

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

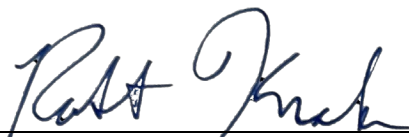
SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

<p>ESSCO CALIBRATION LABORATORY 27 Industrial Avenue, Unit #9 Chelmsford, MA 01824-3618 Mr. James Murphy Phone: 800-325-2201 Ext:156 Fax 978-256-1331 E-mail: jmurphy@esscolab.com URL: http://www.esscolab.com</p>	<p>Fields of Calibration Dimensional Electromagnetics – DC/Low Frequency Time and Frequency Mechanical Electromagnetics – RF/Microwave Thermodynamic</p> <p>This laboratory is compliant to ANSI/NCSL Z540-1-1994; Part 1. (NVLAP Code: 20/A01)</p>
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
DIMENSIONAL			
GAGE BLOCKS (20/D03)			
Gage Block Calibration	0.01 in to 0.049 in 0.05 in to 0.5 in > 0.5 in to 1 in > 1 in to 2 in > 2 in to 3 in > 3 in to 4 in > 4 in to 5 in > 5 in to 6 in > 6 in to 8 in > 8 in to 10 in > 10 in to 12 in > 12 in to 16 in > 16 in to 20 in	2.8 μin 2.5 μin 3.1 μin 4.6 μin 5.3 μin 6.8 μin 9.2 μin 10 μin 11 μin 13 μin 15 μin 18 μin 22 μin	Comparison to master blocks
LENGTH & DIAMETER (20/D05)			
Length Standards, Rods	0.1 in to 40 in	2.0 $\mu\text{in/in} + 9.6 \mu\text{in}$	Comparison to gage blocks
Calipers ^{Note 4}	0 in to 120 in	9.6 $\mu\text{in/in} + 290 \mu\text{in}$	Comparison to gage blocks
Thickness Setting Discs	0.01 in to 0.24 in	21 μin	Comparison to gage blocks

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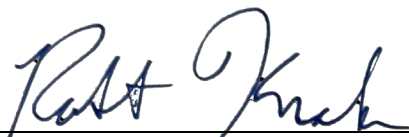
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (<i>k</i>=2) ^{Note 3}	Remarks
Micrometer ^{Note 4}	0 in to 40 in	2.1 μin/in + 28 μin	Comparison to gage blocks
Supermicrometer	0 in to 1 in	12 μin	Comparison to gage blocks
Anvil Parallelism ^{Note 4}	0 μin nominal	13 μin	Optical flat
Anvil Flatness ^{Note 4}	0 μin nominal	5.4 μin	Optical flat
Optical Flats & Parallels			
Flatness	0 μin nominal	2.3 μin	Comparison to standard flat
Parallelism	0 μin nominal	2.7 μin	Gage block comparator
Bore Micrometers and Gages	0.0625 in to 8 in	7.8 μin/in + 47 μin	Comparison to master rings
Dial/Test Indicator ^{Note 4}	0 in to 12 in	1.5 μin/in + 6.7 μin	Gage blocks or Micrometer head
Height Gages ^{Note 4}	0 in to 40 in	1.3 μin/in + 17 μin	Comparison to gage blocks
Depth Gages ^{Note 4}	0 in to 12 in	2.3 μin/in + 29 μin	Comparison to gage blocks
Feeler Gage	Up to 0.2 in	32 μin	Supermicrometer
Durometer (Indentor Length)	0.05 in 0.10 in 0.20 in	0.00019 in 0.00019 in 0.00022 in	Comparison to gage blocks (Note: Spring force component listed in mechanical section)
Electronic Gage Amplifier	0 in to 1 in	8.2 μin	Comparison to gage blocks
Crimp Tools – Crimp Height	0.011 to 1 in	0.00048 in	Indirect comparison to crimp micrometer
MEASURING WIRES (20/D07)			
Thread Wires	4 threads/in to 120 threads/in	8.9 μin	Labmaster, gage blocks

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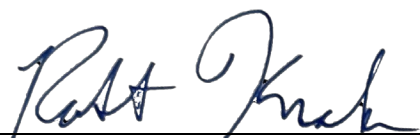
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
OPTICAL REFERENCE PLANES (20/D08)			
Glass Reticules, Stage Micrometers	0 in to 1 in 1 in to 2 in	0.00021 in 0.00043 in	Microscope w/micrometer head
SPHERICAL DIAMETER, PLAIN PLUG/RINGS (20/D11)			
Pin Gages (Class Z & ZZ) ^{Note 4}	0.004 in to 1 in 0.004 in to 1 in	60 μ in 36 μ in/in + 7.9 μ in	Supermicrometer Laser Micrometer
Plain Plugs (Class Y to XXX)	0 in to 12 in	2.9 μ in/in + 3.1 μ in	Labmaster
Plain Ring Gages Discrete sizes	0.04 in 0.125 in 0.1875 in 0.25 in 0.50 in 1.0 in 2.0 in 4.0 in	6.8 μ in 6.1 μ in 6.1 μ in 5.3 μ in 5.3 μ in 5.5 μ in 6.3 μ in 8.7 μ in	Comparison to master gages
Variable Range	0.040 in to 0.044 in > 0.044 in to 0.125 in >0.125 in to 0.1562 in >0.1562 in to 0.186 in >0.186 in to 0.2166 in >0.2166 in to 0.25 in >0.25 in to 0.375 in >0.375 in to 0.50 in >0.50 in to 0.752 in >0.752 in to 1.0 in >1.0 in to 1.32 in >1.32 in to 2.0 in >2.0 in to 3.47 in >3.47 in to 4.0 in >4.0 in to 12 in	1400 μ in/in - 49 μ in 18 μ in - 89 μ in/in 64 μ in/in - 1 μ in 20 μ in/in - 69 μ in/in 63 μ in - 5 μ in 25 μ in/in - 77 μ in/in 3.7 μ in + 9.9 μ in/in 10 μ in - 7.3 μ in/in 14 μ in - 0.72 μ in/in 21 μ in - 14 μ in/in 12 μ in/in - 5.7 μ in 16 μ in/in - 4.0 μ in/in 3.0 μ in/in + 2.6 μ in/in 8.1 μ in + 1.1 μ in/in 4 μ in + 2.1 μ in/in	Comparison to master gages

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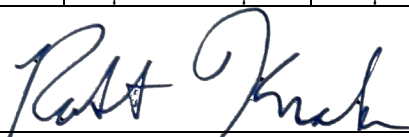
CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
Crimp Tools – Die Dimension	0.005 in to 0.5 in	0.00062 in	Pin gages
SURVEYING RODS and TAPES (20/D13)			
Rules	0 in to 40 in > 40 in to 80 in > 80 in to 120 in > 120 in to 160 in	4.9 $\mu\text{in/in}$ + 170 μin 4.9 $\mu\text{in/in}$ + 340 μin 4.9 $\mu\text{in/in}$ + 500 μin 4.9 $\mu\text{in/in}$ + 670 μin	P & W LMU1000A with digital microscope
Tape Measures	0 ft to 100 ft	0.0063 in + 0.00025 in/ft	Tape-to-tape method
THREADED PLUG/RINGS (20/D14)			
Thread Plugs – Pitch Diameter 6 TPI to 120 TPI 0.20 mm to 10 mm (Pitch)	0.01 in to 5 in 0.1 mm to 127 mm	89 μin 2.3 μm	Thread wires/ Supermicrometer
Adjustable Threaded Rings, Straight Thread – Pitch Diameter 6 TPI to 120 TPI 0.20 mm to 10 mm (Pitch)	0.01 in to 5 in	89 μin 2.3 μm	Ring is sized to a setting plug with plug's uncert. given

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

ELECTROMAGNETICS – DC/LOW FREQUENCY					
AC RESISTANCE and CURRENT (20/E02)					
AC Current – Generate					
Fluke 5730B/05 and 5725A Characterized With Fluke 5790B and A40Bs					
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 1 kHz	1 to 5 kHz	5 to 10 kHz
0 to 220 μA	130 $\mu\text{A/A}$ + 3.9 nA	72 $\mu\text{A/A}$ + 3.9 nA	41 $\mu\text{A/A}$ + 2.4 nA	46 $\mu\text{A/A}$ + 16 nA	310 $\mu\text{A/A}$ + 78 nA
0.22 to 1 mA	130 $\mu\text{A/A}$ + 4.1 nA	74 $\mu\text{A/A}$ + 4.4 nA	44 $\mu\text{A/A}$ + 3.1 nA	53 $\mu\text{A/A}$ + 15 nA	310 $\mu\text{A/A}$ + 78 nA
1 to 2.2 mA	130 $\mu\text{A/A}$	71 $\mu\text{A/A}$ + 3.7 nA	40 $\mu\text{A/A}$ + 2.0 nA	50 $\mu\text{A/A}$ + 13 nA	310 $\mu\text{A/A}$ + 77 nA
2.2 to 10 mA	130 $\mu\text{A/A}$ + 42 nA	71 $\mu\text{A/A}$ + 45 nA	38 $\mu\text{A/A}$ + 34 nA	46 $\mu\text{A/A}$ + 380 nA	310 $\mu\text{A/A}$ + 780 nA
10 to 20 mA	130 $\mu\text{A/A}$	71 $\mu\text{A/A}$ + 37 nA	40 $\mu\text{A/A}$ + 20 nA	50 $\mu\text{A/A}$ + 350 nA	310 $\mu\text{A/A}$ + 770 nA
20 to 22 mA	130 $\mu\text{A/A}$	72 $\mu\text{A/A}$	41 $\mu\text{A/A}$	50 $\mu\text{A/A}$ + 340 nA	310 $\mu\text{A/A}$
22 to 50 mA	130 $\mu\text{A/A}$ + 430 nA	70 $\mu\text{A/A}$ + 470 nA	38 $\mu\text{A/A}$ + 370 nA	47 $\mu\text{A/A}$ + 2.3 μA	310 $\mu\text{A/A}$ + 3.9 μA
50 to 100 mA	130 $\mu\text{A/A}$ + 390 nA	71 $\mu\text{A/A}$ + 410 nA	39 $\mu\text{A/A}$ + 260 nA	48 $\mu\text{A/A}$ + 2.2 μA	310 $\mu\text{A/A}$ + 3.9 μA
100 to 200 mA	130 $\mu\text{A/A}$	71 $\mu\text{A/A}$ + 370 nA	40 $\mu\text{A/A}$ + 200 nA	50 $\mu\text{A/A}$ + 2.1 μA	310 $\mu\text{A/A}$ + 3.9 μA

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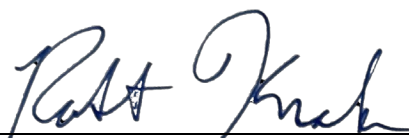
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AC Current – Generate					
Fluke 5730B/05 and 5725A Characterized With Fluke 5790B and A40Bs					
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 1 kHz	1 to 5 kHz	5 to 10 kHz
200 to 220 mA	130 μ A/A	72 μ A/A	41 μ A/A	51 μ A/A + 2.0 μ A	310 μ A/A
220 to 500 mA			49 μ A/A + 4.8 μ A	68 μ A/A + 16 μ A	620 μ A/A + 39 μ A
0.5 to 1 A			51 μ A/A + 3.9 μ A	69 μ A/A + 15 μ A	620 μ A/A + 39 μ A
1 to 2 A			51 μ A/A + 3.5 μ A	72 μ A/A + 14 μ A	620 μ A/A + 39 μ A
2 to 5 A			54 μ A/A + 3.1 μ A	72 μ A/A + 14 μ A	620 μ A/A
5 to 10 A			67 μ A/A + 81 μ A	84 μ A/A + 120 μ A	160 μ A/A + 230 μ A
10 to 11 A			70 μ A/A + 73 μ A	86 μ A/A + 110 μ A	160 μ A/A + 230 μ A

