190 $\mu\text{V/V} + 92 \mu\text{V}$	
	(20 to 50) kHz	300 $\mu\text{V/V} + 140 \mu\text{V}$	
	(50 to 100) kHz	700 $\mu\text{V/V} + 240 \mu\text{V}$	
	(100 to 500) kHz	2.4 mV/V + 1.2 mV	
	(3.3 to 33) V		
	(10 to 45) Hz	300 $\mu\text{V/V} + 2.1 \text{ mV}$	
	45 Hz to 10 kHz	150 $\mu\text{V/V} + 1.1 \text{ mV}$	
(10 to 20) kHz	240 $\mu\text{V/V} + 1.1 \text{ mV}$		
(20 to 50) kHz	350 $\mu\text{V/V} + 1.6 \text{ mV}$		
(50 to 100) kHz	900 $\mu\text{V/V} + 2.9 \text{ mV}$		
(33 to 330) V			
45 Hz to 1 kHz	190 $\mu\text{V/V} + 12 \text{ mV}$		
(1 to 10) kHz	200 $\mu\text{V/V} + 13 \text{ mV}$		
(10 to 20) kHz	250 $\mu\text{V/V} + 13 \text{ mV}$		
(20 to 50) kHz	300 $\mu\text{V/V} + 20 \text{ mV}$		
(50 to 100) kHz	2 mV/V + 94 mV		
(330 to 1 020) V			
45 to 1 kHz	300 $\mu\text{V/V} + 41 \text{ mV}$		
(1 to 5) kHz	250 $\mu\text{V/V} + 44 \text{ mV}$		
(5 to 10) kHz	300 $\mu\text{V/V} + 40 \text{ mV}$		



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Electrical – DC/Low Frequency

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Capacitance - Simulation	(0.19 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 330 μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	5 mF/F + 11 pF 5 mF/F + 11 pF 5 mF/F + 11 pF 2.5 mF/F + 13 pF 2.5 mF/F + 110 pF 2.5 mF/F + 130 pF 2.5 mF/F + 370 pF 2.5 mF/F + 1.3 nF 2.5 mF/F + 3.7 nF 2.5 mF/F + 13 nF 4 mF/F + 37 nF 4.5 mF/F + 130 nF 4.5 mF/F + 310 nF 4.5 mF/F + 1.1 μF 4.5 mF/F + 3.1 μF 4.5 mF/F + 11 μF 7.5 mF/F + 31 μF 11 mF/F + 110 μF	Fluke 5520A Multiproduct Calibrator
Oscilloscopes AC Voltage, Square Wave (50 Ω)	(10 Hz to 10kHz) (1 to 25) mV (25 to 110) mV (110 to 500) mV 500 mV to 2.2 V (2.2 to 6.6) V	4.4 mV/V + 56 μV 4.4 mV/V + 160 μV 4.4 mV/V + 770 μV 4.4 mV/V + 3.9 mV 4.4 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscopes AC Voltage, Square Wave (1 MΩ)	(10 Hz to 1 kHz) (1 to 500) mV 500 mV to 2.2 V (2.2 to 11) V (11 to 130) V (1 to 10) kHz (1 to 500) mV 500 mV to 2.2 V (2.2 to 11) V (11 to 130) V	3.7 mV/V + 770 μV 3.7 mV/V + 3.9 mV 3.7 mV/V + 16 mV 3.7 mV/V + 160 mV 4.4 mV/V + 770 μV 4.4 mV/V + 3.9 mV 4.4 mV/V + 16 mV 4.4 mV/V + 160 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscopes DC Voltage (50 Ω)	(0 to 110) mV (110 to 499) mV 499 mV to 2.2 V (2.2 to 6.6) V	4.4 mV/V + 160 μV 4.4 mV/V + 770 μV 4.4 mV/V + 3.9 mV 4.4 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes DC Voltage (1 MΩ)	(0 to 500) mV 500 mV to 2.2 V (2.2 to 11) V (11 to 70.5) V (70.5 to 130) V	3.6 mV/V + 770 μV 3.6 mV/V + 3.9 mV 3.6 mV/V + 16 mV 3.6 mV/V + 77 mV 3.6 mV/V + 160 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Leveled Sine Wave (Absolute) (50 Ω, 50kHz)	(5 to 10) mVpp (10 to 40) mVpp (40 to 100) mVpp (100 to 800) mVpp 800 mVpp to 1.3 Vpp (1.3 to 5.5) Vpp	20 mV/V + 310 μV 20 mV/V + 310 μV 20 mV/V + 350 μV 20 mV/V + 1 mV 20 mV/V + 1.8 mV 20 mV/V + 8.2 mV	
Leveled Sine Wave (Absolute) (50 Ω) 50 kHz to 10 MHz (10 to 100) MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz	5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 3.5 Vpp	36 mV/V + 7.7 mV 36 mV/V + 7.7 mV 41 mV/V + 7.7 mV 61 mV/V + 7.7 mV 71 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Leveled Sine Wave (Relative to 50 kHz) (50 Ω) 50 kHz to 10 MHz (10 to 100) MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz Oscilloscope Input Resistance Measurement (50 Ω Input) (1 MΩ Input)	5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 3.5 Vpp  (40 to 60) Ω 500 kΩ to 1.5 MΩ	16 mV/V + 7.7 mV 17 mV/V + 7.7 mV 22 mV/V + 7.7 mV 41 mV/V + 7.7 mV 51 mV/V + 7.7 mV  1 mΩ/Ω + 15 mΩ 1 mΩ/Ω + 180 Ω	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscope Input Capacitance Measurement (1 MΩ Input)	(5 to 50) pF	50 mF/F + 780 fF	Fluke 5520A-SC1100 Multiproduct Calibrator
DC Current - Measure	Up to 100 nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA to 1 mA	35 μA/A + 47 pA 24 μA/A + 49 pA 24 μA/A + 190 pA 24 μA/A + 1.8 nA 24 μA/A + 12 nA	Agilent / HP 3458A Multimeter



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DC Current - Measure	(1 to 10) mA (10 to 100) mA 100 mA to 1 A	24 $\mu$ A/A + 150 nA 41 $\mu$ A/A + 2.3 $\mu$ A 130 $\mu$ A/A + 46 $\mu$ A	Agilent / HP 3458A Multimeter
DC Current - Measure	(1 to 3) A	1.4 mA/A + 1.6 mA	Keysight 34401A Multimeter
DC Current - Measure	(3 to 10) A (10 to 100) A (100 to 200) A	1.3 mA/A + 48 $\mu$ A 1.3 mA/A + 480 $\mu$ A 1.3 mA/A + 1.9 mA	Shunts, Keysight 3458A Multimeter
DC Current - Measure	Up to 1 000 A	24 mA/A + 3.4 A	Fluke 381 Clamp Meter
AC Current - Measure	Up to 100 $\mu$ A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 $\mu$ A to 1 mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	4.6 mA/A + 39 nA 1.7 mA/A + 39 nA 700 $\mu$ A/A + 39 nA 700 $\mu$ A/A + 39 nA 4.6 mA/A + 260 nA 1.7 mA/A + 260 nA 700 $\mu$ A/A + 260 nA 350 $\mu$ A/A + 260 nA 700 $\mu$ A/A + 260 nA 4.6 mA/A + 480 nA 6.4 mA/A + 1.8 Ma 4.6 mA/A + 2.6 $\mu$ A 1.7 mA/A + 2.6 $\mu$ A 700 $\mu$ A/A + 2.6 $\mu$ A 350 $\mu$ A/A + 2.6 $\mu$ A 700 $\mu$ A/A + 2.6 $\mu$ A 4.6 mA/A + 4.8 $\mu$ A 6.4 mA/A + 18 $\mu$ A 4.6 mA/A + 26 $\mu$ A 1.7 mA/A + 26 $\mu$ A 700 $\mu$ A/A + 26 $\mu$ A 350 $\mu$ A/A + 26 $\mu$ A 700 $\mu$ A/A + 26 $\mu$ A 4.6 mA/A + 48 $\mu$ A 6.4 mA/A + 180 $\mu$ A	Agilent / HP 3458A Multimeter



