



THE AMERICAN ASSOCIATION FOR  
LABORATORY ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

**INSTRUMENT CALIBRATION SERVICE, INC. an  
Oplink Solutions, Inc. company  
Alpharetta, GA**

for technical competence in the field of **Calibration**

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 18 June 2005*).

Presented this 15<sup>th</sup> day of February 2008.

A handwritten signature in black ink, appearing to read "Peter Abney". The signature is written in a cursive style and is positioned above a horizontal line.

President  
For the Accreditation Council  
Certificate Number 2662.01  
Valid to March 31, 2010  
REVISED: February 17, 2010



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

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

INSTRUMENT CALIBRATION SERVICE, INC. AN OPLINK SOLUTIONS, INC. COMPANY  
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CALIBRATION

Valid To: March 31, 2010

Certificate Number: 2662.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations<sup>1</sup>:

I. Dimensional

Parameter/Equipment	Range	Best Uncertainty <sup>2, 6</sup> (±)	Comments
Snap Gauges <sup>3</sup>	(0 to 24) in	5.7 µin/in + 290 µin	Gage blocks
Micrometer Set Standards <sup>3</sup>	(0.1 to 1) in (2 to 6) in (7 to 12) in (13 to 18) in (19 to 24) in	93 µin 160 µin 28 µin/in + 0.21µin 19 µin/in + 4 7µin 9.8 µin/in +190 µin	Starrett amplifier and indicator blocks
Micrometers <sup>3</sup> -	(0 to 4) in (4 to 24) in	7.4 µin/in + 28 µin 5.7 µin/in + 290 µin	Gage blocks
Height	(0 to 4) in (0 to 24) in	7.9 µin/in + 29 µin 5.7 µin/in + 290 µin	
Depth Gauges	(0 to 24) in (0 to 12) in	5.7 µin/in + 290 µin 4.3 µin/in + 280 µin	
Parallelism	(0 to 1) in	0.6R	
Calipers <sup>3</sup>	(0 to 40) in	510 µin	Gage blocks

Parameter/Equipment	Range	Best Uncertainty <sup>2, 6</sup> ( $\pm$ )	Comments
Indicators <sup>3</sup>	(0 to 1) in (1 to 4) in	0.18 $\mu\text{in/in}$ + 580 $\mu\text{in}$ 0.35 $\mu\text{in/in}$ + 290 $\mu\text{in}$	Gage blocks
Pin Gages <sup>3</sup>	(0 to 1) in	30 $\mu\text{in}$	Laser micrometer
Rulers <sup>3</sup>	Up to 48 in	4.0 $\mu\text{in/in}$ + 200 $\mu\text{in}$	Micro-rule

## II. Electrical – DC & Low Frequency

Parameter/Equipment	Range	Best Uncertainty <sup>2, 4, 5, 8</sup> ( $\pm$ )	Comments
DC Voltage <sup>3</sup> – Generate	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	11 $\mu\text{V/V}$ + 0.6 $\mu\text{V}$ 10 $\mu\text{V/V}$ + 1.0 $\mu\text{V}$ 11 $\mu\text{V/V}$ + 3.5 $\mu\text{V}$ 10 $\mu\text{V/V}$ + 6.5 $\mu\text{V}$ 11 $\mu\text{V/V}$ + 80 $\mu\text{V}$ 13 $\mu\text{V/V}$ + 500 $\mu\text{V}$	Fluke 5700A
DC High Voltage <sup>3</sup> – Generate	(1 to 15) kV	0.13 % + 250 mV	Peschel P20Y-D, Ross Eng. VD15-50Y-A-LB-AL, HP 34401A
DC Voltage <sup>3</sup> – Measure	(0.01 to 1) mV (1 to 10) mV  Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	52 nV/mV + 10 nV 41 nV/mV + 10 nV  7.0 $\mu\text{V/V}$ + 0.3 $\mu\text{V}$ 6.0 $\mu\text{V/V}$ + 0.3 $\mu\text{V}$ 6.0 $\mu\text{V/V}$ + 0.5 $\mu\text{V}$ 8.0 $\mu\text{V/V}$ + 30 $\mu\text{V}$ 22 $\mu\text{V/V}$ + 120 $\mu\text{V}$	HP 34420A  HP 3458A
DC High Voltage <sup>3</sup> – Measure	(1 to 15) kV	0.13 % + 250 mV	Ross Eng., VD15-50Y-A-LB-AL, HP34401A
DC Voltage <sup>3</sup> – Measure	(15 to 100) kV	0.58 % + 150 mV	Hipotronics KVM 100D
DC Current <sup>3</sup> – Generate	(20 to 120) A	0.23 $\mu\text{A/A}$ + 2.1 mA	HP 6031A, Guildline 9711A, HP3458A