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
AC Current – Generate	> 11 A to 20.5 A	45 Hz to 100 Hz > 100 Hz to 1 kHz > 1 kHz to 5 kHz	0.93 mA/A + 3.9 mA 1.2 mA/A + 3.9 mA 23 mA/A + 3.9 mA	Fluke 5522A
(no field capability)	20 A to 120 A	10 Hz to 65 Hz > 65 Hz to 300 Hz > 0.3 kHz to 1 kHz > 1 kHz to 3 kHz > 3 kHz to 6 kHz > 6 kHz to 10 kHz	1.3 mA/A 2.0 mA/A 6.3 mA/A 16 mA/A 33 mA/A 76 mA/A	Fluke 52120A/Fluke 5730A
Current Clamp, Non-Toroidal ^{Note 4}	20 A to 1000 A	45 Hz to 65 Hz > 65 Hz to 440 Hz	7.2 mA/A + 0.27 A 12 mA/A + 0.27 A	Fluke 5522A with 5500A/COIL
Current Clamp, Toroidal ^{Note 4}	20 A to 1000 A	45 Hz to 65 Hz > 65 Hz to 440 Hz	3.3 mA/A + 27 mA 9.2 mA/A + 29 mA	Fluke 5522A with 5500A/COIL
Current Clamp	0 A to 300 A 120 A to 1000 A 120 A to 3000 A	1 kHz to 3 kHz 0.3 kHz to 1 kHz 10 Hz to 300 Hz	6.7 mA/A 5.6 mA/A 5.6 mA/A	Fluke 5730A with Fluke 52120A, Fluke 52120A/Coil3kA

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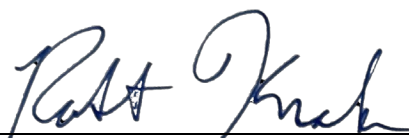
CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Current – Measure				
Fluke 8508A				
Range	1 to 10 Hz	0.010 to 10 kHz	10 to 30 kHz	30 to 100 kHz
0 to 200 μ A	0.25 mA/A + 20 nA	0.25 mA/A + 25 nA	0.60 mA/A + 78 nA	3.9 mA/A + 53 nA
0.200 to 2 mA	0.25 mA/A + 0.20 μ A	0.25 mA/A + 0.20 μ A	0.68 mA/A + 0.21 μ A	4.0 mA/A + 0.21 μ A
2 to 20 mA	0.25 mA/A + 2.0 μ A	0.25 mA/A + 2.0 μ A	0.68 mA/A + 2.1 μ A	4.0 mA/A + 2.1 μ A
20 to 200 mA	0.25 mA/A + 20 μ A	0.25 mA/A + 20 μ A	0.67 mA/A + 20 μ A	
0.200 to 2 A	0.60 mA/A + 0.20 mA	0.70 mA/A + 0.20 mA	3.1 mA/A + 0.20 mA	
2 to 20 A	0.80 mA/A + 2.0 mA	2.5 mA/A + 2.0 mA		

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Current – Measure											
Fluke 5790B/05 With Fluke A40B Shunts											
Expanded uncertainties are in μ A/A for the level shown at left at indicated frequencies below											
Range	10 to 20Hz	20 to 40Hz	40 to 55Hz	55 to 400Hz	0.4 to 1kHz	1 to 10kHz	10 to 20kHz	20 to 30kHz	30 to 50kHz	50 to 70kHz	70 to 100kHz
0 to 1 mA	61	42	39	39	39	39	39	40	49	60	64
1 to 10 mA	56	35	32	32	32	32	33	33	37	51	55
10 to 20 mA	56	35	32	32	32	33	33	33	37	51	53
20 to 50 mA	57	36	33	33	33	33	37	37	37	51	55
50 to 100 mA	56	35	32	32	32	32	33	33	33	49	51
100 to 200 mA	56	35	32	32	32	32	33	33	33	49	50
200 to 500 mA	57	36	33	34	33	33	34	34	36	50	53
0.5 to 1 A	57	36	33	33	33	32	35	35	35	50	53
1 to 2 A	56	35	32	33	33	36	39	40	45	57	67
2 to 5 A	59	40	37	37	37	36	42	42	53	64	80
5 to 10 A	61	43	40	40	40	39	61	62	71	79	99
10 to 20 A	66	49	47	48	48	56	74	74	95	100	130
20 to 50 A	72	57	56	56	55	63	82	82	100	110	160
50 to 100 A	78	65	63	63	62	80	90	90	140	150	180

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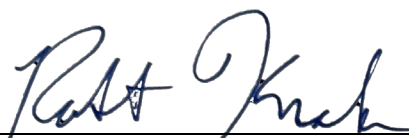
CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
AC Resistance – Generate	0.1 Ω	> 0.1 Hz to 1 MHz	0.18 %	Agilent 16074A
		> 1 MHz to 13 MHz	0.27 %	
	1 Ω	> 0.1 Hz to 1 MHz	0.12 %	
		> 1 MHz to 13 MHz	0.12 %	
	10 Ω	> 0.1 Hz to 1 MHz	0.036 %	
		> 1 MHz to 13 MHz	0.036 %	
	100 Ω	> 0.1 Hz to 1 MHz	0.035 %	
> 1 MHz to 13 MHz		0.036 %		
1 k Ω	> 0.1 Hz to 1 MHz	0.035 %		
	> 1 MHz to 13 MHz	0.035 %		
10 k Ω	> 0.1 Hz to 1 MHz	0.040 %		
	> 1 MHz to 13 MHz	0.14 %		
100 k Ω	> 0.1 Hz to 1 MHz	0.099 %		
	> 1 MHz to 13 MHz	0.62 %		
AC Resistance – Measure	0 Ω to 15 Ω	50 Hz to 1 MHz	0.14 %	Agilent 4284A
	15 Ω to 320 k Ω	100 Hz to 100 kHz	0.08 %	
	> 320 k Ω to 10 M Ω	100 Hz to 100 kHz	0.26 %	

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
DC RESISTANCE and CURRENT (20/E05)			
Direct Current – Generate ^{Note 4}	0 pA to 2 pA > 2 pA to 20 pA > 20 pA to 200 pA > 0.2 nA to 2 nA	4.9 fA/pA + 12 fA 4.1 fA/pA + 17 fA 2.9 fA/pA + 42 fA 0.76 pA/nA + 0.12 pA	Keithley 263

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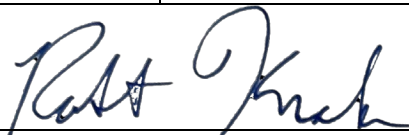
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Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks	
	> 2 nA to 20 nA	0.76 pA/nA + 1.2 pA		
	> 20 nA to 200 nA	0.41 pA/nA + 12 pA		
	> 0.2 μ A to 2 μ A	0.29 nA/ μ A + 0.12 nA		
	> 2 μ A to 20 μ A	0.27 nA/ μ A + 1.7 nA		
	> 20 μ A to 200 μ A	0.29 nA/ μ A + 12 nA		
	> 0 μ A to 20 μ A	6 μ A/A + 1.2 nA		Characterized Fluke 5730A and Fluke 5725A
	> 20 μ A to 220 μ A	7 μ A/A + 1.1 nA		
	> 220 μ A to 2.2 mA	9.6 μ A/A + 0.97 nA		
	> 2.2 mA to 22 mA	9.8 μ A/A + 4.9 nA		
	> 22 mA to 220 mA	13 μ A/A		
> 220 mA to 2.2 A	19 μ A/A - 220 nA			
> 2.2 A to 7.5 A	56 μ A/A - 73 μ A			
> 7.5 A to 11 A	37 μ A/A + 100 μ A			
> 11 A to 20 A	0.77 mA/A + 0.77 mA			
> 20 A to 100 A	0.43 mA/A			
Current Clamp – Non-Toroidal ^{Note 4}	20 A to 1000 A	5.8 mA/A + 0.58 A	Fluke 5522A w/ 5500A/COIL	
	1000 A to 2500 A	4.9 mA/A	Fluke 5730A with Fluke 52120A, Fluke 52120A/Coil3kA	
Direct Current – Measure ^{Note 4}	0 pA to 2 pA	16 μ A/A + 13 fA	Keithley 617	
	> 2 pA to 20 pA	14 μ A/A + 110 fA		
	> 20 pA to 200 pA	18 μ A/A + 110 fA		
	> 200 pA to 2 nA	2.6 μ A/A + 1.3 pA		
	> 2 nA to 20 nA	2.8 μ A/A + 5.3 pA		
	> 20 nA to 200 nA	8.7 μ A/A + 0.32 pA		Fluke 8508A With Standard Resistors
	> 200 nA to 2 μ A	4.1 μ A/A + 0.29 pA		
	2 μ A to 20 μ A	1.7 μ A/A + 82 pA		
	20 μ A to 200 μ A	3.1 μ A/A + 39 pA		
	200 μ A to 2 mA	3.6 μ A/A + 0.23 nA		

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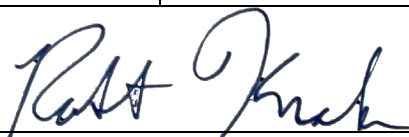
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Resistance – Variable Generate ^{Note 4}	2 mA to 20 mA	3.2 $\mu\text{A}/\text{A} + 2.5 \text{ nA}$	Fluke 5522A
	20 mA to 100 mA	3.6 $\mu\text{A}/\text{A} + 22 \text{ nA}$	
	100 mA to 200 mA	5.0 $\mu\text{A}/\text{A} + 65 \text{ nA}$	
	0.2 A to 7.5 A	11 $\mu\text{A}/\text{A} + 0.45 \mu\text{A}$	
	7.5 A to 50 A	22 $\mu\text{A}/\text{A}$	
	50 A to 200 A	13 $\mu\text{A}/\text{A} + 38 \mu\text{A}$	
	0 Ω to 11 Ω	47 $\mu\Omega/\Omega + 1.2 \text{ m}\Omega$	
> 11 Ω to 33 Ω	40 $\mu\Omega/\Omega + 1.7 \text{ m}\Omega$		
> 33 Ω to 110 Ω	34 $\mu\Omega/\Omega + 1.8 \text{ m}\Omega$		
> 110 Ω to 330 Ω	34 $\mu\Omega/\Omega + 2.4 \text{ m}\Omega$		
> 330 Ω to 1.1 k Ω	34 $\mu\Omega/\Omega + 2.4 \text{ m}\Omega$		
> 1.1 k Ω to 3.3 k Ω	34 $\mu\Omega/\Omega + 22 \text{ m}\Omega$		
> 3.3 k Ω to 11 k Ω	34 $\mu\Omega/\Omega + 23 \text{ m}\Omega$		
> 11 k Ω to 33 k Ω	34 $\mu\Omega/\Omega + 0.22 \Omega$		
> 33 k Ω to 110 k Ω	34 $\mu\Omega/\Omega + 0.24 \Omega$		
> 110 k Ω to 330 k Ω	44 $\mu\Omega/\Omega + 1.6 \Omega$		
> 330 k Ω to 1.1 M Ω	40 $\mu\Omega/\Omega + 3.0 \Omega$		
> 1.1 M Ω to 3.3 M Ω	0.12 m Ω/Ω		
> 3.3 M Ω to 11 M Ω	0.16 m $\Omega/\Omega + 86 \Omega$		
Resistance – Variable Generate ^{Note 4}	> 11 M Ω to 33 M Ω	0.70 m $\Omega/\Omega + 2.5 \text{ k}\Omega$	Fluke 5730A Characterized
	> 33 M Ω to 110 M Ω	0.76 m $\Omega/\Omega + 3.5 \text{ k}\Omega$	
	> 110 M Ω to 330 M Ω	0.65 m Ω/Ω	
	> 330 M Ω to 1100 M Ω	15 m $\Omega/\Omega + 730 \text{ k}\Omega$	
Resistance – Fixed Generate Instrument-Based ^{Note 4}	1 Ω	22 $\mu\Omega/\Omega$	Fluke 5730A Characterized
	1.9 Ω	17 $\mu\Omega/\Omega$	
	10 Ω	4.5 $\mu\Omega/\Omega$	
	19 Ω	3.9 $\mu\Omega/\Omega$	
	100 Ω	1.8 $\mu\Omega/\Omega$	
	190 Ω	1.7 $\mu\Omega/\Omega$	
	1 k Ω	2.4 $\mu\Omega/\Omega$	
	1.9 k Ω	2.4 $\mu\Omega/\Omega$	
	10 k Ω	1.8 $\mu\Omega/\Omega$	