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Measure	100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	4.6 mA/A + 320 $\mu$ A 1.8 mA/A + 320 $\mu$ A 930 $\mu$ A/A + 320 $\mu$ A 1.2 mA/A + 320 $\mu$ A 3.5 mA/A + 320 $\mu$ A 12 mA/A + 510 $\mu$ A	Agilent / HP 3458A Multimeter
AC Current - Measure	(1 to 3) A (3 to 5) Hz (5 to 10) Hz (10 to 5 000) Hz	13 mA/A + 3.4 mA 4 mA/A + 3.4 mA 1.7 mA/A + 3.4 mA	Keysight 34401A Multimeter
AC Current - Measure	(3 to 10) A (40 to 1 000) Hz (10 to 100) A (40 to 1 000) Hz (100 to 200) A (40 to 1 000) Hz	1.8 mA/A + 520 $\mu$ A 1.7 mA/A + 5.2 mA 1.8 mA/A + 21 mA	Shunts, Keysight 34401A Multimeter
AC Current - Measure	(200 to 1 000) A (10 to 100) Hz (100 to 500) Hz	24 mA/A + 4.1 A 58 mA/A + 4.1 mA	Fluke 381 Clamp Meter
	(1 000 to 2 500) A (45 to 500) Hz	35 mA/A + 7.2 A	Fluke 381 Clamp Meter w/ iFlex Current Probe
DC Voltage – Measure	Up to 1 mV (1 to 10) mV	58 $\mu$ V/V + 27 nV 58 $\mu$ V/V + 100 nV	Keysight 34420A Multimeter
DC Voltage - Measure	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1 000) V	11 $\mu$ V/V + 520 nV 9.2 $\mu$ V/V + 2.7 $\mu$ V 9.2 $\mu$ V/V + 25 $\mu$ V 12 $\mu$ V/V + 270 $\mu$ V 12 $\mu$ V/V + 5.9 mV	Agilent / HP 3458A Multimeter
DC Voltage – Measure	(1 to 1.4) kV (1.4 to 10) kV	350 $\mu$ V/V + 46 mV 350 $\mu$ V/V + 680 mV	Vitrek 4700 Voltmeter
DC Voltage – Measure	(10 to 35) kV	290 $\mu$ V/V + 2.7 V	Vitrek 4700 Voltmeter w/ HVL-35 High Voltage Probe
AC Voltage - Measure	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	350 $\mu$ V/V + 3.6 $\mu$ V 240 $\mu$ V/V + 1.6 $\mu$ V 350 $\mu$ V/V + 1.7 $\mu$ V 1.2 mV/V + 8.6 $\mu$ V 5.8 mV/V + 8.6 $\mu$ V 47 mV/V + 66 $\mu$ V	Agilent / HP 3458A Multimeter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	(10 to 100) mV		Agilent / HP 3458A Multimeter
	(1 to 40) Hz	81 $\mu$ V/V + 6.5 $\mu$ V	
	40 Hz to 1 kHz	81 $\mu$ V/V + 5.1 $\mu$ V	
	(1 to 20) kHz	170 $\mu$ V/V + 7.3 $\mu$ V	
	(20 to 50) kHz	350 $\mu$ V/V + 7.3 $\mu$ V	
	(50 to 100) kHz	930 $\mu$ V/V + 37 $\mu$ V	
	(100 to 300) kHz	350 $\mu$ V/V + 69 $\mu$ V	
	300 kHz to 1 MHz	12 mV/V + 70 $\mu$ V	
	(1 to 2) MHz	18 mV/V + 180 $\mu$ V	
	100 mV to 1 V		
	(1 to 40) Hz	81 $\mu$ V/V + 62 $\mu$ V	
	40 Hz to 1 kHz	81 $\mu$ V/V + 47 $\mu$ V	
	(1 to 20) kHz	170 $\mu$ V/V + 68 $\mu$ V	
	(20 to 50) kHz	350 $\mu$ V/V + 140 $\mu$ V	
	(50 to 100) kHz	930 $\mu$ V/V + 210 $\mu$ V	
	(100 to 300) kHz	350 $\mu$ V/V + 620 $\mu$ V	
	300 kHz to 1 MHz	12 mV/V + 1.7 mV	
	(1 to 2) MHz	18 mV/V + 1.7 mV	
	(1 to 10) V		
	(1 to 40) Hz	81 $\mu$ V/V + 720 $\mu$ V	
	40 Hz to 1 kHz	81 $\mu$ V/V + 470 $\mu$ V	
	(1 to 20) kHz	170 $\mu$ V/V + 690 $\mu$ V	
	(20 to 50) kHz	350 $\mu$ V/V + 1.3 mV	
	(50 to 100) kHz	930 $\mu$ V/V + 1.7 mV	
	(100 to 300) kHz	350 $\mu$ V/V + 5.3 mV	
	300 kHz to 1 MHz	12 mV/V + 16 mV	
	(1 to 2) MHz	18 mV/V + 21 mV	
	(10 to 100) V		
	(1 to 40) Hz	240 $\mu$ V/V + 6.2 mV	
	40 Hz to 1 kHz	240 $\mu$ V/V + 4.8 mV	
(1 to 20) kHz	240 $\mu$ V/V + 8.3 mV		
(20 to 50) kHz	410 $\mu$ V/V + 7.9 mV		
(50 to 100) kHz	1.4 mV/V + 24 mV		
(100 to 300) kHz	4.6 mV/V + 26 mV		
300 kHz to 1 MHz	18 mV/V + 26 mV		
750 V			
(1 to 40) Hz	470 $\mu$ V/V + 70 mV		
40 Hz to 1 kHz	470 $\mu$ V/V + 63 mV		
(1 to 20) kHz	700 $\mu$ V/V + 63 mV		
(20 to 50) kHz	1.4 mV/V + 63 mV		
(50 to 100) kHz	3.5 mV/V + 63 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	(750 to 10 000) V (0.01 to 1) Hz (10 to 65) Hz (30 to 200) Hz (200 to 450) Hz	1.4 mV/V + 2.6 V 1.4 mV/V + 2.6 V 1.4 mV/V + 2.6 V 4.6 mV/V + 2.6 V	Vitrek 4700 Voltmeter
	(10 to 30) kV (0.01 to 1) Hz (30 to 200) Hz (200 to 450) Hz	1.7 mV/V + 5.9 V 580 $\mu$ V/V + 5.9 V 6.9 mV/V + 5.9 V	Vitrek 4700 Voltmeter w/ HVL-35 High Voltage Probe
DC Resistance – Measure (Current Shunts)	(0.25 to 10) m $\Omega$	550 $\mu\Omega/\Omega$	Keysight 3458A, Transmille 4015
AC Resistance – Measure (Current Shunts)	(0.25 to 10) m $\Omega$ (45 to 1 000) Hz	1.5 m $\Omega/\Omega$	
Resistance – Measure	Up to 1 $\Omega$ (1 to 10) $\Omega$	81 $\mu\Omega/\Omega$ + 8.1 $\mu\Omega$ 70 $\mu\Omega/\Omega$ + 81 $\mu\Omega$	Keysight 34420A
Resistance Measure	Up to 100 $\Omega$ (10 to 100) $\Omega$ 100 $\Omega$ to 1 k $\Omega$ (1 to 10) k $\Omega$ (10 to 100) k $\Omega$ 100 k $\Omega$ to 1 M $\Omega$ (1 to 10) M $\Omega$ (10 to 100) M $\Omega$ 100 M $\Omega$ to 1 G $\Omega$	18 $\mu\Omega/\Omega$ + 110 $\mu\Omega$ 14 $\mu\Omega/\Omega$ + 1.1 m $\Omega$ 12 $\mu\Omega/\Omega$ + 7.4 m $\Omega$ 12 $\mu\Omega/\Omega$ + 75 m $\Omega$ 12 $\mu\Omega/\Omega$ + 750 m $\Omega$ 18 $\mu\Omega/\Omega$ + 8.0 $\Omega$ 58 $\mu\Omega/\Omega$ + 250 $\Omega$ 580 $\mu\Omega/\Omega$ + 18 k $\Omega$ 5.8 m $\Omega/\Omega$ + 180 k $\Omega$	Agilent / HP 3458A Multimeter
Resistance – Measure	(20 to 200) M $\Omega$ (200 to 2 000) M $\Omega$ (2 to 20) G $\Omega$ (20 to 200) G $\Omega$ (200 to 2 000) G $\Omega$ (2 to 20) T $\Omega$	1.7 m $\Omega/\Omega$ + 9.5 k $\Omega$ 2.6 m $\Omega/\Omega$ + 150 k $\Omega$ 2.6 m $\Omega/\Omega$ + 2.3 M $\Omega$ 4 m $\Omega/\Omega$ + 72 M $\Omega$ 4 m $\Omega/\Omega$ + 2.9 G $\Omega$ 12 m $\Omega/\Omega$ + 57 G $\Omega$	Keithley 6517A Multimeter
Electrical Simulation of RTD Indicating Devices	Pt 385 100 $\Omega$ (-200 to -80) $^{\circ}$ C (-80 to 0) $^{\circ}$ C (0 to 100) $^{\circ}$ C (100 to 300) $^{\circ}$ C (300 to 400) $^{\circ}$ C (400 to 630) $^{\circ}$ C (630 to 800) $^{\circ}$ C	0.053 $^{\circ}$ C 0.053 $^{\circ}$ C 0.072 $^{\circ}$ C 0.092 $^{\circ}$ C 0.11 $^{\circ}$ C 0.13 $^{\circ}$ C 0.24 $^{\circ}$ C	Fluke 5520A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices	Pt 385 200 Ω		
	(-200 to -80) °C	0.043 °C	
	(-80 to 0) °C	0.043 °C	
	(0 to 100) °C	0.043 °C	
	(100 to 260) °C	0.053 °C	
	(260 to 300) °C	0.13 °C	
	(300 to 400) °C	0.14 °C	
	(400 to 600) °C	0.15 °C	
	(600 to 630) °C	0.17 °C	
	Pt 385 500 Ω		
	(-200 to -80) °C	0.043 °C	
	(-80 to 0) °C	0.053 °C	
	(0 to 100) °C	0.053 °C	
	(100 to 260) °C	0.062 °C	
	(260 to 300) °C	0.082 °C	
	(300 to 400) °C	0.082 °C	
	(400 to 600) °C	0.092 °C	
	(600 to 630) °C	0.12 °C	
Pt 385 1 000 Ω			
(-200 to -80) °C	0.035 °C		
(-80 to 0) °C	0.035 °C		
(0 to 100) °C	0.044 °C		
(100 to 260) °C	0.053 °C		
(260 to 300) °C	0.063 °C		
(300 to 400) °C	0.072 °C		
(400 to 600) °C	0.072 °C		
(600 to 630) °C	0.24 °C		
Electrical Simulation of Thermocouple Indicating Devices	Type B		
	(600 to 800) °C	0.49 °C	
	(800 to 1 000) °C	0.39 °C	
	(1 000 to 1 550) °C	0.35 °C	
	(1 550 to 1 820) °C	0.38 °C	
	Type E		
	(-250 to -100) °C	0.53 °C	
	(-100 to -25) °C	0.23 °C	
	(-25 to 350) °C	0.21 °C	
	(350 to 650) °C	0.23 °C	
(650 to 1 000) °C	0.26 °C		
			Fluke 5520A Multiproduct Calibrator
			Fluke 5520A Multiproduct Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices	Type J		Fluke 5520A Multiproduct Calibrator
	(-210 to -100) °C	0.32 °C	
	(-100 to -30) °C	0.23 °C	
	(-30 to 150) °C	0.21 °C	
	(150 to 760) °C	0.23 °C	
	(760 to 1 200) °C	0.28 °C	
	Type K		
	(-200 to -100) °C	0.37 °C	
	(-100 to -25) °C	0.24 °C	
	(-25 to 120) °C	0.23 °C	
	(120 to 1 000) °C	0.31 °C	
	(1 000 to 1 372) °C	0.43 °C	
	Type N		
	(-200 to -100) °C	0.44 °C	
	(-100 to -25) °C	0.28 °C	
	(-25 to 120) °C	0.25 °C	
	(120 to 410) °C	0.24 °C	
	(410 to 1 300) °C	0.32 °C	
	Type R		
	(0 to 250) °C	0.61 °C	
	(250 to 400) °C	0.4 °C	
	(400 to 1 000) °C	0.38 °C	
	(1 000 to 1 767) °C	0.44 °C	
	Type S		
(0 to 200) °C	0.52 °C		
(200 to 1 000) °C	0.41 °C		
(1 000 to 1 400) °C	0.41 °C		
(1 400 to 1 767) °C	0.5 °C		
Type T			
(-250 to -150) °C	0.66 °C		
(-150 to 0) °C	0.29 °C		
(0 to 120) °C	0.23 °C		
(120 to 400) °C	0.21 °C		