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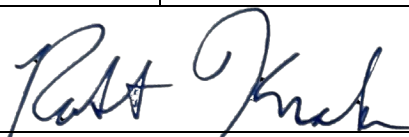
CALIBRATION LABORATORIES

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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
	19 k Ω	1.7 $\mu\Omega/\Omega$	Keithley 263
	100 k Ω	4.5 $\mu\Omega/\Omega$	
	190 k Ω	4.5 $\mu\Omega/\Omega$	
	1 M Ω	3.8 $\mu\Omega/\Omega$	
	1.9 M Ω	3.7 $\mu\Omega/\Omega$	
	10 M Ω	12 $\mu\Omega/\Omega$	
	19 M Ω	16 $\mu\Omega/\Omega$	
	100 M Ω	1.8 $\mu\Omega/\Omega$	
	10 G Ω	1.7 m Ω/Ω	
	100 G Ω	4.5 m Ω/Ω	
Fixed Resistor-Based	0.001 Ω	0.01 %	Ohms-Lab CS-200 Guildline 9230-100 Guildline 9230-15 Fluke 742A-1 Fluke 742A-1.9 Guildline 9334-10 Guildline 9334-100 Fluke 742A-1k Fluke 742A-10k Fluke 742A-100k Fluke 742A-1M Guildline 9334-10M Guildline 9330-100M Guildline 9334-1G Ohm-Labs 110 IET VRS-100-10-1K-BP
	0.01 Ω	23 $\mu\Omega/\Omega$	
	0.1 Ω	12 $\mu\Omega/\Omega$	
	1 Ω	3.6 $\mu\Omega/\Omega$	
	1.9 Ω	1.1 $\mu\Omega/\Omega$	
	10 Ω	2.8 $\mu\Omega/\Omega$	
	100 Ω	2.6 $\mu\Omega/\Omega$	
	1 k Ω	1.9 $\mu\Omega/\Omega$	
	10 k Ω	1.1 $\mu\Omega/\Omega$	
	100 k Ω	4.0 $\mu\Omega/\Omega$	
	1 M Ω	2.9 $\mu\Omega/\Omega$	
	10 M Ω	11 $\mu\Omega/\Omega$	
	100 M Ω	13 $\mu\Omega/\Omega$	
	1 G Ω	20 $\mu\Omega/\Omega$	
	10 G Ω	100 $\mu\Omega/\Omega$	
	100 G Ω	0.99 m Ω/Ω	
1 T Ω	5.0 m Ω/Ω		
Resistance – Measure ^{Note 4}	0 Ω to 2 Ω	4.9 $\mu\Omega/\Omega$ + 3.1 $\mu\Omega$	Fluke 8508 transfer accuracy
	> 2 Ω to 20 Ω	2.4 $\mu\Omega/\Omega$ + 8.3 $\mu\Omega$	
	> 20 Ω to 200 Ω	1.1 $\mu\Omega/\Omega$ + 13 $\mu\Omega$	
	> 200 Ω to 2 k Ω	2.0 $\mu\Omega/\Omega$ + 83 $\mu\Omega$	
	> 2 k Ω to 20 k Ω	1.1 $\mu\Omega/\Omega$ + 1.3 m Ω	
	> 20 k Ω to 200 k Ω	4.3 $\mu\Omega/\Omega$ + 4.2 m Ω	
> 200 k Ω to 2 M Ω	3.0 $\mu\Omega/\Omega$ + 0.46 Ω		

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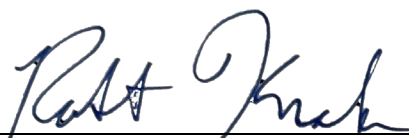
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
(No field capability above 20 GΩ)	> 2 MΩ to 20 MΩ	9.8 μΩ/Ω + 1.9 Ω	Guildline 6530B
	> 20 MΩ to 200 MΩ	9.5 μΩ/Ω + 28 Ω	
	> 0.2 GΩ to 2 GΩ	70 μΩ/Ω + 68 kΩ	
	> 2 GΩ to 20 GΩ	0.74 mΩ/Ω + 6.8 MΩ	
	> 20 GΩ to 200 GΩ	0.93 mΩ/Ω	
	> 200 GΩ to 2 TΩ	1.4 mΩ/Ω	
	> 2 TΩ to 20 TΩ	4.0 mΩ/Ω	
> 20 TΩ to 200 TΩ	6.9 mΩ/Ω		
DC VOLTAGE (20/E06)			
DC Voltage – Variable Generate ^{Note 4}	0 V to 220 mV	0.58 μV/V + 330 nV	Characterized Fluke 5730A
	> 0.22 V to 2.2 V	0.43 μV/V + 1.3 μV	
	> 2.2 V to 11 V	0.29 μV/V + 3.7 μV	
	> 11 V to 22 V	0.57 μV/V + 3.2 μV	
	> 22 V to 220 V	0.54 μV/V + 89 μV	
	> 220 V to 1.1 kV	0.24 μV/V + 760 μV	
DC Voltage – Fixed Generate	1 kV to 50 kV	0.49 mV/V + 0.21 V	Hipotronics Source and Vitrek
	> 50 kV to 70 kV	0.47 mV/V + 1.4 V	
DC Voltage – Fixed Measure ^{Note 4}	10 V	0.43 μV/V	Fluke 732A
	100 mV	2.8 μV/V	
	1 V	1.1 μV/V	
	10 V	0.62 μV/V	
	100 V	0.88 μV/V	
	1000 V	0.92 μV/V	
DC Voltage – Fixed Measure ^{Note 4}	100 mV	1.2 μV/V	Agilent 34420A, Fluke 732A, 752A
	1 V	0.52 μV/V	
	10 V	0.44 μV/V	
	100 V	0.53 μV/V	
	1000 V	0.74 μV/V	

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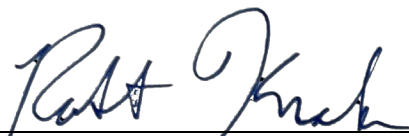
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
DC Voltage – Variable Measure ^{Note 4}	0 V to 200 mV > 200 mV to 2 V > 2 V to 20 V > 20 V to 200 V > 200 V to 1000 V	1.3 $\mu\text{V}/\text{V}$ + 23 nV 0.56 $\mu\text{V}/\text{V}$ + 0.15 μV 0.80 $\mu\text{V}/\text{V}$ + 1.3 μV 0.49 $\mu\text{V}/\text{V}$ + 1.9 μV 0.71 $\mu\text{V}/\text{V}$ + 13 μV	Fluke 8508A w/732A,752A

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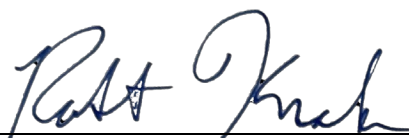
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC VOLTAGE (20/E09)															
AC Voltage – Source/Measure															
Fluke 792A, Fluke 732A, Fluke 752A, Fluke 8508, Fluke 5730A/05, Fluke 5725A															
Expanded uncertainties are in $\mu\text{V/V}$ for the level shown at left at indicated frequencies below															
Range	Level	10 Hz	20 Hz	40 Hz	100 Hz	1k Hz	10 kHz	20 kHz	30 kHz	50 kHz	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
22 mV	2 mV	460	460	460	460	460	460	460		460	530	610	700	800	810
22 mV	6 mV	240	240	210	200	200	200	200		240	300	420	480	590	630
22 mV	10 mV	110	100	99	99	100	99	99		110	160	220	290	350	400
22 mV	20 mV	88	71	70	71	70	70	69		90	150	220	310	400	420
220 mV	20 mV	94	84	85	71	70	71	70		89	150	210	280	320	370
220 mV	50 mV	65	39	35	34	33	36	34		38	76	140	210	280	290
220 mV	100 mV	45	28	17	16	14	14	14		25	42	80	120	190	190
220 mV	200 mV	31	22	14	15	11	13	14		22	41	76	110	160	190
700 mV	200 mV	30	21	13	14	12	12	12		21	41	76	110	160	190
700 mV	600 mV	28	20	11	11	11	12	11		12	16	26	31	53	71
2.2 V	600 mV	26	16	6.9	6.9	6.8	6.9	7.7		8.3	11	22	26	32	42
2.2 V	1 V	25	15	7.2	5.6	5.7	5.7	5.9		7.7	11	21	25	31	41
2.2 V	2 V	26	15	7.7	5.8	5.5	5.5	5.6		5.5	10	20	25	31	42
7 V	2 V	25	16	8.4	5.5	5.6	5.8	5.9		6.7	11	21	26	30	41
7 V	6 V	25	15	5.8	5.7	5.5	5.5	5.4		6.3	7.4	20	25	31	41
22 V	6 V	29	17	5.9	5.4	5.3	5.8	5.4		6.3	7.5	20	25	30	40
22 V	10 V	29	17	5.8	5.5	5.3	5.6	5.7		6.2	8.3	20	25	30	40
22 V	20 V	29	17	6.7	6.2	6.2	6.5	6.3		7.2	10	20	25	31	42
70 V	20 V	26	16	6.5	7.2	6.5	6.7	6.5		7.5	10	25			
70 V	60 V	26	16	6.9	6.9	6.8	6.8	6.9		8.6	11	25			
220 V	60 V	25	16	7.3	7.2	7.1	7.3	7.3		9.4	11	30			
220 V	100 V	31	16	7.4	7.8	6.7	6.6	6.6		9.4	16				
220 V	200 V	40	16	9.1	9.6	8.6	8.5	8.4		11	16				
1000 V	200 V	40	16	9.4	9.1	8.4	8.9	8.9		12	31				
1000 V	600 V			12	12	11	12	12		17	42				
1000 V	1000 V			12	12	11	12	12	13						

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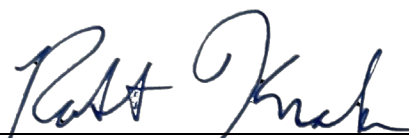
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Measure								
Fluke 5790B/05								
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 20 kHz	20 to 50 kHz	50 to 100 kHz	100 to 300 kHz	300 to 500 kHz	0.500 to 1 MHz
0.6 to 2.2 mV	130 μ V/V + 0.99 μ V	95 μ V/V + 0.99 μ V	91 μ V/V + 0.99 μ V	82 μ V/V + 1.5 μ V	92 μ V/V + 1.9 μ V	200 μ V/V + 3.1 μ V	600 μ V/V + 6.2 μ V	2200 μ V/V + 6.1 μ V
2.2 to 7 mV	84 μ V/V + 0.99 μ V	50 μ V/V + 0.98 μ V	49 μ V/V + 0.98 μ V	48 μ V/V + 1.5 μ V	58 μ V/V + 1.9 μ V	150 μ V/V + 3 μ V	380 μ V/V + 6.2 μ V	1600 μ V/V + 6.1 μ V
7 to 22 mV	87 μ V/V + 0.88 μ V	49 μ V/V + 0.94 μ V	40 μ V/V + 0.96 μ V	48 μ V/V + 1.5 μ V	74 μ V/V + 1.8 μ V	170 μ V/V + 2.8 μ V	370 μ V/V + 5.9 μ V	1200 μ V/V + 6.1 μ V
22 to 70 mV	64 μ V/V + 0.98 μ V	39 μ V/V + 1 μ V	35 μ V/V + 1 μ V	43 μ V/V + 1.4 μ V	80 μ V/V + 1.6 μ V	160 μ V/V + 2.5 μ V	300 μ V/V + 5.6 μ V	800 μ V/V + 6.1 μ V
70 to 220 mV	68 μ V/V + 0.14 μ V	26 μ V/V + 1.1 μ V	23 μ V/V + 1.1 μ V	28 μ V/V + 1.3 μ V	57 μ V/V + 1.6 μ V	120 μ V/V + 2.7 μ V	250 μ V/V + 5.8 μ V	760 μ V/V + 6 μ V
220 to 700 mV	57 μ V/V	25 μ V/V + 1.1 μ V	22 μ V/V + 1.1 μ V	22 μ V/V + 1.4 μ V	44 μ V/V + 1.8 μ V	97 μ V/V + 3 μ V	210 μ V/V + 6.2 μ V	740 μ V/V + 6.2 μ V
0.7 to 2.2 V	67 μ V/V - 10 μ V	23 μ V/V	18 μ V/V	19 μ V/V	40 μ V/V	88 μ V/V	180 μ V/V	690 μ V/V
2.2 to 7 V	56 μ V/V - 11 μ V	23 μ V/V	18 μ V/V	21 μ V/V	50 μ V/V	120 μ V/V	300 μ V/V	930 μ V/V
7 to 22 V	70 μ V/V - 120 μ V	25 μ V/V	18 μ V/V	21 μ V/V	51 μ V/V	120 μ V/V	300 μ V/V	930 μ V/V
22 to 70 V	55 μ V/V - 73 μ V	25 μ V/V	21 μ V/V	23 μ V/V	54 μ V/V	120 μ V/V	300 μ V/V	930 μ V/V
70 to 220 V	68 μ V/V - 1000 μ V	27 μ V/V	21 μ V/V	29 μ V/V	56 μ V/V	130 μ V/V	370 μ V/V	
220 to 700 V	50 μ V/V + 200 μ V	29 μ V/V	23 μ V/V	87 μ V/V	390 μ V/V			
700 to 1100 V	50 μ V/V	29 μ V/V	24 μ V/V	87 μ V/V	390 μ V/V			