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length Standards <sup>2,3</sup>	Up to 1 in (1 to 10) in (10 to 20) in	20 µin (11 + 7.8L) µin (20 + 10L) µin	Gauge Blocks, Supermicrometer, Electronic Indicator

**Length – Dimensional Metrology**

<b>Parameter/Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Calipers <sup>3</sup>	Up to 36 in (36 to 84) in	(670 + 9.2L) μin (41 + 1.2L) μin	Gauge Blocks
Micrometers – Outside <sup>3</sup>	Up to 1 in (1 to 36) in	14 μin (73 + 5.8L) μin	Gauge Blocks
Plunger Indicators – Dial or Digital	Up to 0.001 in (0.001 to 1) in (1 to 2) in	24 μin 81 μin 84 μin	Gauge Blocks, Micrometer Head
Lever Indicators – Dial, Digital, or Electronic <sup>3</sup>	Up to 0.001 in (0.001 to 0.06) in	(10 + 31 000L) μin (46 + 1 300L) μin	Gauge Blocks
Micrometer Heads	Up to 2 in	77 μin	Gauge Blocks, Electronic Indicator
Height Gages	Up to 6 in (6 to 12) in (12 to 20) in	63 μin 130 μin 170 μin	Gauge Blocks, Surface Plate
Cylindrical Gauges - Thread Wires, Pin Gauges, Plain Plug Gauges <sup>2,3</sup>	Up to 1 in (1 to 10) in	18 μin (11 + 5.7L) μin	Supermicrometer, Gauge Blocks
Thread Wires <sup>2,3</sup>	Up to 1 in	18 μin	Universal Supermicrometer, Gauge Blocks
Thread Plug Gauges <sup>2</sup> Major Diameter Pitch Diameter	Up to 1 in Up to 1 in	18 μin 73 μin	Universal Supermicrometer, Gauge Blocks, Thread Wires
Feeler Gauges	Up to 1 in	20 μin	Universal Supermicrometer, Gauge Blocks
Bore Gauges (2 Point) <sup>3</sup>	Up to 6 in	(140 + 4.3L) μin	Bore Gauge Setting Master Kit
Bore Gauges (3 Point) <sup>3</sup>	(0.625 to 7.875) in	(97 + 54L) μin	Tru-Cal, Gauge Blocks Master Pins
Micrometer - Inside	(1 to 6) in	97 μin	Bore Gauge Setting Master Kit
Micrometer – Depth	Up to 6 in	97 μin	Square Gauge Blocks, Surface Plate
Parallels / Straight Edges	Up to 36 in	130 μin	Electronic Gauging Head / Surface Plate
Ring Gauges <sup>2,3</sup>	(0.04 to 11.5) in	(23 + 6.8L) μin	Universal Supermicrometer, Master Rings

### Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Bars / Plates <sup>2</sup>	Up to 5 in (5 to 10) in	110 μin 150 μin	Electronic Gauging Head, Surface Plate, ???
Angle Blocks <sup>3</sup>	Up to 60 °	(0.72 + 0.17A) arcsec	Sine Plate, Electronic Gauging Head
Digital Inclinometers	Up to 90 °	0.067 °	Angle Blocks, Sine Plate
Cylindrical Squares Up to 24 in tall	Up to 0.001 in	67 μin	Electronic Gauging Head, Surface Plate
Squares / Angle Plates Up to 24 in tall	Up to 0.001 in	370 μin	Cylindrical Square, Electronic Gauging Head, Surface Plate

### Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tensiometers <sup>3</sup>	Up to 200 lbf (200 to 2 000) lbf	(0.22 + 0.0023X) lbf (0.81 + 2.1X) lbf	Dead weights Torque Sensor
Torque Wrenches <sup>3</sup>	Up to 10 lbf·in (10 to 100) lbf·in (100 to 200) lbf·in Up to 100 lbf·ft (100 to 2 000) lbf·ft (2 000 to 2 500) lbf·ft	0.056 lbf·in 0.34 lbf·in (0.13 + 0.000 93X) lbf·in (0.025 + 0.001 2X) lbf·ft (0.68 + 0.001 1X) lbf·ft 3.9 lbf·ft	Torque Sensor
Torque Multipliers	(100 to 3 000) lbf·ft (3 000 to 6 000) lbf·ft <sup>2</sup>	3.9 lbf·ft 0.012 % of reading	Torque Sensor Torque Arm, Dead Weight
Torque Transducers <sup>2</sup>	(5 to 1 200) lbf·in (100 to 1 000) lbf·ft (1 000 to 2 500) lbf·ft (2 500 to 6 000) lbf·ft <sup>2</sup>	0.015 % of reading 0.012 % of reading 0.012 % of reading 0.012 % of reading	Torque Arm, Dead Weight
Force Gages and Load Cells Tension & Compression	Up to 200 lbf (200 to 2 000) lbf	0.002 6 % of reading + 0.000 22 lbf 0.002 1 % of reading + 0.009 3 lbf	Dead Weights
	(1 000 to 10 000) lbf (10 000 to 30 000) lbf	4.4 lbf 13 lbf	Load Cell
Force Gages and Load Cells Compression <sup>2</sup>	(30 000 to 100 000) lbf	44 lbf	Load Cell
Scales	Up to 5 000 g	0.002 % of reading + 0.11 mg	Class 1 weights

### Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales	Up to 50 lbf (50 to 2 000) lbf	0.002 6 % of reading + 0.000 22 lbf 0.002 1 % of reading + 0.009 3 lbf	Class S-1 weights Class F weights Class F weights
Scales	(2 000 to 10 000) lbf (10 000 to 30 000) lbf	4.4 lbf 13 lbf	Load Cell
Scales <sup>2</sup>	(30 000 to 100 000) lbf	44 lbf	
Pressure Gauges	Up to 100 psi	0.049 psi	Setra 370 Pressure Indicator
	(35 to 500) psi (500 to 5 000) psi (5 000 to 10 000) psi (10 000 to 15 000) psi	0.74 psi 11 psi 7.7 psi 11 psi	Pressure Indicators
	Up to 19 psia	0.003 psi	Druck DPI 145 Pressure Tester
	(19 to 110) psia	0.032 psi	Setra 370 Pressure Indicator

### Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Measure – Air	(-80 to 420) °C	0.027 °C	PRT, Indicator
Temperature Measure – Dry Well	(-25 to 420) °C	0.027 °C	PRT, Indicator
Temperature Measure – Liquid Bath	(-20 to 150) °C	0.027 °C	PRT, Indicator
Humidity – Measure	(0 to 90) %RH (90 to 95) %RH	1.5 %RH 2.2 %RH	Humidity Air Probe
Thermometers – Dry Well	(-25 to 420) °C	0.12 °C	PRT, Indicator
Thermometers – Chamber <sup>2</sup>	(-70 to 175) °C	0.046 °C	PRT, Indicator
Thermometers – Liquid Bath <sup>2</sup>	(-20 to 150) °C	0.038 °C	PRT, Indicator



**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Hygrometer <sup>2</sup>	(0 to 90) %RH (90 to 95) %RH	1.6 %RH 2.3 %RH	Humidity Air Probe, Humidity Chamber
Temperature – Fixed Point	0 °C	0.067 °C	Kaye Ice Point Reference - TPW

**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Logic Pulses - Source (0.01, 0.025, 0.1, 0.25, 1, 2.5) V Pulse Width	(4 to 500) ns	50 ms/s + 3.2 ns	Fluke 5520A-SC1100 Multiproduct Calibrator with ERC 130 Frequency Standard
Logic Pulses - Source (0.01, 0.025, 0.1, 0.25, 1, 2.5) V Period	200 ns to 20 ms	100 ns/s + 500 ps	
Time Markers (Spike or Square Wave)	5 ns to 20 ms	100 ns/s + 390 ps	Fluke 5520A-SC1100 Multiproduct Calibrator with ERC 130 Frequency Standard
Frequency - Source	0.01 Hz to 1 100 MHz (1.1 to 26) GHz	5.8 μHz + 750 pHz/Hz 5.8 μHz + 750 pHz/Hz	Fluke 5520A-SC1100 Multiproduct Calibrator with ERC 130 Frequency Standard
Frequency - Source / Fixed 10 MHz	10 MHz	7.5 mHz	ERC 130 Frequency Standard
Photo Tachometers - Simulate	(6 to 200 000) RPM	0.000 35 RPM + 7.5 E <sup>-10</sup> RPM/RPM	Signal Generator with ERC 130 Frequency Standard
RPM – Measure	(5 to 99) RPM (100 to 999) RPM (1 000 to 9 999) RPM (10 000 to 99 999) RPM (100 000 to 200 000) RPM	0.013 RPM + 1.2 E <sup>-4</sup> RPM/RPM 0.13 RPM + 1.2 E <sup>-4</sup> RPM/RPM 0.61 RPM + 1.2 E <sup>-4</sup> RPM/RPM 6.1 RPM + 1.2 E <sup>-4</sup> RPM/RPM 17 RPM + 1.2 E <sup>-4</sup> RPM/RPM	Photo Tachometer
Timers & Stopwatches	(10 to 600 000) s	0.041 s + 750 ps/s	Signal Generator, Timer/Counter, Frequency Standard
Frequency – Measure	10 Hz to 225 MHz 225 MHz to 26 GHz	12 mHz + 750 pHz/Hz 1.2 Hz + 750 pHz/Hz	Timer/Counter, Freq Std Freq Counter, Frequency Standard



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**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Time Interval / Period or Pulse Width – Measure	(4.4ns to 10 s (10 to 100 000) s	390 ps + 750 ps/s 1.3 ns + 750 ps/s	Universal Timer / Counter, Frequency Standard
Duty Cycle – Measure Up to 225 MHz <sup>3</sup>	(0 to 100) %PW	5.5 x E <sup>-8</sup> %PW/Hz	Universal Timer / Counter, Frequency Standard

**DIMENSIONAL MEASUREMENT**

**1 Dimensional**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Height / Linear Measurement <sup>3</sup>	Up to 6 in	200 μin	Electronic Height Gauge
Optical Linear Measurement <sup>2</sup>	Up to 2 in Up to 6 in	150 μin 370 μin	Toolmakers Microscope Optical Comparator / Readout

### Services performed at satellite location

975 Platte River Blvd., Unit M  
Brighton, CO 80601  
DuWain Ake 937-832-3322 x200

## CALIBRATION

### Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source	Up to 330 $\mu$ A 330 $\mu$ A to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3.0) A (3.0 to 11) A (11 A to 20.5) A	150 $\mu$ A/A + 22 nA 100 $\mu$ A/A + 59 nA 100 $\mu$ A/A + 480 nA 100 $\mu$ A/A + 4.8 $\mu$ A 200 $\mu$ A/A + 51 $\mu$ A 380 $\mu$ A/A + 86 $\mu$ A 500 $\mu$ A/A + 980 $\mu$ A 1.0 mA/A + 1.8 mA	Fluke 5520A Multiproduct Calibrator
	(20.5 to 30) A	470 $\mu$ A/A + 2.2 mA	Transmille 4015 Multiproduct Calibrator
DC Current – Source (Clamp Meters Only)	(20 to 30) A (30 to 110) A (110 to 205) A	2.4 mA/A + 860 $\mu$ A 2.5 mA/A + 9.8 mA 3 mA/A + 18 mA	Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil
	(205 to 300) A	2.8 mA/A + 22 mA	Transmille 4015 Multiproduct Calibrator w/ 10 Turn Coil
DC Current – Source (Clamp Meters Only)	(205 to 550) A (550 to 1 025) A	2.5 mA/A + 49 mA 3.0 mA/A + 89 mA	Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil
	(1 025 to 1 500) A	2.8 mA/A + 110 mA	Transmille 4015 Multiproduct Calibrator w/ 50 Turn Coil
DC Voltage - Source	Up to 330 mV 330 mV to 3.3 V (3.3 to 33) V (33 to 330) V (330 to 1.0) kV	20 $\mu$ V/V + 1.4 $\mu$ V 11 $\mu$ V/V + 8.7 $\mu$ V 12 $\mu$ V/V + 83 $\mu$ V 18 $\mu$ V/V + 830 $\mu$ V 18 $\mu$ V/V + 3.3 mV	Fluke 5520A Multiproduct Calibrator
DC Resistance - Source	Up to 11 $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ 330 $\Omega$ to 1.1 k $\Omega$	40 $\mu\Omega/\Omega$ + 1.1 m $\Omega$ 30 $\mu\Omega/\Omega$ + 1.6 m $\Omega$ 28 $\mu\Omega/\Omega$ + 1.7 m $\Omega$ 28 $\mu\Omega/\Omega$ + 2.8 m $\Omega$ 28 $\mu\Omega/\Omega$ + 4.3 m $\Omega$	Fluke 5520A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance - Source	(1.1 to 3.3) k $\Omega$	28 $\mu\Omega/\Omega$ + 26 m $\Omega$	Fluke 5520A Multiproduct Calibrator
	(3.3 to 11) k $\Omega$	28 $\mu\Omega/\Omega$ + 33 m $\Omega$	
	(11 to 33) k $\Omega$	28 $\mu\Omega/\Omega$ + 340 m $\Omega$	
	(33 to 110) k $\Omega$	28 $\mu\Omega/\Omega$ + 710 m $\Omega$	
	(110 to 330) k $\Omega$	32 $\mu\Omega/\Omega$ + 3.6 $\Omega$	
	330 k $\Omega$ to 1.1 M $\Omega$	32 $\mu\Omega/\Omega$ + 12 $\Omega$	
	(1.1 to 3.3) M $\Omega$	60 $\mu\Omega/\Omega$ + 120 $\Omega$	
	(3.3 to 11) M $\Omega$	130 $\mu\Omega/\Omega$ + 230 $\Omega$	
	(11 to 33) M $\Omega$	250 $\mu\Omega/\Omega$ + 3.1 k $\Omega$	
	(33 to 110) M $\Omega$	500 $\mu\Omega/\Omega$ + 12 k $\Omega$	
(110 to 330) M $\Omega$	3.0 m $\Omega/\Omega$ + 200 k $\Omega$		
330 M $\Omega$ to 1.1 G $\Omega$	15 m $\Omega/\Omega$ + 4.2 M $\Omega$		
Conductance – Source	910 pS to 3.0 nS	40 $\mu\text{S}/\text{S}$ + 12 pS	Fluke 5520A Multiproduct Calibrator
	(3.0 to 9.1) nS	4.2 mS/S + 12 pS	
	(9.1 to 30) nS	620 $\mu\text{S}/\text{S}$ + 3.5 pS	
	(30 to 91) nS	620 $\mu\text{S}/\text{S}$ + 3.5 pS	
	(91 to 300) nS	150 $\mu\text{S}/\text{S}$ + 17 pS	
	(300 to 910) nS	95 $\mu\text{S}/\text{S}$ + 17 pS	
	910 nS to 3.0 $\mu\text{S}$	39 $\mu\text{S}/\text{S}$ + 34 pS	
	(3.0 to 9.1) $\mu\text{S}$	55 $\mu\text{S}/\text{S}$ + 57 pS	
	(9.1 to 30) $\mu\text{S}$	35 $\mu\text{S}/\text{S}$ + 300 pS	
	(30 to 91) $\mu\text{S}$	51 $\mu\text{S}/\text{S}$ + 300 pS	
	(91 to 300) $\mu\text{S}$	35 $\mu\text{S}/\text{S}$ + 1.9 nS	
	(300 to 910) $\mu\text{S}$	51 $\mu\text{S}/\text{S}$ + 3.2 nS	
	910 $\mu\text{S}$ to 3.0 mS	35 $\mu\text{S}/\text{S}$ + 20 nS	
	(3.0 to 9.1) mS	51 $\mu\text{S}/\text{S}$ + 68 nS	
	(9.1 to 30) mS	80 $\mu\text{S}/\text{S}$ + 380 nS	
	(30 to 91) mS	210 $\mu\text{S}/\text{S}$ + 2.5 $\mu\text{S}$	
(91 to 300) mS	420 $\mu\text{S}/\text{S}$ + 26 $\mu\text{S}$		
(300 to 910) mS	1.2 mS/S + 210 $\mu\text{S}$		
910 mS to 3.0 S	3.8 mS/S + 2.3 mS		
(3.0 to 9.1) S	12 mS/S + 21 mS		
AC Current – Source	(29 to 330) $\mu\text{A}$	2 mA/A + 150 nA	Fluke 5520A Multiproduct Calibrator
	(10 Hz to 20) Hz	1.5 mA/A + 140 nA	
	(20 to 45) Hz	1.3 mA/A + 140 nA	
	45 Hz to 1 kHz	3 mA/A + 180 nA	
	(1 to 5) kHz	8 mA/A + 220 nA	
	(5 to 10) kHz	16 mA/A + 420 nA	
(10 to 30) kHz			



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source	330 $\mu$ A to 3.3 mA (10 Hz to 20) Hz	2 mA/A + 730 nA	Fluke 5520A Multiproduct Calibrator
	(20 to 45) Hz	1.3 mA/A + 540 nA	
	45 Hz to 1 kHz (1 to 5) kHz	1 mA/A + 560 nA	
	(5 to 10) kHz	2 mA/A + 590 nA	
	(10 to 30) kHz	5 mA/A + 700 nA	
	(3.3 to 33) mA (10 to 20) Hz	10 mA/A + 930 nA	
	(20 to 45) Hz	1.8 mA/A + 6.7 $\mu$ A	
	45 Hz to 1 kHz (1 to 5) kHz	900 $\mu$ A/A + 6.7 $\mu$ A	
	(5 to 10) kHz	400 $\mu$ A/A + 6.7 $\mu$ A	
	(10 to 30) kHz	800 $\mu$ A/A + 4 $\mu$ A	
	(33 to 330) mA (10 to 20) Hz	2 mA/A + 8.8 $\mu$ A	
	(20 to 45) Hz	4 mA/A + 8.8 $\mu$ A	
	45 Hz to 1 kHz (1 to 5) kHz	1.8 mA/A + 89 $\mu$ A	
	(5 to 10) kHz	900 $\mu$ A/A + 89 $\mu$ A	
	(10 to 30) kHz	400 $\mu$ A/A + 38 $\mu$ A	
	330 mA to 1.1 A (10 to 45) Hz	1 mA/A + 57 $\mu$ A	
	45 Hz to 1 kHz (1 to 5) kHz	2 mA/A + 110 $\mu$ A	
	(5 to 10) kHz	4 mA/A + 220 $\mu$ A	
	(1.1 to 3.0) A (10 to 45) Hz	1.8 mA/A + 270 $\mu$ A	
	45 Hz to 1 kHz (1 to 5) kHz	500 $\mu$ A/A + 160 $\mu$ A	
	(5 to 10) kHz	6 mA/A + 1.1 mA	
	(3.0 to 11) A (45 Hz to 100) Hz	25 mA/A + 5.1 mA	
	100 Hz to 1 kHz (1 to 5) kHz	1.8 mA/A + 730 $\mu$ A	
	(5 to 10) kHz	600 $\mu$ A/A + 400 $\mu$ A	
(11 to 20.5) A (45 to 100) Hz	6 mA/A + 1.2 mA		
100 Hz to 1 kHz (1 to 5) kHz	25 mA/A + 5.1 mA		
	600 $\mu$ A/A + 2.5 mA		
	1 mA/A + 2.7 mA		
	30 mA/A + 4.5 mA		
	1.2 mA/A + 6.4 mA		
	1.5 mA/A + 6.4 mA		
	30 mA/A + 12 mA		



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source	(20.5 to 30) A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	2.3 mA/A + 16 mA 2.3 mA/A + 16 mA 1 mA/A + 5.4 mA 6.9 mA/A + 8.0 mA	Transmille 4015 Multiproduct Calibrator
AC Current – Source (Clamp Meters Only)	(30 to 110) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	2.6 mA/A + 25 mA 3 mA/A + 27 mA 32 mA/A + 45 mA	Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil
	(110 to 205) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	3.2 mA/A + 64 mA 3.5 mA/A + 64 mA 32 mA/A + 120 mA	
AC Current – Source (Clamp Meters Only)	(205 to 300) A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	4.6 mA/A + 1606 mA 4.6 mA/A + 160 mA 3.3 mA/A + 54 mA 9.2 mA/A + 80 mA	Transmille 4015 Multiproduct Calibrator w/ 10 Turn Coil
	(205 to 550) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	2.6 mA/A + 130 mA 3 mA/A + 140 mA 32 mA/A + 230 mA	
AC Current – Source (Clamp Meters Only)	(550 to 1 025) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	3.2 mA/A + 320 mA 3.5 mA/A + 320 mA 32 mA/A + 560 mA	Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil
	(1 025 to 1 500) A (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	4.6 mA/A + 800 mA 4.6 mA/A + 800 mA 3.3 mA/A + 270 mA 9.2 mA/A + 400 mA	
AC Voltage – Source	(1 to 33) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	800 $\mu$ V/V + 6.7 $\mu$ V 150 $\mu$ V/V + 6.7 $\mu$ V 200 $\mu$ V/V + 6.7 $\mu$ V 1 mV/V + 7.4 $\mu$ V 3.5 mV/V + 15 $\mu$ V 8 mV/V + 56 $\mu$ V	Fluke 5520A Multiproduct Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
AC Voltage – Source	(33 to 330) mV		Fluke 5520A Multiproduct Calibrator	
	(10 to 45) Hz	300 $\mu\text{V}/\text{V}$ + 21 $\mu\text{V}$		
	45 Hz to 10 kHz	150 $\mu\text{V}/\text{V}$ + 13 $\mu\text{V}$		
	(10 to 20) kHz	160 $\mu\text{V}/\text{V}$ + 14 $\mu\text{V}$		
	(20 to 50) kHz	350 $\mu\text{V}/\text{V}$ + 20 $\mu\text{V}$		
	(50 to 100) kHz	800 $\mu\text{V}/\text{V}$ + 42 $\mu\text{V}$		
	(100 to 500) kHz	2 mV/V + 120 $\mu\text{V}$		
	330 mV to 3.3 V			
	(10 to 45) Hz	300 $\mu\text{V}/\text{V}$ + 110 $\mu\text{V}$		
	45 Hz to 10 kHz	150 $\mu\text{V}/\text{V}$ + 95 $\mu\text{V}$		
	(10 to 20) kHz	190 $\mu\text{V}/\text{V}$ + 92 $\mu\text{V}$		
	(20 to 50) kHz	300 $\mu\text{V}/\text{V}$ + 140 $\mu\text{V}$		
	(50 to 100) kHz	700 $\mu\text{V}/\text{V}$ + 240 $\mu\text{V}$		
	(100 to 500) kHz	2.4 mV/V + 1.2 mV		
	(3.3 to 33) V			
	(10 to 45) Hz	300 $\mu\text{V}/\text{V}$ + 2.1 mV		
	45 Hz to 10 kHz	150 $\mu\text{V}/\text{V}$ + 1.1 mV		
	(10 to 20) kHz	240 $\mu\text{V}/\text{V}$ + 1.1 mV		
(20 to 50) kHz	350 $\mu\text{V}/\text{V}$ + 1.6 mV			
(50 to 100) kHz	900 $\mu\text{V}/\text{V}$ + 2.9 mV			
(33 to 330) V				
45 Hz to 1 kHz	190 $\mu\text{V}/\text{V}$ + 12 mV			
(1 to 10) kHz	200 $\mu\text{V}/\text{V}$ + 13 mV			
(10 to 20) kHz	250 $\mu\text{V}/\text{V}$ + 13 mV			
(20 to 50) kHz	300 $\mu\text{V}/\text{V}$ + 20 mV			
(50 to 100) kHz	2 mV/V + 94 mV			
(330 to 1 020) V				
45 to 1 kHz	300 $\mu\text{V}/\text{V}$ + 41 mV			
(1 to 5) kHz	250 $\mu\text{V}/\text{V}$ + 44 mV			
(5 to 10) kHz	300 $\mu\text{V}/\text{V}$ + 40 mV			
Capacitance - Simulation	(0.19 to 0.4) nF	5 mF/F + 11 pF	Fluke 5520A Multiproduct Calibrator	
	(0.4 to 1.1) nF	5 mF/F + 11 pF		
	(1.1 to 3.3) nF	5 mF/F + 11 pF		
	(3.3 to 11) nF	2.5 mF/F + 13 pF		
	(11 to 33) nF	2.5 mF/F + 110 pF		
	(33 to 110) nF	2.5 mF/F + 130 pF		
	(110 to 330) nF	2.5 mF/F + 370 pF		
	330 nF to 1.1 $\mu\text{F}$	2.5 mF/F + 1.3 nF		
	(1.1 to 3.3) $\mu\text{F}$	2.5 mF/F + 3.7 nF		
	(3.3 to 11) $\mu\text{F}$	2.5 mF/F + 13 nF		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance - Simulation	(11 to 33) $\mu$ F (33 to 110) $\mu$ F (110 to 330) $\mu$ F 330 $\mu$ F to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	4 mF/F + 37 nF 4.5 mF/F + 130 nF 4.5 mF/F + 310 nF 4.5 mF/F + 1.1 $\mu$ F 4.5 mF/F + 3.1 $\mu$ F 4.5 mF/F + 11 $\mu$ F 7.5 mF/F + 31 $\mu$ F 11 mF/F + 110 $\mu$ F	Fluke 5520A Multiproduct Calibrator
Oscilloscopes AC Voltage, Square Wave (50 $\Omega$ )	(10 Hz to 10kHz) (1 to 25) mV (25 to 110) mV (110 to 500) mV 500 mV to 2.2 V (2.2 to 6.6) V	4.4 mV/V + 56 $\mu$ V 4.4 mV/V + 160 $\mu$ V 4.4 mV/V + 770 $\mu$ V 4.4 mV/V + 3.9 mV 4.4 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscopes AC Voltage, Square Wave (1 M $\Omega$ )	(10 Hz to 1 kHz) (1 to 500) mV 500 mV to 2.2 V (2.2 to 11) V (11 to 130) V (1 to 10) kHz (1 to 500) mV 500 mV to 2.2 V (2.2 to 11) V (11 to 130) V	3.7 mV/V + 770 $\mu$ V 3.7 mV/V + 3.9 mV 3.7 mV/V + 16 mV 3.7 mV/V + 160 mV 4.4 mV/V + 770 $\mu$ V 4.4 mV/V + 3.9 mV 4.4 mV/V + 16 mV 4.4 mV/V + 160 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscopes DC Voltage (50 $\Omega$ )	(0 to 110) mV (110 to 499) mV 499 mV to 2.2 V (2.2 to 6.6) V	4.4 mV/V + 160 $\mu$ V 4.4 mV/V + 770 $\mu$ V 4.4 mV/V + 3.9 mV 4.4 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscopes DC Voltage (1 M $\Omega$ )	(0 to 500) mV 500 mV to 2.2 V (2.2 to 11) V (11 to 70.5) V (70.5 to 130) V	3.6 mV/V + 770 $\mu$ V 3.6 mV/V + 3.9 mV 3.6 mV/V + 16 mV 3.6 mV/V + 77 mV 3.6 mV/V + 160 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Leveled Sine Wave (Absolute) (50 $\Omega$ , 50kHz)	(5 to 10) mVpp (10 to 40) mVpp (40 to 100) mVpp (100 to 800) mVpp 800 mVpp to 1.3 Vpp (1.3 to 5.5) Vpp	20 mV/V + 310 $\mu$ V 20 mV/V + 310 $\mu$ V 20 mV/V + 350 $\mu$ V 20 mV/V + 1.0 mV 20 mV/V + 1.8 mV 20 mV/V + 8.2 mV	