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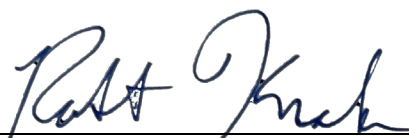
CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Source								
Fluke 5730A/05 and Fluke 5725A Characterized with Fluke 5790B/05								
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 20 kHz	20 to 50 kHz	50 to 100 kHz	100 to 300 kHz	300 to 500 kHz	0.500 to 1 MHz
0 to 2.2 mV	26 μ V/V + 5.9 μ V	18 μ V/V + 5.9 μ V	40 μ V/V + 2.5 μ V	46 μ V/V + 2.8 μ V	47 μ V/V + 4 μ V	140 μ V/V + 4.6 μ V	470 μ V/V + 8.5 μ V	1800 μ V/V + 8.3 μ V
2.2 to 22 mV	27 μ V/V + 5.9 μ V	11 μ V/V + 5.9 μ V	17 μ V/V + 2.6 μ V	29 μ V/V + 2.8 μ V	40 μ V/V + 4 μ V	96 μ V/V + 6.6 μ V	220 μ V/V + 13 μ V	800 μ V/V + 19 μ V
22 to 220 mV	180 μ V/V + 23 μ V	95 μ V/V + 17 μ V	25 μ V/V + 2.6 μ V	26 μ V/V + 3 μ V	54 μ V/V + 3.1 μ V	110 μ V/V + 5.8 μ V	260 μ V/V + 14 μ V	730 μ V/V + 26 μ V
0.22 to 2.2 V	190 μ V/V + 22 μ V	95 μ V/V + 17 μ V	22 μ V/V + 5 μ V	25 μ V/V + 6.6 μ V	41 μ V/V + 7.7 μ V	90 μ V/V + 15 μ V	190 μ V/V + 31 μ V	700 μ V/V + 44 μ V
2.2 to 22 V	190 μ V/V + 19 μ V	96 μ V/V + 16 μ V	23 μ V/V + 6.2 μ V	27 μ V/V + 5.2 μ V	55 μ V/V - 17 μ V	130 μ V/V - 60 μ V	320 μ V/V - 190 μ V	970 μ V/V - 490 μ V
22 to 220 V	190 μ V/V + 230 μ V	96 μ V/V + 160 μ V	26 μ V/V	35 μ V/V - 64 μ V	59 μ V/V - 63 μ V	140 μ V/V	370 μ V/V + 7700 μ V	840 μ V/V + 17 mV

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Source						
Fluke 5730A Characterized with Fluke 5790B Continued						
Range	15 to 40 Hz	0.040 to 1 kHz	1 to 20 kHz	20 to 30 kHz	30 to 50 kHz	50 to 100 kHz
220 to 750 V					120 μ V/V - 11 mV	540 μ V/V - 74 mV
220 to 1100 V	180 μ V/V	27 μ V/V - 310 μ V	30 μ V/V + 1200 μ V	100 μ V/V - 12 mV		

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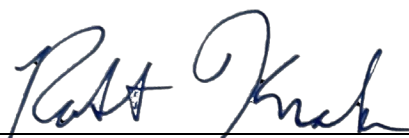
CALIBRATION LABORATORIES

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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
AC Voltage – Measure ^{Note 4}	1 mV to 10 mV	1 MHz to 4 MHz > 4 MHz to 8 MHz	54 mV/V + 11 µV 160 mV/V + 8.2 µV	HP 3458A
	> 10 mV to 100 mV	1 MHz to 2 MHz > 2 MHz to 4 MHz > 4 MHz to 8 MHz > 8 MHz to 10 MHz	12 mV/V + 19 µV 30 mV/V + 130 µV 30 mV/V + 220 µV 120 mV/V + 160 µV	
	> 0.1 V to 1 V	1 MHz to 2 MHz > 2 MHz to 4 MHz > 4 MHz to 8 MHz > 8 MHz to 10 MHz	12 mV/V + 110 µV 30 mV/V + 1.3 mV 30 mV/V + 2.2 mV 120 mV/V + 1.6 mV	
	> 1 V to 10 V	1 MHz to 2 MHz > 2 MHz to 4 MHz > 4 MHz to 8 MHz > 8 MHz to 10 MHz	12 mV/V + 1.2 mV 31 mV/V + 6.2 mV 31 mV/V + 7.9 mV 120 mV/V + 8.5 mV	
	1.1 kV to 5 kV > 5 kV to 44 kV	50 Hz to 60 Hz 50 Hz to 60 Hz	2.5 mV/V + 1.5 V 1.4 mV/V + 27 V	Quadtech Sentry 20 w/Vitretek 4700 & HLV70
	1.1 kV to 5 kV > 5 kV to 50 kV	50 Hz to 60 Hz 50 Hz to 60 Hz	2.5 mV/V + 1.5 V 1.4 mV/V + 27 V	Vitretek 4700 w/HLV70

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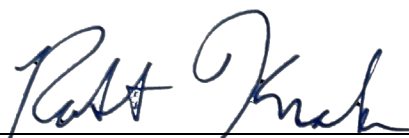
CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

AC Voltage – Wideband Generate							
Fluke 5730A/05							
Range	10 to 30 Hz	0.030 to 120 kHz	0.120 to 2 MHz	2 to 10 MHz	10 to 20 MHz	20 to 30 MHz	30 to 50 MHz
0.3 to 1.1 mV	0.24 %	0.085 %	0.39 %	0.55 %	0.71 %	2.3 %	3.6 %
1.1 to 3.3 mV	0.24 %	0.080 %	0.16 %	0.31 %	0.47 %	1.3 %	2.5 %
3.3 to 11 mV	0.23 %	0.079 %	0.10 %	0.18 %	0.35 %	0.82 %	1.7 %
11 to 33 mV	0.30 %	0.079 %	0.089 %	0.17 %	0.33 %	0.80 %	1.7 %
33 to 110 mV	0.23 %	0.083 %	0.083 %	0.16 %	0.33 %	0.80 %	1.7 %
110 to 330 mV	0.23 %	0.082 %	0.082 %	0.16 %	0.32 %	0.79 %	1.7 %
0.33 to 1.1 V	0.23 %	0.081 %	0.081 %	0.16 %	0.32 %	0.79 %	1.7 %
1.1 to 3.5 V	0.23 %	0.081 %	0.081 %	0.16 %	0.32 %	0.79 %	1.7 %

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

AC Voltage – Wideband Measure								
Fluke 5790B/05								
Range	10 to 30 Hz	0.030 to 120 kHz	120 to 500 kHz	0.5 to 2 MHz	2 to 10 MHz	10 to 20 MHz	20 to 30 MHz	30 to 50 MHz
0.1 to 2.2 mV	0.088 %	0.050 %	0.13 %	0.13 %	0.21 %	0.32 %	0.71 %	0.88 %
2.2 to 7 mV	0.082 %	0.051 %	0.079 %	0.080 %	0.11 %	0.17 %	0.42 %	0.46 %
7 to 22 mV	0.081 %	0.040 %	0.055 %	0.056 %	0.084 %	0.15 %	0.32 %	0.52 %
22 to 70 mV	0.10 %	0.040 %	0.040 %	0.042 %	0.084 %	0.12 %	0.31 %	0.51 %
70 to 220 mV	0.080 %	0.032 %	0.032 %	0.041 %	0.083 %	0.13 %	0.28 %	0.51 %
220 to 700 mV	0.079 %	0.025 %	0.025 %	0.041 %	0.083 %	0.13 %	0.30 %	0.51 %
0.7 to 2.2 V	0.080 %	0.025 %	0.025 %	0.041 %	0.10 %	0.13 %	0.30 %	0.50 %
2.2 to 7 V	0.080 %	0.024 %	0.024 %	0.041 %	0.083 %	0.13 %	0.30 %	0.50 %

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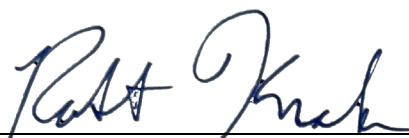
CALIBRATION LABORATORIES

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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Source								
Fluke 5730A/05 Characterized with EL1100 and JFW Attenuators								
Expanded uncertainties are in $\mu\text{V/V}$ for the frequencies shown at left at indicated levels below								
Frequency	3.2 V	1 V	320 mV	100 mV	32 mV	10 mV	3.2 mV	10 mV
10 Hz	480	510	620	620	620	740	810	810
20 Hz	160	240	290	340	380	420	480	560
50 Hz	160	170	180	190	210	210	270	340
100 Hz	170	170	190	200	210	230	270	350
200 Hz	160	170	180	190	200	230	250	390
2 kHz	160	170	180	190	200	210	230	390
10 kHz	160	170	180	190	200	220	240	380
20 kHz	160	170	180	190	210	210	230	360
50 kHz	160	170	180	190	200	210	230	340
100 kHz	160	180	190	200	220	230	240	400
200 kHz	160	170	180	190	200	210	260	280
500 kHz	220	240	250	270	280	300	320	380
700 kHz	230	250	270	290	300	320	340	440
1 MHz	230	260	270	290	300	320	340	500
1.2 MHz	230	260	280	300	320	340	370	510
2 MHz	370	400	440	460	490	520	560	630
3 MHz	400	430	470	500	530	560	590	670
4 MHz	450	500	520	560	590	620	650	720
6 MHz	510	560	580	620	640	680	700	770
8 MHz	530	570	590	630	650	690	710	770
9 MHz	530	570	590	630	650	690	720	800
10 MHz	530	570	590	630	650	690	720	800
12 MHz	770	830	880	930	980	1000	1100	1100
15 MHz	770	830	880	930	980	1000	1100	1200
17 MHz	900	960	1000	1000	1100	1100	1200	1200
20 MHz	950	1000	1100	1200	1200	1300	1300	1400
23 MHz	1500	1500	1600	1600	1700	1700	1800	1900
26 MHz	1800	1900	1900	2000	2100	2100	2200	2300
28 MHz	2000	2100	2200	2300	2400	2500	2500	2600
30 MHz	2200	2300	2400	2500	2600	2700	2700	2800
35 MHz	2500	2600	2700	2800	2800	2900	3000	3100
40 MHz	2700	2800	2900	3000	3100	3200	3300	3400
45 MHz	2900	3000	3200	3300	3400	3500	3600	3700
50 MHz	3100	3300	3400	3600	3700	3800	3900	4100

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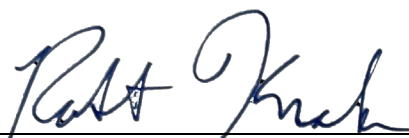
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks	
CAPACITANCE (20/E10)					
Capacitance – Measure	0.001 nF to 1.2 μ F	100 Hz to 10 kHz	8 μ F/F	ESI 701B with GenRad 1404-A	
	1.2 μ F to 800 μ F		1.3 nF/ μ F	HP 4284A	
	> 800 μ F to 100 mF		1.7 μ F/mF + 4.3 nF		
	> 100 mF to 1000 mF		3.1 μ F/mF + 57 μ F		
	0.01 fF to 10 pF	20 Hz to 12.5 kHz	3.8 fF/pF + 3.1 aF	HP 4284A	
		> 12.5 kHz to 48 kHz	3.0 fF/pF + 3.5 aF		
		> 48 kHz to 96 kHz	3.4 fF/pF + 3.3 aF		
		> 96 kHz to 1 MHz	3.1 fF/pF + 3.5 aF		
		> 10 pF to 100 pF	20 Hz to 500 Hz	3.5 fF/pF + 38 fF	
			> 500 Hz to 1 kHz	3.4 fF/pF + 38 fF	
		> 1 kHz to 12.5 kHz	1.7 fF/pF + 19 fF		
		> 12.5 kHz to 48 kHz	2.0 fF/pF + 22 fF		
		> 48 kHz to 96 kHz	1.6 fF/pF + 18 fF		
		> 96 kHz to 1 MHz	1.5 fF/pF + 16 fF		
	> 100 pF to 1000 pF	20 Hz to 50 Hz	33 fF/pF + 3.7 pF		
		> 50 Hz to 500 Hz	3.3 fF/pF + 0.37 pF		
		> 500 Hz to 1 kHz	1.5 fF/pF + 0.17 pF		
		> 1 kHz to 12.5 kHz	1.6 fF/pF + 0.18 pF		
		> 12.5 kHz to 48 kHz	1.6 fF/pF + 0.18 pF		
		> 48 kHz to 96 kHz	1.7 fF/pF + 0.19 pF		
		> 96 kHz to 1 MHz	1.9 fF/pF + 0.21 pF		

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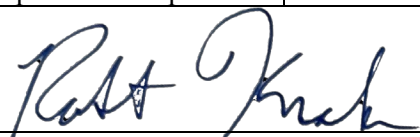
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
Capacitance – Generate Variable ^{Note 4}	1 fF to 110 pF	50 Hz to 0.5 kHz	3.9 aF/pF + 2.0 aF	Andeen-Hagerling AH2700A OPT. E
		> 0.5 kHz to 1.5 kHz	3.7 aF/pF + 1.3 aF	
		> 1.5 kHz to 10 kHz	4.8 aF/pF + 7.1 aF	
		> 10 kHz to 20 kHz	14 aF/pF + 0.21 fF	
	> 110 pF to 1 nF	50 Hz to 0.5 kHz	3.9 aF/pF + 4.2 aF	
		> 0.5 kHz to 1.5 kHz	3.9 aF/pF – 4.0 aF	
		> 1.5 kHz to 10 kHz	8.2 aF/pF – 0.33 fF	
		> 10 kHz to 20 kHz	7.8 aF/pF + 0.13 fF	
	> 1 nF to 10 nF	50 Hz to 0.5 kHz	3.7 fF/nF + 1.5 fF	
		> 0.5 kHz to 1.5 kHz	4.8 fF/nF + 0.16 fF	
		> 1.5 kHz to 10 kHz	5.7 fF/nF – 51 aF	
		> 10 kHz to 20 kHz	70 fF/nF – 0.71 fF	
	> 10 nF to 100 nF	50 Hz to 0.5 kHz	7.8 fF/nF – 0.64 fF	
		> 0.5 kHz to 1.5 kHz	9.6 fF/nF – 7.4 fF	
		> 1.5 kHz to 10 kHz	9.9 fF/nF – 7.5 fF	
		> 10 kHz to 20 kHz	0.22 pF/nF – 0.32 pF	
	> 100 nF to 1.2 μF	50 Hz to 0.5 kHz	13 fF/nF – 0.56 pF	
		> 0.5 kHz to 1.5 kHz	15 fF/nF – 0.38 pF	
		> 1.5 kHz to 10 kHz	23 fF/nF – 0.79 pF	
		> 10 kHz to 20 kHz	0.74 pF/nF – 34 pF	
0.19 nF to 0.39 nF 0.4 nF to 1.1 nF > 1.1 nF to 3.3 nF > 3.3 nF to 11 nF > 11 nF to 33 nF	10 Hz to 10 kHz	5.8 pF/nF + 12 pF	Fluke 5522A	
	10 Hz to 10 kHz	5.8 pF/nF + 12 pF		
	10 Hz to 3 kHz	5.8 pF/nF + 12 pF		
	10 Hz to 1 kHz	2.9 pF/nF + 12 pF		
	10 Hz to 1 kHz	2.9 pF/nF + 120 pF		

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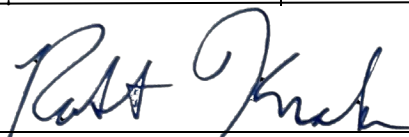
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks	
Capacitance – Generate, Fixed ^{Note 4}	> 33 nF to 110 nF	10 Hz to 1 kHz	2.9 pF/nF + 120 pF		
	> 110 nF to 330 nF	10 Hz to 1 kHz	2.9 pF/nF + 350 pF		
	> 0.33 μF to 1.1 μF	10 Hz to 600 Hz	2.9 nF/μF + 1.2 nF		
	> 1.1 μF to 3.3 μF	10 Hz to 300 Hz	2.9 nF/μF + 3.5 nF		
	> 3.3 μF to 11 μF	10 Hz to 150 Hz	2.9 nF/μF + 11 nF		
	> 11 μF to 33 μF	10 Hz to 120 Hz	4.7 nF/μF + 35 nF		
	> 33 μF to 110 μF	10 Hz to 80 Hz	5.2 nF/μF + 110 nF		
	> 110 μF to 330 μF	DC to 50 Hz	5.2 nF/μF + 350 nF		
	> 0.33 mF to 1.1 mF	DC to 20 Hz	5.2 μF/mF + 1.2 μF		
	> 1.1 mF to 3.3 mF	DC to 6 Hz	5.2 μF/mF + 3.5 μF		
	> 3.3 mF to 11 mF	DC to 2 Hz	5.2 μF/mF + 12 μF		
	> 11 mF to 33 mF	DC to 0.6 Hz	8.7 μF/mF + 35 μF		
	> 33 mF to 110 mF	DC to 0.2 Hz	13 μF/mF + 120 μF		
	1 pF	1 kHz	1.2 μF/F		Andeen-Hagerling AH1100
	10 pF		0.35 μF/F		
	100 pF		0.35 μF/F		
	1000 pF	1 kHz	24 fF		GenRad 1404-A
0.001 μF	1 kHz	0.60 pF	GenRad 1409		
0.01 μF		6.0 pF			
0.1 μF		410 pF			
1 μF		600 pF			
10 μF	100 Hz	4.6 nF			
10 μF	1 kHz	3.1 nF			
100 μF	100 Hz	76 nF			
100 μF	1 kHz	70 nF			
10 μF	100 Hz, 120 Hz, or 1 kHz	0.034 μF	GenRad 1417		
100 μF		0.34 μF			
1 mF		3.6 μF			
10 mF		52 μF			

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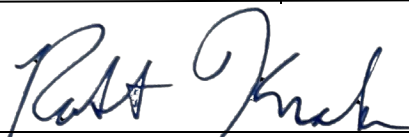
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks
	100 mF 1 F	100 Hz, 120 Hz	0.41 mF 5.8 mF	
	10 nF	120 Hz to 100 kHz	3.5 pF	HP 16385A
	100 nF		35 pF	HP 16386A
	1 μF		0.36 nF	HP 16387A
	1 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.083 fF 0.11 fF 0.24 fF 0.42 fF 0.63 fF 0.88 fF 2.5 fF 3.7 fF	HP 16381A
	10 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.70 fF 0.70 fF 0.70 fF 0.72 fF 0.75 fF 0.79 fF 1.3 fF 1.7 fF	HP 16382A
	100 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	7.0 fF 7.1 fF 7.6 fF 8.9 fF 11 fF 14 fF 34 fF 49 fF	HP 16383A

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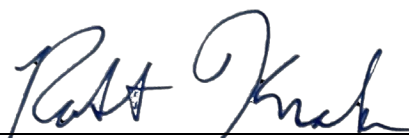
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks
	1000 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	71 fF 86 fF 0.16 pF 0.29 pF 0.44 pF 0.62 pF 1.9 pF 2.8 pF	HP 16384A
INDUCTANCE (20/E11)				
Inductance – Measure	10 nH to 10 H 10 µH to 10 H 0.1 mH to 0.5 mH > 0.5 mH to 2 mH > 2 mH to 10 mH > 10 mH to 50 mH > 50 mH to 200 mH > 200 mH to 1 H > 1 H to 5 H 5 H to 10 H	12 Hz to 100 kHz 100 Hz or 1 kHz 100 Hz to 1 kHz	2.2 mH/H + 4.8 nH 1.5 mH/H + 0.12 µH 49 µH/H + 0.49 µH 0.14 mH/H + 0.44 µH 0.24 mH/H + 0.24 µH 0.26 mH/H + 69 nH 0.26 mH/H + 1.8 nH 0.27 mH/H - 1.2 µH 0.37 mH/H - 0.11 mH 0.59 mH/H - 0.62 mH	GenRad 1693 HP 4284A ESI LCR Bridge w/ DT72A Transformer
Inductance – Generate ^{Note 4}	50 µH 100 µH 1 mH 10 mH 100 mH 1 H 10 H	100 Hz or 1 kHz	0.17 µH 0.12 µH 0.46 µH 1.7 µH 26 µH 0.99 mH 19 mH	GenRad 1482 Set

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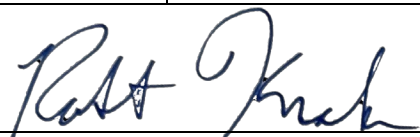
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks	
LF POWER & ENERGY (20/E12)				
DC Power – Generate ^{Note 4}				
0.33 mA to 330 mA	11 μ W to 1.1 mW	0.024 %	Fluke 5522A	
	> 1.1 mW to 110 mW	0.027 %		
	> 0.11W to 110 W	0.024 %		
	> 110 W to 330 W	0.018 %		
> 0.33 A to 3 A	11 W to 110 mW	0.044 %		
	> 0.11 W to 990 W	0.053 %		
	> 0.99 kW to 3 kW	0.0096 %		
> 3 A to 20.5 A	0.099 W to 0.99 W	0.088 %		
	> 0.99 W to 6.8 kW	0.070 %		
	> 6.8 kW to 20.5 kW	0.040 %		
AC Power – Generate ^{Notes 4,7} (PF = 1, $\Phi = 0^\circ$ at 10 Hz to 65 Hz)				
3.3 mA to 9 mA	0.11 mW to 3.0 mW	0.13%		Fluke 5522A
	> 3.0 mW to 9 W	0.077 %		
> 9 mA to 33 mA	0.3 mW to 10 mW	0.089 %		
	> 10 mW to 33 W	0.077 %		
> 33 mA to 90 mA	1 mW to 30 mW	0.071 %		
	> 30 mW to 90 W	0.057 %		
> 90 mA to 330 mA	3.0 mW to 100 mW	0.089 %		
	> 100 mW to 300 W	0.078 %		
> 0.33 A to 0.9 A	11 mW to 300 mW	0.071 %		
	> 300 mW to 900 W	0.058 %		
> 0.9 A to 2.2 A	30 mW to 720 mW	0.089 %		
	> 720 mW to 2 kW	0.079 %		