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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Leveled Sine Wave (Absolute) (50 Ω) 50 kHz to 10 MHz (10 to 100) MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz	5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 3.5 Vpp	36 mV/V + 7.7 mV 36 mV/V + 7.7 mV 41 mV/V + 7.7 mV 61 mV/V + 7.7 mV 71 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Leveled Sine Wave (Relative to 50 kHz) (50 Ω) 50 kHz to 10 MHz (10 to 100) MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz	5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 5.5 Vpp 5 mVpp to 3.5 Vpp	16 mV/V + 7.7 mV 17 mV/V + 7.7 mV 22 mV/V + 7.7 mV 41 mV/V + 7.7 mV 51 mV/V + 7.7 mV	Fluke 5520A-SC1100 Multiproduct Calibrator
Oscilloscope Input Resistance Measurement (50 Ω Input) (1 MΩ Input)	(40 to 60) Ω 500 kΩ to 1.5 MΩ	1 mΩ/Ω + 15 mΩ 1 mΩ/Ω + 180 Ω	
Oscilloscope Input Capacitance Measurement (1 MΩ Input)	(5 to 50) pF	50 mF/F + 780 fF	Fluke 5520A-SC1100 Multiproduct Calibrator
DC Current - Measure	(20 to 100) nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	35 μA/A + 47 pA 24 μA/A + 49 pA 24 μA/A + 190 pA 24 μA/A + 1.8 nA 24 μA/A + 12 nA 24 μA/A + 150 nA 41 μA/A + 2.3 μA 130 μA/A + 46 μA	Keysight 3458A Multimeter
DC Current - Measure	(1 to 3) A	1.4 mA/A + 1.6 mA	Keysight 34401A Multimeter
DC Current - Measure	(3 to 10) A (10 to 100) A (100 to 200) A	1.3 mA/A + 48 μA 1.3 mA/A + 480 μA 1.3 mA/A + 1.9 mA	Shunts, Keysight 3458A Multimeter
DC Current - Measure	Up to 1 000 A	24 mA/A + 3.4 A	Fluke 381 Clamp Meter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Measure	Up to 100 $\mu$ A		Keysight 3458A Multimeter
	(10 to 20) Hz	4.6 mA/A + 39 nA	
	(20 to 45) Hz	1.7 mA/A + 39 nA	
	(45 to 100) Hz	700 $\mu$ A/A + 39 nA	
	100 Hz to 5 kHz	700 $\mu$ A/A + 39 nA	
	100 $\mu$ A to 1 mA		
	(10 to 20) Hz	4.6 mA/A + 260 nA	
	(20 to 45) Hz	1.7 mA/A + 260 nA	
	(45 to 100) Hz	700 $\mu$ A/A + 260 nA	
	100 Hz to 5 kHz	350 $\mu$ A/A + 260 nA	
	(5 to 20) kHz	700 $\mu$ A/A + 260 nA	
	(20 to 50) kHz	4.6 mA/A + 480 nA	
	(50 to 100) kHz	6.4 mA/A + 1.8 $\mu$ A	
	(1 to 10) mA		
	(10 to 20) Hz	4.6 mA/A + 2.6 $\mu$ A	
	(20 to 45) Hz	1.7 mA/A + 2.6 $\mu$ A	
	(45 to 100) Hz	700 $\mu$ A/A + 2.6 $\mu$ A	
	100 Hz to 5 kHz	350 $\mu$ A/A + 2.6 $\mu$ A	
	(5 to 20) kHz	700 $\mu$ A/A + 2.6 $\mu$ A	
	(20 to 50) kHz	4.6 mA/A + 4.8 $\mu$ A	
	(50 to 100) kHz	6.4 mA/A + 18 $\mu$ A	
	(10 to 100) mA		
	(10 to 20) Hz	4.6 mA/A + 26 $\mu$ A	
	(20 to 45) Hz	1.7 mA/A + 26 $\mu$ A	
(45 to 100) Hz	700 $\mu$ A/A + 26 $\mu$ A		
100 Hz to 5 kHz	350 $\mu$ A/A + 26 $\mu$ A		
(5 to 20) kHz	700 $\mu$ A/A + 26 $\mu$ A		
(20 to 50) kHz	4.6 mA/A + 48 $\mu$ A		
(50 to 100) kHz	6.4 mA/A + 180 $\mu$ A		
100 mA to 1 A			
(10 to 20) Hz	4.6 mA/A + 320 $\mu$ A		
(20 to 45) Hz	1.8 mA/A + 320 $\mu$ A		
(45 to 100) Hz	930 $\mu$ A/A + 320 $\mu$ A		
100 Hz to 5 kHz	1.2 mA/A + 320 $\mu$ A		
(5 to 20) kHz	3.5 mA/A + 320 $\mu$ A		
(20 to 50) kHz	12 mA/A + 510 $\mu$ A		
AC Current - Measure	(1 to 3) A		Keysight 34401A Multimeter
	(3 to 5) Hz	13 mA/A + 3.4 mA	
	(5 to 10) Hz	4.0 mA/A + 3.4 mA	
	(10 to 5 000) Hz	1.7 mA/A + 3.4 mA	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Measure	(3 to 10) A (40 to 1 000) Hz	1.8 mA/A + 520 $\mu$ A	Shunts, Keysight 34401A Multimeter
	(10 to 100) A (40 to 1 000) Hz	1.7 mA/A + 5.2 mA	
	(100 to 200) A (40 to 1 000) Hz	1.8 mA/A + 21 mA	
AC Current - Measure	(200 to 1 000) A (10 to 100) Hz (100 to 500) Hz	24 mA/A + 4.1 A 58 mA/A + 4.1 mA	Fluke 381 Clamp Meter
	(1 000 to 2 500) A (45 to 500) Hz	35 mA/A + 7.2 A	Fluke 381 Clamp Meter w/ iFlex Current Probe
DC Voltage – Measure	Up to 1 mV (1 to 10) mV	58 $\mu$ V/V + 27 nV 58 $\mu$ V/V + 100 nV	Keysight 34420A Multimeter
DC Voltage - Measure	(10 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1 000) V	11 $\mu$ V/V + 520 nV 9.2 $\mu$ V/V + 2.7 $\mu$ V 9.2 $\mu$ V/V + 25 $\mu$ V 12 $\mu$ V/V + 270 $\mu$ V 12 $\mu$ V/V + 5.9 mV	Keysight 3458A Multimeter
DC Voltage – Measure	(1 to 1.4) kV (1.4 to 10) kV	350 $\mu$ V/V + 46 mV 350 $\mu$ V/V + 680 mV	Vitrek 4700 Voltmeter
DC Voltage – Measure	(10 to 35) kV	290 $\mu$ V/V + 2.7 V	Vitrek 4700 Voltmeter w/ HVL-35 High Voltage Probe
AC Voltage - Measure	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (10 to 100) mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	350 $\mu$ V/V + 3.6 $\mu$ V 240 $\mu$ V/V + 1.6 $\mu$ V 350 $\mu$ V/V + 1.7 $\mu$ V 1.2 mV/V + 8.6 $\mu$ V 5.8 mV/V + 8.6 $\mu$ V 47 mV/V + 66 $\mu$ V 81 $\mu$ V/V + 6.5 $\mu$ V 81 $\mu$ V/V + 5.1 $\mu$ V 170 $\mu$ V/V + 7.3 $\mu$ V 350 $\mu$ V/V + 7.3 $\mu$ V 930 $\mu$ V/V + 37 $\mu$ V 350 $\mu$ V/V + 69 $\mu$ V 12 mV/V + 70 $\mu$ V 18 mV/V + 180 $\mu$ V	Keysight 3458A Multimeter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	100 mV to 1 V (1 to 40) Hz	81 $\mu$ V/V + 62 $\mu$ V	Keysight 3458A Multimeter