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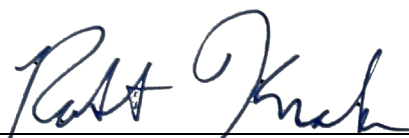
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
> 2.2 A to 4.5 A	80 mW to 1.4 W > 1.4 W to 4.5 kW	0.088 % 0.05 %	
> 4.5 A to 20.5 A	150 mW to 6.7 W > 6.7 W to 20 kW	0.17 % 0.17 %	
PHASE (20/E15)			
Phase – Measure (10 mV to 630 V)	5 Hz to 2 kHz > 2 kHz to 5 kHz > 5 kHz to 10 kHz > 10 kHz to 50 kHz > 50 kHz to 1 MHz	0.038° 0.053° 0.069° 0.085° 0.0012°/kHz + 0.015°	Clark Hess 6000A
Phase – Generate ^{Note 4}	10 Hz to 65 Hz > 65 Hz to 500 Hz > 500 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz > 10 kHz to 30 kHz	0.14° 0.30° 0.58° 2.9° 5.8° 12°	Fluke 5522A
OSCILLOSCOPES (20/E20)			
Leveled Sine Amplitude	50 kHz reference 0.1 Hz to 6.4 GHz	17 μ V/mV + 1.9 nV 17 μ V/mV + 1.9 nV	Fluke 9500B / 9560
Leveled Sine Flatness ^{Note 4} 50 kHz – 10 MHz Reference	0.1 Hz to 300 MHz > 300 MHz to 550 MHz > 550 MHz to 3 GHz > 3 GHz to 6 GHz	0.20 dB 0.25 dB 0.30 dB 0.40 dB	Fluke 9500B/9560
Time Marker, 50 Ω ^{Note 4}	180.19 ps to 9.009 ns 9.0091 ns to 55 s	0.29 as/ns + 1.1 as 0.29 ns/ms – 1.7 as	Fluke 9500B /9560
CONDUCTANCE (20/E21)			
Conductivity ^{Note 4}	10 μ S/cm 100 μ S/cm 1000 μ S/cm	0.65 μ S/cm 2.1 μ S/cm 4.6 μ S/cm	Conductivity solutions

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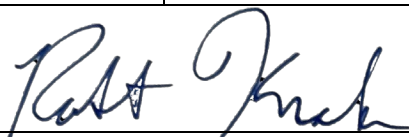
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
> 17.1 GHz to 26.5 GHz	5 % to 99 %	0.19 %	Keysight N5531X
> 26.5 GHz to 34.5 GHz	5 % to 99 %	0.24 %	
> 34.5 GHz to 50 GHz	5 % to 99 %	0.46 %	
Frequency Modulation – Generate and measure ^{Notes 4,8} 100 kHz to 3.6 GHz	0.2 < β ≤ 100 β > 100	0.004 <i>FM</i> 0.0092 <i>FM</i>	
> 3.6 GHz to 8.4 GHz	0.2 < β ≤ 100 β > 100	0.0081 <i>FM</i> 0.023 <i>FM</i>	
> 8.4 GHz to 17.1 GHz	0.2 < β ≤ 100 β > 100	0.0081 <i>FM</i> 0.029 <i>FM</i>	
> 17.1 GHz to 34.5 GHz	0.2 < β ≤ 100 β > 100	0.0092 <i>FM</i> 0.035 <i>FM</i>	
> 34.5 GHz to 50 GHz	0.2 < β ≤ 100 β > 100	0.016 <i>FM</i> 0.046 <i>FM</i>	
Phase Modulation – Measure & Generate ^{Note 4}	100 kHz to 3.6 GHz	0.014 rad	
	> 3.6 GHz to 13.6 GHz	0.015 rad	
	> 13.6 GHz to 17.1 GHz	0.018 rad	
	> 17.1 GHz to 26.5 GHz	0.021 rad	
	> 26.5 GHz to 34.5 GHz	0.025 rad	
	> 34.5 GHz to 50 GHz	0.027 rad	

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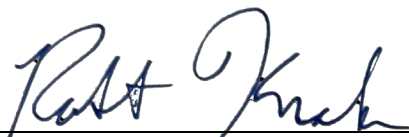
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
PULSE WAVEFORM (20/F04)			
Rise Time – Generate	14 ps 500 ps 150 ps 70 ps	4.0 ps 49 ps 20 ps 16 ps	Tek 067-1338-00 Fluke 9500B/9530 Fluke 9500B/9560
Rise Time – Measure	> 30 ps and <500 ps	24 ps	HP 54750A/54751A
STOPWATCHES & TIMERS (20/F05)			
Time – Measure ^{Note 4}	Up to 19.99 s/day	0.059 s/day	Helmut Klein Timometer 4500
MECHANICAL			
AIRSPEED (20/M03)			
Air Velocity – Measure	400 ft/min to 800 ft/min 800 ft/min to 9000 ft/min	21 ft/min - 1.6 % of reading 5.0 ft/min + 0.43 % of reading	Comparison of Pitot tube with UUT using wind tunnel
FLOW RATE (20/M05)			
Gas Flow	Up to 50 SCCM 50 SCCM to 500 SCCM 500 SCCM to 5 SLPM 5 SLPM to 50 SLPM 50 SLPM to 100 SLPM	0.26 % + 0.012 SCCM 0.26 % + 0.12 SCCM 0.26 % + 1.2 SCCM 0.26 % + 12 SCCM 0.52 % + 140 SCCM	Molbox1 & 5E1 Molbloc Molbox1 & 5E2 Molbloc Molbox1 & 5E3 Molbloc Molbox1 & 3E4 Molbloc Molbox1 & 1E5Molbloc Nitrogen under measurement at laboratory pressure & temperature. Standardized to 0 °C & 101.325 kPa.
FORCE (20/M06)			
Crimp Tool – Pull Force	Up to 100 lbf	7.8 % of rdg. + 2.6 lbf	Crimp pull tester

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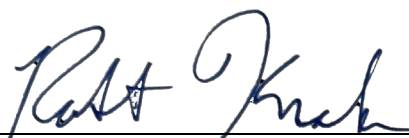
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Durometer – Spring Force	78 gf 113 gf 821 gf 4533 gf	1.1 gf 0.91 gf 5.4 gf 14 gf	Electronic balance
Supermicrometer Gaging Force	2 ozf 4 ozf 8 ozf 16 ozf 40 ozf	0.090 ozf 0.22 ozf 0.22 ozf 0.88 ozf 2.5 ozf	Gram gage Force gage
Force Gages	0.03125 ozf to 8 ozf 0.5 lbf to 500 lbf 3.2 lbf to 300 lbf > 300 lbf to 1000 lbf > 1000 lbf to 10 000 lbf	0.056 % + 0.000024 ozf 0.055 % + 0.000023 lbf 0.010 % + 0.0064 lbf 0.012 % + 0.0012 lbf 0.010 % + 0.16 lbf	Class 6 Weights Class 7 Weights Morehouse HADI 300LBF Morehouse M4215A- 1000LBF Morehouse M4215A-10000LBF
MASS DISSEMINATION (20/M08)			
Mass – Measure	1 mg to 2 g > 2 g to 10 g > 10 g to 31 g > 31 g to 610 g > 610 g to 5 kg > 5 kg to 34 kg	3.1 µg + 2.4 µg/g 6.7 µg + 0.59 µg/g 7.3 µg + 0.53 µg/g 9.6 µg + 0.64 µg/g 0.23 mg + 0.53 µg/g 130 mg	Weights, MCM36 Balance Weights, MCM36 Balance Weights, MCM36 Balance Weights, MCM605 Balance Weights, CCE5004 Balance Weights, CPA34001S Balance
VIBRATION (20/M11)			
Accelerometers Voltage Charge Sensitivity (0.2 to 1000) mV/g	(5 - 9) Hz (10 - 99) Hz 100 Hz (101 - 920) Hz (921 - 5000) Hz (>5 - 10) kHz	1.7 % of reading 1.2 % of reading 0.75 % of reading 1.0 % of reading 1.4 % of reading 1.9 % of reading	TMS9155D Air Bearing Shaker System

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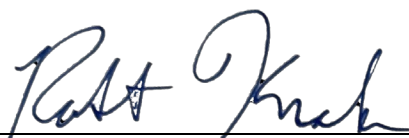
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
	(>10 - 15) kHz (>15 - 20) kHz	2.2 % of reading 2.8 % of reading	
VOLUME & DENSITY (20/M12)			
Viscosity	100 cps 1000 cps 5000 cps 100 000 cps	0.33 % 0.50 % 0.45 % 0.60 %	Viscosity solutions
SPEED INDICATORS (20/M14)			
Photo ^{Note 4}	1 rpm to 100 000 rpm	8.6 E-6 rpm/rpm + 0.0058 rpm	Signal generator
Contact	10 rpm to 50 000 rpm	5.9 E-5 rpm/rpm + 0.012 rpm	Ideal Aerosmith 1921
TORQUE (20/M15)			
Torque – Generate	0.088 cNm to 0.35 cNm 0.35 cNm to 2.82 cNm 0.282 Nm to 3.39 Nm 3.39 Nm to 339 Nm 339 Nm to 2712 Nm	0.13 % 0.074 % 0.070 % 0.066 % 0.071 %	Torque wheel or arm with Class 6 weights
Torque – Measure	0.5 ozf-in to 2.5 ozf-in > 2.5 ozf-in to 10 ozf-in > 10 ozf-in to 15 ozf-in > 15 ozf-in to 200 ozf-in > 200 ozf-in to 50 lbf-in > 50 lbf-in to 150 lbf-in > 150 lbf-in to 400 lbf-in > 400 lbf-in to 1000 lbf-in > 1000 lbf-in to 125 lbf-ft > 125 lbf-ft to 250 lbf-ft > 250 lbf-ft to 600 lbf-ft	0.51 % + 0.0022 ozf-in 0.51 % + 0.0086 ozf-in 0.58 % + 0.0035 ozf-in 0.29 % + 0.029 ozf-in 0.30 % + 0.0028 lbf-in 0.30 % + 0.0067 lbf-in 0.30 % + 0.026 lbf-in 0.30 % + 0.084 lbf-in 0.27 % + 0.036 lbf-ft 0.30 % + 0.013 lbf-ft 0.30 % + 0.031 lbf-ft	Waters 6500T4 Waters 6500T4 CDI 2000-4-02 CDI 2000-5-02 CDI 2000-6-02 CDI 2000-65-02 CDI 2000-7-02 CDI 2000-8-02 CDI 2000-10-02 CDI 2000-11-02 CDI 2000-12-02

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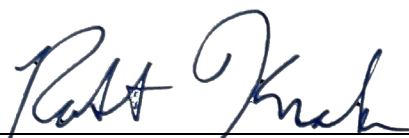
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
	> 600 lbf-ft to 1000 lbf-ft	0.30 % + 0.083 lbf-ft	CDI 2000-13-02
	> 1000 lbf-ft to 2000 lbf-ft	0.30 % + 0.042 lbf-ft	CDI 2000-14-02
WEIGHING INSTRUMENTS (20/M16)			
Scales & Balances ^{Note 4}	1 mg to 20 mg	0.0023 mg	Class 1 Weights
	> 20 mg to 500 mg	0.0030 mg	
	> 500 mg to 5 g	0.0081 mg	
	> 5 g to 10 g	0.012 mg	
	> 10 g to 20 g	0.017 mg	
	> 20 g to 50 g	0.034 mg	
	> 50 g to 100 g	0.068 mg	
	> 100 g to 5 kg	0.17 μ g + 0.58 μ g/g	
	> 5 kg to 20 kg	0.59 μ g/g	
	> 20 kg to 30 kg	13 mg	
	> 30 kg to 50 kg	18 mg	Class F Weights
	> 50 kg to 250 kg	4.4 μ g/g + 470 mg	
ELECTROMAGNETICS – RF/MICROWAVE			
RF/MICROWAVE POWER (20/R17)			
RF Absolute Power – Measure ^{Note 4}			
100 kHz to 2.6 GHz	-20 dBm to 30 dBm	0.15 dB	HP 8902A w/ 11722A
50 MHz to 1.3 GHz	-20 dBm to 30 dBm	0.15 dB	HP 8902A w/ 11792A
1.3 GHz to 18 GHz		0.25 dB	
18 GHz to 26.5 GHz		0.31 dB	
50 MHz to 100 MHz	-30 dBm to 20 dBm	0.14 dB	HP E4419B w/ HP N8487A
100 MHz to 2 GHz		0.12 dB	
2 GHz to 12.4 GHz		0.14 dB	
12.4 GHz to 18 GHz		0.15 dB	
18 GHz to 26.5 GHz		0.18 dB	
26.5 GHz to 40 GHz		0.22 dB	
40 GHz to 50 GHz		0.31 dB	