	40 Hz to 1 kHz (1 to 20) kHz	81 $\mu$ V/V + 47 $\mu$ V	
	(20 to 50) kHz	170 $\mu$ V/V + 68 $\mu$ V	
	(50 to 100) kHz	350 $\mu$ V/V + 140 $\mu$ V	
	(100 to 300) kHz	930 $\mu$ V/V + 210 $\mu$ V	
	300 kHz to 1 MHz (1 to 2) MHz	350 $\mu$ V/V + 620 $\mu$ V	
	(1 to 10) V	12 mV/V + 1.7 mV	
	(1 to 40) Hz	18 mV/V + 1.7 mV	
	40 Hz to 1 kHz (1 to 20) kHz	81 $\mu$ V/V + 720 $\mu$ V	
	(20 to 50) kHz	81 $\mu$ V/V + 470 $\mu$ V	
	(50 to 100) kHz	170 $\mu$ V/V + 690 $\mu$ V	
	(100 to 300) kHz	350 $\mu$ V/V + 1.3 mV	
	300 kHz to 1 MHz (1 to 2) MHz	930 $\mu$ V/V + 1.7 mV	
	(10 to 100) V	350 $\mu$ V/V + 5.3 mV	
	(1 to 40) Hz	12 mV/V + 16 mV	
	40 Hz to 1 kHz (1 to 20) kHz	18 mV/V + 21 mV	
	(20 to 50) kHz	240 $\mu$ V/V + 6.2 mV	
	(50 to 100) kHz	240 $\mu$ V/V + 4.8 mV	
	(100 to 300) kHz	240 $\mu$ V/V + 8.3 mV	
	300 kHz to 1 MHz	410 $\mu$ V/V + 7.9 mV	
(100 to 750) V	1.4 mV/V + 24 mV		
(1 to 40) Hz	4.6 mV/V + 26 mV		
40 Hz to 1 kHz (1 to 20) kHz	18 mV/V + 26 mV		
(20 to 50) kHz	470 $\mu$ V/V + 70 mV		
(50 to 100) kHz	470 $\mu$ V/V + 63 mV		
AC Voltage - Measure	(750 to 10 000) V (0.01 to 1) Hz	700 $\mu$ V/V + 63 mV	Vitretek 4700 Voltmeter
	(10 to 65) Hz	1.4 mV/V + 2.6 V	
	(30 to 200) Hz	1.4 mV/V + 2.6 V	
	(200 to 450) Hz	4.6 mV/V + 2.6 V	
	(10 to 30) kV (0.01 to 1) Hz	1.7 mV/V + 5.9 V	Vitretek 4700 Voltmeter w/ HVL-35 High Voltage Probe
	(30 to 200) Hz	580 $\mu$ V/V + 5.9 V	
	(200 to 450) Hz	6.9 mV/V + 5.9 V	
	DC Resistance – Measure (Current Shunts)	(0.25 to 10) m $\Omega$	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance – Measure (Current Shunts)	(0.25 to 10) mΩ (45 to 1 000) Hz	1.5 mΩ/Ω	4015 Multiproduct Calibrator
Resistance – Measure	Up to 1 Ω (1 to 10) Ω	81 μΩ/Ω + 8.1 μΩ 70 μΩ/Ω + 81 μΩ	Keysight 34420A Multimeter
Resistance - Measure	(10 to 100) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	18 μΩ/Ω + 110 μΩ 14 μΩ/Ω + 1.1 mΩ 12 μΩ/Ω + 7.4 mΩ 12 μΩ/Ω + 75 mΩ 12 μΩ/Ω + 750 mΩ 18 μΩ/Ω + 8.0 Ω 58 μΩ/Ω + 250 Ω 580 μΩ/Ω + 18 kΩ 5.8 mΩ/Ω + 180 kΩ	Keysight 3458A Multimeter
Resistance – Measure	(20 to 200) MΩ (200 to 2 000) MΩ (2 to 20) GΩ (20 to 200) GΩ (200 to 2 000) GΩ (2 to 20) TΩ	1.7 mΩ/Ω + 9.5 kΩ 2.6 mΩ/Ω + 150 kΩ 2.6 mΩ/Ω + 2.3 MΩ 4 mΩ/Ω + 72 MΩ 4 mΩ/Ω + 2.9 GΩ 12 mΩ/Ω + 57 GΩ	Keithley 6517A Multimeter
Electrical Simulation of RTD Indicating Devices	Pt 385 100 Ω (-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C Pt 385 200 Ω (-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.053 °C 0.053 °C 0.072 °C 0.092 °C 0.11 °C 0.13 °C 0.13 °C 0.24 °C 0.043 °C 0.043 °C 0.043 °C 0.053 °C 0.13 °C 0.14 °C 0.15 °C 0.17 °C	Fluke 5520A Multiproduct Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices	Pt 385 500 Ω		Fluke 5520A Multiproduct Calibrator
	(-200 to -80) °C	0.043 °C	
	(-80 to 0) °C	0.053 °C	
	(0 to 100) °C	0.053 °C	
	(100 to 260) °C	0.062 °C	
	(260 to 300) °C	0.082 °C	
	(300 to 400) °C	0.082 °C	
	(400 to 600) °C	0.092 °C	
	(600 to 630) °C	0.12 °C	
	Pt 385 1 000 Ω		
	(-200 to -80) °C	0.035 °C	
	(-80 to 0) °C	0.035 °C	
	(0 to 100) °C	0.044 °C	
	(100 to 260) °C	0.053 °C	
	(260 to 300) °C	0.063 °C	
	(300 to 400) °C	0.072 °C	
(400 to 600) °C	0.072 °C		
(600 to 630) °C	0.24 °C		
Electrical Simulation of Thermocouple Indicating Devices	Type B		Fluke 5520A Multiproduct Calibrator
	(600 to 800) °C	0.49 °C	
	(800 to 1 000) °C	0.39 °C	
	(1 000 to 1 550) °C	0.35 °C	
	(1 550 to 1 820) °C	0.38 °C	
	Type E		
	(-250 to -100) °C	0.53 °C	
	(-100 to -25) °C	0.23 °C	
	(-25 to 350) °C	0.21 °C	
	(350 to 650) °C	0.23 °C	
	(650 to 1 000) °C	0.26 °C	
	Type J		
	(-210 to -100) °C	0.32 °C	
	(-100 to -30) °C	0.23 °C	
	(-30 to 150) °C	0.21 °C	
	(150 to 760) °C	0.23 °C	
(760 to 1 200) °C	0.28 °C		
Type K			
(-200 to -100) °C	0.37 °C		
(-100 to -25) °C	0.24 °C		
(-25 to 120) °C	0.23 °C		
(120 to 1 000) °C	0.31 °C		
(1 000 to 1 372) °C	0.43 °C		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices	Type N		Fluke 5520A Multiproduct Calibrator
	(-200 to -100) °C	0.44 °C	
	(-100 to -25) °C	0.28 °C	
	(-25 to 120) °C	0.25 °C	
	(120 to 410) °C	0.24 °C	
	(410 to 1 300) °C	0.32 °C	
	Type R		
	(0 to 250) °C	0.61 °C	
	(250 to 400) °C	0.4 °C	
	(400 to 1 000) °C	0.38 °C	
	(1 000 to 1 767) °C	0.44 °C	
	Type S		
	(0 to 200) °C	0.52 °C	
	(200 to 1 000) °C	0.41 °C	
(1 000 to 1 400) °C	0.41 °C		
(1 400 to 1 767) °C	0.5 °C		
Type T			
(-250 to -150) °C	0.66 °C		
(-150 to 0) °C	0.29 °C		
(0 to 120) °C	0.23 °C		
(120 to 400) °C	0.21 °C		