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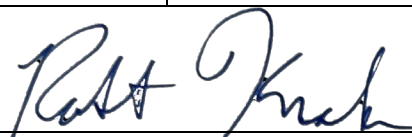
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
50 MHz to 100 MHz	-70 dBm to -20 dBm	0.15 dB	HP E4419B w/ HP 8487D
100 MHz to 2 GHz		0.16 dB	
2 GHz to 12.4 GHz		0.17 dB	
12.4 GHz to 18 GHz		0.20 dB	
18 GHz to 34 GHz		0.23 dB	
34 GHz to 40 GHz		0.29 dB	
40 GHz to 50 GHz		0.37 dB	
30 MHz to 4 GHz		-70 dBm to -20 dBm	
4 GHz to 10 GHz	0.16 dB		
10 GHz to 15 GHz	0.19 dB		
15 GHz to 18 GHz	0.21 dB		
RF Absolute Power – Measure ^{Note 4}	-60 dBm to 20 dBm	0.15 dB	HP E4419B w/ HP E9304A
9 kHz to 2 GHz			
2 GHz to 6 GHz		0.16 dB	
50 MHz to 100 MHz	-70 dBm to 20 dBm	0.21 dB	HP E4419B w/ HP E4413A
100 MHz to 8 GHz		0.21 dB	
8 GHz to 18 GHz		0.22 dB	
18 GHz to 26.5 GHz		0.23 dB	
50 MHz	1 mW	0.0033 mW	Tegam 1830A w/HP 478A-H76
Tuned RF Power – Absolute - Measure ^{Note 4}	2.5 MHz to 26.5 GHz		HP 8902 w/11722A or 11792A sensor
10 dBm to -22 dBm		0.14 dB	
-22 dBm to -42 dBm		0.15 dB	
-42 dBm to -50 dBm		0.17 dB	
-50 dBm to -60 dBm		0.17 dB	
-60 dBm to -72 dBm		0.19 dB	
-72 dBm to -80 dBm		0.20 dB	
-80 dBm to -92 dBm		0.21 dB	
-92 dBm to -102 dBm	0.27 dB		

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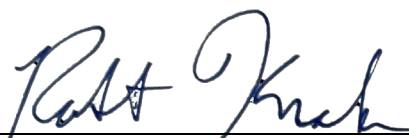
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks		
Tuned RF Power – Relative Measure ^{Note 4} 2.5 MHz to 26.5 GHz	-102 dBm to -110 dBm	0.32 dB	HP 8902 w/11722A or 11792A sensor		
	-110 dBm to -120 dBm	0.37 dB			
	-120 dBm to -127 dBm	0.43 dB			
	10 dB to 2 dB	0.087 dB			
	2 dB to -12 dB	0.099 dB			
	-12 dB to -22 dB	0.11 dB			
	-22 dB to -31 dB	0.11 dB			
	-31 dB to -40 dB	0.093 dB			
	-40 dB to -50 dB	0.10 dB			
	-50 dB to -61 dB	0.11 dB			
	-61 dB to -71 dB	0.12 dB			
	-71 dB to -80 dB	0.15 dB			
	-80 dB to -90 dB	0.16 dB			
RF Power – Flatness ^{Note 4} 9kHz to 6 GHz	-90 dB to -100 dB	0.16 dB	Agilent E4419B, Agilent E9304A		
	-100 dB to -110 dB	0.20 dB			
	-110 dB to -120 dB	0.22 dB			
	-120 dB to -127 dB	0.34 dB			
	-60 to 20 dBm	0.041 dB			
	RF Power – Generate 1 Hz to 10 MHz	(-35 to -24) dBm		1.1 dB	Signal Generator
		(>-24 to -8) dBm		0.42 dB	
(>-8 to 20) dBm		0.23 dB			
10 MHz to 50 MHz	(-35 to -24) dBm	1.1 dB			
	(>-24 to -8) dBm	0.49 dB			
	(>-8 to 20) dBm	0.35 dB			
50 MHz to 80 MHz	(-35 to -24) dBm	1.2 dB			
	(>-24 to -8) dBm	0.61 dB			
	(>-8 to 20) dBm	0.50 dB			

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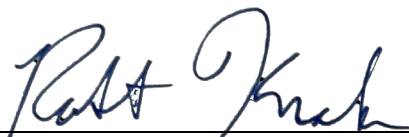
CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

SCATTERING PARAMETERS (20/R18)				
S₁₁, S₂₂ Parameters, Reflection Coefficient (0 to 1)				
HP 8757A w/85027B				
Return Loss	10 MHz to 8.4 GHz	8.4 GHz to 12 GHz	12 GHz to 20 GHz	20 GHz to 26.5 GHz
1 dB	0.067	0.16	0.069	0.027
2 dB	0.054	0.13	0.056	0.022
3 dB	0.044	0.10	0.047	0.018
4 dB	0.037	0.084	0.039	0.015
5 dB	0.031	0.068	0.034	0.12
6 dB	0.027	0.055	0.030	0.11
7 dB	0.026	0.047	0.032	0.11
8 dB	0.022	0.039	0.031	0.097
9 dB	0.022	0.034	0.030	0.092
10 dB	0.022	0.030	0.029	0.089
11 dB	0.021	0.028	0.029	0.086
12 dB	0.021	0.026	0.028	0.085
20 dB	0.022	0.045	0.042	0.16
30 dB	0.017	0.068	0.10	0.44
40 dB	0.091	0.11	0.037	0.31

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Attenuation – Generate ^{Note 4} (50 Ω) 200 Hz to 80 MHz	0 dB to 38 dB 40 dB to 58 dB 60 dB to 98 dB	0.26 dB 0.32 dB 0.51 dB	HP 3335A (BNC F)
Attenuation – Generate ^{Note 4} (75 Ω) 200 Hz to 25 MHz	0 dB to 18 dB	0.28 dB	
> 25 MHz to 80 MHz		0.40 dB	
200 Hz to 25 MHz	20 dB to 58 dB	0.39 dB	
> 25 MHz to 80 MHz		0.52 dB	
200 Hz to 25 MHz	60 dB to 98 dB	0.47 dB	
> 25 MHz to 80 MHz		0.81 dB	

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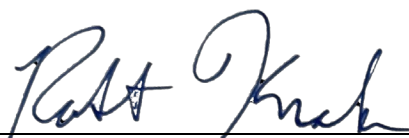
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
DC to 18 GHz (Fixed Value)	3 dB	0.46 dB	Weinschel 44 Series
	6 dB	0.46 dB	
	10 dB	0.65 dB	
	20 dB	0.65 dB	
Attenuation – Generate ^{Note 4} 30 MHz	0 dB	0.0040 dB	Agilent 11812A
	10 dB	0.0083 dB	
	20 dB	0.019 dB	
	30 dB	0.020 dB	
	40 dB	0.033 dB	
	50 dB	0.022 dB	
Attenuation – Measure ^{Note 4} 2.5 MHz to 26.5 GHz	0 dB to 2 dB	0.081 dB	HP8902 with 11722A or 11792A sensor
	> 2 dB to -12 dB	0.070 dB	
	> -12 dB to -22 dB	0.081 dB	
	> -22 dB to -31 dB	0.081 dB	
	> -31 dB to -40 dB	0.093 dB	
	> -40 dB to -50 dB	0.10 dB	
	> -50 dB to -61 dB	0.11 dB	
	> -61 dB to -71 dB	0.12 dB	
	> -71 dB to -80 dB	0.15 dB	
	> -80 dB to -90 dB	0.16 dB	
	> -90 dB to -100 dB	0.16 dB	
	> -100 dB to -110 dB	0.20 dB	
	> -110 dB to -120 dB	0.22 dB	
> -120 dB to -127 dB	0.34 dB		

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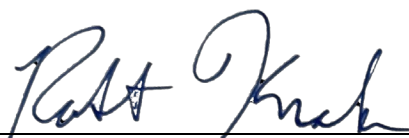
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
THERMODYNAMIC			
HUMIDITY (20/T02)			
Relative Humidity Generate/ Measure ^{Note 4}	10 % RH to 95 % RH	0.15 % RH + 0.29 % rdg.	Thunder Scientific 2500
Relative Humidity Measure	10 % RH to 95 % RH	1.6 %RH	Rotronics HydroPalm & HC2A-S
Dew Point Measure	10 % RH to 95 % RH	0.16 °C	RH Systems 473
LABORATORY THERMOMETERS (20/T03)			
Temperature – Generate & Measure	-197 °C -95 °C to -80 °C ≥ -80 °C to 0 °C 0.01 °C > 0 °C to 100 °C ≥ 100 °C to 250 °C > 250 °C to 660 °C > 660 °C to 700 °C > 700 °C to 1000 °C > 1000 °C to 1200 °C	6.4 mK 13 mK 7.2 mK+ 0.014 mK/°C 4.4 mK 7.6 mK+ 0.018 mK/°C 6.3 mK+ 0.029 mK/°C 20 mK+ 0.079 mK/°C 0.47 °C + 1.2 E-04 °C/°C 1.2 °C 0.85 °C + 7.6 E-04 °C/°C	Additel ADT286 w/AccuMac 1960A or Fixed Point TPW Fluke 9118A w/AccuMac AM1210-20
Thermistor	0 °C to 100 °C	5.8 mK + 0.036 mK/°C	Fluke 5644S w/Additel ADT286
PRESSURE (20/T05)			
Pressure – Generate & Measure ^{Note 4}	0 Pa to 746 Pa > 746 Pa to 7460 Pa 1245 Pa to 10 kPa > 10 kPa to 62 kPa > 62 kPa to 689 kPa > 689 kPa to 6.89 MPa > 6.89 MPa to 20 MPa > 20 MPa to 68.9 MPa	0.0048 % + 0.045 Pa 0.011 % - 0.00015 Pa 1.2 Pa 0.012 % 0.0098 % + 0.068 Pa 0.0098 % + 1.8 Pa 0.016 % + 1.4 Pa 0.017 % + 3.0 Pa	Fluke 7250 LP Pressurements T3500/3 DHI RPM4-A700kp DHI RPM4-A7Mp DHI RPM4-A20Ms DHI RPM4-A70Ms

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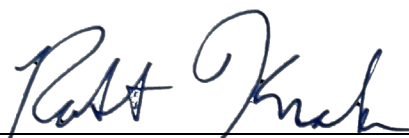
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
	69 MPa to 207 MPa	0.025 % + 9.6 Pa	Fluke/DHI E-DWT-H-A200Me-L
RADIATION THERMOMETRY (20/T06)			
Source ^{Note 4}	-15 °C to 120 °C 120 °C to 200 °C 200 °C to 500 °C	0.00071 °C /°C + 0.28 °C 0.0025 °C /°C + 0.11 °C 0.0026 °C /°C + 0.096 °C	Fluke 4180 infrared source Fluke 4181 infrared source
RESISTANCE THERMOMETRY (20/T07)			
Comparison – RTDs	-197 °C -95 °C to -80 °C ≥ -80 °C to 0 °C 0.01 °C > 0 °C to 100 °C ≥ 100 °C to 250 °C > 250 °C to 660 °C > 660 °C to 700 °C > 700 °C to 1000 °C > 1000 °C to 1200 °C	6.4 mK 13 mK 7.2 mK + 0.014 mK/°C 4.4 mK 7.6 mK + 0.018 mK/°C 6.3 mK + 0.029 mK/°C 20 mK + 0.079 mK/°C 470 mK + 0.12 mK/°C 1.2 °C 850 mK + 0.76 mK /°C	Additel ADT286 w/AccuMac 1960A or Fixed Point TPW Fluke 9118A w/AccuMac AM1210-20
TEMPERATURE INDICATORS (20/T08)			
Thermocouple Simulation ^{Note 4}			
Type B	600 °C to 800 °C > 800 °C to 1000 °C > 1000 °C to 1550 °C > 1550 °C to 1820 °C	0.33 °C 0.26 °C 0.23 °C 0.20 °C	Fluke 5522A
Type C	0 °C to 150 °C > 150 °C to 650 °C > 650 °C to 1000 °C > 1000 °C to 1800 °C > 1800 °C to 2316 °C	0.18 °C 0.15 °C 0.18 °C 0.30 °C 0.49 °C	

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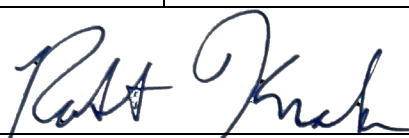
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Type E	-250 °C to -100 °C	0.30 °C	
	> -100 °C to -25 °C	0.093 °C	
	> -25 °C to 350 °C	0.078 °C	
	> 350 °C to 650 °C	0.093 °C	
	> 650 °C to 1000 °C	0.12 °C	
Type J	-210 °C to -100 °C	0.16 °C	
	> -100 °C to -30 °C	0.093 °C	
	> -30 °C to 150 °C	0.078 °C	
	> 150 °C to 760 °C	0.10 °C	
	> 760 °C to 1200 °C	0.14 °C	
Type K	-210 °C to -100 °C	0.19 °C	
	> -100 °C to -25 °C	0.11 °C	
	> -25 °C to 120 °C	0.093 °C	
	> 120 °C to 1000 °C	0.15 °C	
	> 1000 °C to 1372 °C	0.23 °C	
Type L	-200 °C to -100 °C	0.29 °C	
	> -100 °C to 800 °C	0.20 °C	
	> 800 °C to 900 °C	0.13 °C	
Type N	-200 °C to -100 °C	0.23 °C	
	> -100 °C to -25 °C	0.13 °C	
	> -25 °C to 120 °C	0.12 °C	
	> 120 °C to 410 °C	0.11 °C	
	> 410 °C to 1300 °C	0.16 °C	
Type R	0 °C to 250 °C	0.37 °C	
	> 250 °C to 400 °C	0.22 °C	
	> 400 °C to 1000 °C	0.20 °C	
	> 1000 °C to 1767 °C	0.23 °C	

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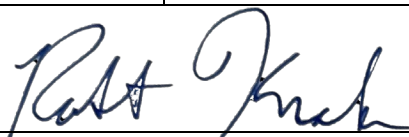
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Type S	0 °C to 250 °C	0.36 °C	
	> 250 °C to 1000 °C	0.23 °C	
	> 1000 °C to 1400 °C	0.23 °C	
	> 1400 °C to 1767 °C	0.26 °C	
Type T	-250 °C to -150 °C	0.37 °C	
	> -150 °C to 0 °C	0.14 °C	
	> 0 °C to 120 °C	0.093 °C	
	> 120 °C to 400 °C	0.078 °C	
Type U	-200 °C to 0 °C	0.43 °C	
	> 0 °C to 600 °C	0.21 °C	
Half Junction Simulation			
Type E	-200 °C to 1000 °C	0.045 °C	
Type J	-210 °C to 1200 °C	0.093 °C	
Type K	-270 °C to 1373 °C	0.11 °C	
Type N	-270 °C to 1260 °C	0.092 °C	
Type S	-50 °C to 1480 °C	0.15 °C	
Type T	-200 °C to 400 °C	0.082 °C	
RTD Simulation ^{Note 4}			
Pt 385, 100 Ω	-200 °C to -80 °C	0.039 °C	
	> -80 °C to 0 °C	0.039 °C	
	> 0 °C to 100 °C	0.054 °C	
	> 100 °C to 300 °C	0.070 °C	
	> 300 °C to 400 °C	0.078 °C	
	> 400 °C to 630 °C	0.093 °C	
	> 630 °C to 800 °C	0.18 °C	

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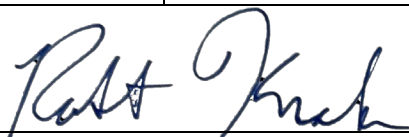
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Pt 3926, 100 Ω	-200 °C to -80 °C	0.039 °C	
	> -80 °C to 0 °C	0.039 °C	
	> 0 °C to 100 °C	0.054 °C	
	> 100 °C to 300 °C	0.070 °C	
	> 300 °C to 400 °C	0.078 °C	
	> 400 °C to 630 °C	0.093 °C	
Pt 3916, 100 Ω	-200 °C to -190 °C	0.29 °C	
	> -190 °C to -80 °C	0.046 °C	
	> -80 °C to 0 °C	0.058 °C	
	> 0 °C to 100 °C	0.069 °C	
	> 100 °C to 260 °C	0.081 °C	
	> 260 °C to 300 °C	0.092 °C	
	> 300 °C to 400 °C	0.10 °C	
	> 400 °C to 600 °C	0.12 °C	
Pt 385, 200 Ω	-200 °C to -80 °C	0.031 °C	
	> -80 °C to 0 °C	0.031 °C	
	> 0 °C to 100 °C	0.031 °C	
	> 100 °C to 260 °C	0.039 °C	
	> 260 °C to 300 °C	0.093 °C	
	> 300 °C to 400 °C	0.10 °C	
	> 400 °C to 600 °C	0.11 °C	
	> 600 °C to 630 °C	0.12 °C	
Pt 385, 500 Ω	-200 °C to -80 °C	0.039 °C	
	> -80 °C to 0 °C	0.031 °C	
	> 0 °C to 100 °C	0.039 °C	
	> 100 °C to 260 °C	0.047 °C	
	> 260 °C to 300 °C	0.062 °C	
	> 300 °C to 400 °C	0.062 °C	
	> 400 °C to 600 °C	0.070 °C	
	> 600 °C to 630 °C	0.085 °C	

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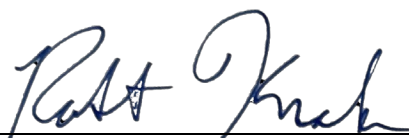
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Pt 385, 1000 Ω	-200 °C to -80 °C > -80 °C to 0 °C > 0 °C to 100 °C > 100 °C to 260 °C > 260 °C to 300 °C > 300 °C to 400 °C > 400 °C to 600 °C > 600 °C to 630 °C	0.023 °C 0.023 °C 0.031 °C 0.039 °C 0.047 °C 0.054 °C 0.055 °C 0.18 °C	
PtNi, 120 Ω	-80 °C to 0 °C > 0 °C to 100 °C > 100 °C to 260 °C	0.062 °C 0.062 °C 0.11 °C	
Cu 427, 10 Ω	-100 °C to 260 °C	0.23 °C	
VACUUM & LOW PRESSURE GAGES (20/T09)			
Vacuum – Measure ^{Note 4}	0 mTorr to 1000 mTorr > 1 Torr to 10 Torr	0.14 mTorr + 1.3 % 0.0013 Torr + 1.3 %	MKS 390411-0-YE-T with: MKS 660B20/626C01TDE MKS660B10/626C11TQD
THERMOCOUPLES (20/T11)			
Type E	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1000°C	0.14 °C 0.15 °C 0.17 °C + 0.092 mK/°C 1.2°C	Additel ADT286 w/ Fluke 5628 Accumac AM1210-20
Type J	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.14 °C 0.16 °C 0.18 °C + 0.077 mK/°C 1.2 °C 2.2 °C	

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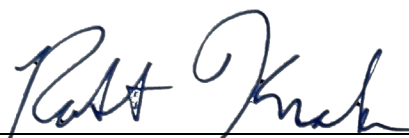
CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Type K	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.15 °C 0.16 °C 0.18 °C + 0.077 mK/°C 1.2 °C 2.2 °C	
Type N	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.15 °C 0.16 °C 0.18 °C + 0.077 mK/°C 1.2 °C 2.2 °C	
Type R	> -50 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.29°C – 1.3 mK/°C 0.23 °C 1.3 °C 2.2 °C	
Type S	> -50 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.28°C – 1.1 mK/°C 0.24 °C 1.3 °C 2.2 °C	
Type T	-196°C > -95 °C to 50 °C > 50°C to 400°C	0.15 °C 0.16 °C 0.18°C + 0.057 mK/°C	
END			

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Notes

Note 1: A Calibration and Measurement Capability (CMC) is a description of the best result of a calibration or measurement (result with the smallest uncertainty of measurement) that is available to the laboratory's customers under normal conditions, when performing more or less routine calibrations of nearly ideal measurement standards or instruments. The CMC is described in the laboratory's scope of accreditation by: the measurement parameter/device being calibrated, the measurement range, the uncertainty associated with that range (see note 3), and remarks on additional parameters, if applicable.

Note 2: Calibration and Measurement Capabilities are traceable to the national measurement standards of the U.S. or to the national measurement standards of other countries and are thus traceable to the internationally accepted representation of the appropriate SI (Système International) unit.

Note 3: The uncertainty associated with a measurement in a CMC is an expanded uncertainty with a level of confidence of approximately 95 %, typically using a coverage factor of $k = 2$. However, laboratories may report a coverage factor different than $k = 2$ to achieve the 95 % level of confidence. Units for the measurand and its uncertainty are to match. Exceptions to this occur when marketplace practice employs mixed units, such as when the artifact to be measured is labeled in non-SI units and the uncertainty is given in SI units (Example: 5 lb weight with uncertainty given in mg).

Note 3a: The uncertainty of a specific calibration by the laboratory may be greater than the uncertainty in the CMC due to the condition and behavior of the customer's device and specific circumstances of the calibration. The uncertainties quoted do not include possible effects on the calibrated device of transportation, long term stability, or intended use.

Note 3b: As the CMC represents the best measurement results achievable under normal conditions, the accredited calibration laboratory shall not report smaller uncertainty of measurement than that given in a CMC for calibrations or measurements covered by that CMC.

Note 3c: As described in Note 1, CMCs cover calibrations and measurements that are available to the laboratory's customers under *normal conditions*. However, the laboratory may have the capability to offer special tests, employing special conditions, which yield calibration or measurement results with lower uncertainties. Such special tests are not covered by the CMCs and are outside the laboratory's scope of accreditation. In this case, NVLAP requirements for the labeling, on calibration reports, of results outside the laboratory's scope of accreditation apply. These requirements are set out in Annex A.5 of NIST Handbook 150, Procedures and General Requirements.

Note 4: Uncertainties associated with field service calibration may be greater as they incorporate on-site environmental contributions, transportation effects, or other factors that affect the measurements. (This note applies only if marked in the body of the scope.)

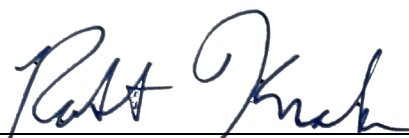
Note 5: Values listed with percent (%) are percent of reading or generated value unless otherwise noted.

Note 6: NVLAP accreditation is the formal recognition of specific calibration capabilities. Neither NVLAP nor NIST guarantee the accuracy of individual calibrations made by accredited laboratories.

Note 7: Uncertainties are listed at optimal conditions ($PF = 1, \Phi = 0^\circ$ at 10 Hz - 65 Hz). Under different conditions, the uncertainty of the power measurement will vary based on the laboratory's AC voltage and current measurement uncertainties. PFs of less than one will increase the uncertainty of the power measurement, ramping up as PF approaches zero. Essco may also report reactive power, apparent power, and power factor under this accreditation. Uncertainties at other conditions can be obtained from the laboratory.

Note 8: Where FM is measured peak expressed in Hertz.

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