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length Standards <sup>2,3</sup>	Up to 1 in (1 to 20) in	24 μin (15 + 8.2L) μin	Gauge Blocks, Electronic Indicator
Calipers <sup>3</sup>	Up to 36 in (36 to 84) in	(670 + 9.2L) μin (41 + 1.2L) μin	Gauge Blocks
Micrometers – Outside <sup>3</sup>	Up to 1 in (1 to 36) in	14 μin (73 + 5.8L) μin	Gauge Blocks
Plunger Indicators – Dial or Digital <sup>3</sup>	Up to 0.001 in (0.001 to 2) in	24 μin (66 + 10L) μin	Gauge Blocks, Surface Plate
Lever Indicators – Dial, Digital, or Electronic <sup>3</sup>	Up to 0.01 in (0.01 to 0.06) in	(10 + 31 000L) μin (46 + 1 300L) μin	Gauge Blocks
Micrometer Heads	Up to 2 in	77 μin	Gauge Blocks, Electronic Indicator

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Height Gages	Up to 6 in (6 to 12) in (12 to 20) in	63 μin 130 μin 170 μin	Gauge Blocks, Surface Plate
Cylindrical Gauges - Pin Gauges, Plain Plug Gauges <sup>2</sup>	Up to 1 in	34 μin	MDH Hand Micrometer
Thread Wires <sup>3</sup>	Up to 1 in	34 μin	MDH Hand Micrometer
Thread Plug Gauges <sup>2</sup> Major Diameter Pitch Diameter	Up to 1 in Up to 1 in	18 μin 73 μin	MDH Hand Micrometer, Thread Wires
Feeler Gauges	Up to 1 in	30 μin	MDH Hand Micrometer
Bore Gauges (2 Point) <sup>3</sup>	Up to 6 in	(140 + 4.3L) μin	Bore Gauge Setting Master Kit
Bore Gauges (3 Point) <sup>3</sup>	(0.62 to 3.0) in	(103 + 33L) μin	Master Rings
Micrometer - Inside	(1 to 6) in	97 μin	Bore Gauge Setting Master Kit
Micrometer – Depth	Up to 6 in	97 μin	Square Gauge Blocks, Surface Plate
Parallels / Straight Edges	Up to 36"	130 μin	Electronic Gauging Head / Surface Plate
Sine Bars / Plates	Up to 5 in (5 to 10) in	110 μin 150 μin	Electronic Gauging Head, Surface Plate, Gauge Blocks
Angle Blocks <sup>3</sup>	Up to 60°	(0.72 + 0.17A) arcsec	Sine Plate, Electronic Gauging Head
Digital Inclinometers	Up to 90°	0.067 °	Angle Blocks, Sine Plate, Angle Plate
Cylindrical Squares Up to 24 in tall	Up to 0.001 in	67 μin	Electronic Gauging Head, Surface Plate
Squares / Angle Plates Up to 24 in tall	Up to 0.001 in	370 μin	Cylindrical Square, Electronic Gauging Head, Surface Plate





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**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tensiometers <sup>3</sup>	Up to 1 000 lbf (1 000 to 2 000) lbf	(0.22 + 0.002 3X) lbf (0.81 + 2.1X) lbf	Dead weights, Torque Sensor, Torque Arm
Torque Wrenches <sup>3</sup>	Up to 10 lbf·in (10 to 50) lbf·in (50 to 240) lbf·in (20 to 100) lbf·ft (100 to 2 000) lbf·ft (2 000 to 3 000) lbf·ft	0.056 lbf·in 0.34 lbf·in (0.13 + 0.000 93X) lbf·in (0.025 + 0.001 2X) lbf·ft (0.68 + 0.001 1X) lbf·ft 3.9 lbf·ft	Torque Sensor
Torque Multipliers	(100 to 3 000) lbf·ft	3.9 lbf·ft	Torque Sensor
Force Gages and Load Cells Tension & Compression	Up to 50 lbf (50 to 1 000) lbf	0.002 6 % of reading + 0.000 22 lbf 0.002 1 % of reading + 0.009 3 lbf	Class F Weights
	(1 000 to 10 000) lbf (10 000 to 30 000) lbf	4.4 lbf 13 lbf	Load Cell
Scales	Up to 5 000 g	0.002 % of reading + 0.11 mg	Class 1 weights
	Up to 50 lbf (50 to 1 000) lbf	0.002 6 % of reading + 0.000 25 lbf 0.002 1 % of reading + 0.009 3 lbf	Class S-1 weights Class F weights
	(1 000 to 10 000) lbf (10 000 to 30 000) lbf	4.4lbf 16 lbf	Load Cell
Pressure Gauges	Up to 100 psi	0.049 psi	Setra 370 Pressure Indicator
	(35 to 500) psi (500 to 5 000) psi (5 000 to 10 000) psi (10 000 to 15 000) psi	0.74 psi 11 psi 7.7 psi 11 psi	Pressure Indicators
	Up to 19 psia	0.003 3 psi	Druck DPI 145 Pressure Tester
	(19 to 110) psia	0.032 psi	Setra 370 Pressure Indicator

### Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Logic Pulses - Source (0.01, 0.025, 0.1, 0.25, 1, 2.5) V Pulse Width	(4 to 500) ns	50 ms/s + 3.2 ns	Fluke 5520A-SC1100 Multiproduct Calibrator with ERC 130 Frequency Standard
Logic Pulses - Source (0.01, 0.025, 0.1, 0.25, 1, 2.5) V Period	200 ns to 20 ms	100 ns/s + 500 ps	
Time Markers (Spike or Square Wave)	5 ns to 20 ms	100 ns/s + 390 ps	Fluke 5520A-SC1100 Multiproduct Calibrator with ERC 130 Frequency Standard
Frequency - Source	0.01 Hz to 1 100 MHz	5.8 $\mu$ Hz + 750 pHz/Hz	Fluke 5520A-SC1100 Multiproduct Calibrator with ERC 130 Frequency Standard
Frequency - Source / Fixed 10 MHz - Source	10 MHz	7.5 mHz	ERC 130 Frequency Standard
Photo Tachometers - Simulate	(10 to 200 000) RPM	0.000 035 RPM + 7.5 E <sup>-10</sup> RPM/RPM	Signal Generator with ERC 130 Frequency Standard
RPM – Measure	(5 to 99) RPM (100 to 999) RPM (1 000 to 9 999) RPM (10 000 to 99 000) RPM (100 000 to 200 000) RPM	0.013 RPM + 1.2 E <sup>-4</sup> RPM/RPM 0.13 RPM + 1.2 E <sup>-4</sup> RPM/RPM 0.61 RPM + 1.2 E <sup>-4</sup> RPM/RPM 6.1 RPM + 1.2 E <sup>-4</sup> RPM/RPM 17 RPM + 1.2 E <sup>-4</sup> RPM/RPM	Photo Tachometer
Timers & Stopwatches	(10 to 600 000) s	0.041 s + 750 ps/s	Signal Generator, Timer/Counter, Frequency Standard
Frequency – Measure	10 Hz to 3 GHz	12 mHz + 750 pHz/Hz	Agilent 53131A Freq Counter, Freq Std
Time Period or Pulse Width – Measure	4.4 ns to 10 s (10 to 100 000) s	390 ps + 750 ps/s 1.3 ns + 750 ps/s	Universal Timer / Counter, Freq Std.
Duty Cycle – Measure (Up to 225 MHz) <sup>3</sup>	(0 to 100) %PW	5.5 E <sup>-8</sup> %PW/Hz	Universal Timer / Counter, Freq Std

**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Measure – Air	(-80 to 420) °C	0.027 °C	PRT, Indicator
Temperature Measure – Dry Well	(-25 to 420) °C	0.027 °C	PRT, Indicator
Temperature Measure – Liquid Bath	(-20 to 150) °C	0.027 °C	PRT, Indicator
Humidity – Measure	(0 to 90) %RH (90 to 95) %RH	1.5 %RH 2.2 %RH	Humidity Air Probe
Thermometers – Dry Well	(-25 to 420) °C	0.12 °C	PRT, Indicator

**DIMENSIONAL MEASUREMENT**

**1 Dimensional**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Height / Linear Measurement <sup>3</sup>	Up to 6 in	200 µin	Electronic Indicator, Gauge Blocks, Surface Plate

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 ( $k=2$ ), corresponding to a confidence level of approximately 95%.

Notes:

1. On-site calibration service is available for most parameters, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. This parameter is only available at the laboratory facility.
3.  $A$  = angle in degrees,  $L$  = length in inches,  $PW$  = pulse width in seconds,  $X$  = force/torque applied.
4. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1647.



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