Parameter/Equipment	Range	Best Uncertainty <sup>2, 4, 5, 8</sup> ( $\pm$ )	Comments
DC Current <sup>3</sup> – Generate (cont)	Up to 220 $\mu$ A 220 $\mu$ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 11) A	6.8 $\mu$ A/A + 9 nA 5.8 $\mu$ A/A + 9 nA 5.8 $\mu$ A/A + 92 nA 70 $\mu$ A/A + 0.92 $\mu$ A 93 $\mu$ A/A + 26 $\mu$ A 0.042 % + 0.55 mA	Fluke 5700A/5725A
	Clamp On Only	(11 to 20.5) A  (20 to 1000) A	0.1 % + 750 $\mu$ A  Fluke 5520A 5500A/coil 0.26 % + 0.13A
DC Current <sup>3</sup> – Measure	100 nA to 10 $\mu$ A (10 to 100) $\mu$ A 100 $\mu$ A to 10 mA (10 to 100) mA 100 mA to 1 A	22 $\mu$ A/A + 0.14 nA 19 $\mu$ A/A + 1.0 nA 24 $\mu$ A/A + 58 nA 41 $\mu$ A/A + 12 $\mu$ A 0.013 % + 12 $\mu$ A	HP 3458A
	(1 to 10) A (10 to 100) A (1 to 300) A	0.012 % + 10 $\mu$ A 0.058 % + 18 $\mu$ A 0.12 % + 16 $\mu$ A	Guildline 9711A, HP 3458A
DC Resistance <sup>3</sup> – Generate	(0 to 11) $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (0.11 to 1.1) k $\Omega$ (1.1 to 11) k $\Omega$ (11 to 110) k $\Omega$ (0.11 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 to 1100) M $\Omega$	48 $\mu\Omega/\Omega$ + 0.002 $\Omega$ 48 $\mu\Omega/\Omega$ + 0.002 $\Omega$ 48 $\mu\Omega/\Omega$ + 0.002 $\Omega$ 48 $\mu\Omega/\Omega$ + 0.002 $\Omega$ 34 $\mu\Omega/\Omega$ + 0.02 $\Omega$ 34 $\mu\Omega/\Omega$ + 0.02 $\Omega$ 38 $\mu\Omega/\Omega$ + 2 $\Omega$ 0.016 % + 50 $\Omega$ 0.016 % + 50 $\Omega$ 0.06 % + 3.0 k $\Omega$ 0.06 % + 3.0 k $\Omega$ 0.004 % + 100 k $\Omega$ 0.0024 % + 500 k $\Omega$	Fluke 5520A
	(1 to 100) M $\Omega$	0.11 % + 1.3 k $\Omega$	Biddle 72-6346-1
DC Resistance <sup>3</sup> – Generate, Fixed Points	0 $\Omega$ 1.0 $\Omega$ 1.9 $\Omega$ 10 $\Omega$ 19 $\Omega$ 100 $\Omega$ 190 $\Omega$ 1 k $\Omega$ 1.9 k $\Omega$	58 $\mu\Omega$ 110 $\mu\Omega$ 210 $\mu\Omega$ 320 $\mu\Omega$ 590 $\mu\Omega$ 2.0 m $\Omega$ 3.7 m $\Omega$ 15 m $\Omega$ 29 m $\Omega$	Fluke 5700A

Parameter/Equipment	Range	Best Uncertainty <sup>2, 4, 5, 8</sup> ( $\pm$ )	Comments
DC Resistance <sup>3</sup> – Generate, Fixed Points (cont)	10 k $\Omega$ 19 k $\Omega$ 100 k $\Omega$ 190 k $\Omega$ 1 M $\Omega$ 1.9 M $\Omega$ 10 M $\Omega$ 19 M $\Omega$ 100 M $\Omega$  1 G $\Omega$ 10 G $\Omega$ 100 G $\Omega$ 1 T $\Omega$	140 m $\Omega$ 260 m $\Omega$ 1.6 $\Omega$ 3.1 $\Omega$ 23 $\Omega$ 47 $\Omega$ 460 $\Omega$ 1 k $\Omega$ 13 k $\Omega$  0.2 % of reading 0.2 % of reading 0.21 % of reading 0.31 % of reading	Fluke 5700A          Keithley 5155-9 Keithley 5155-10 Keithley 5155-11 Keithley 5155-11
DC Resistance <sup>3</sup> – Measure	(0.01 to 1) $\Omega$ (1 to 10) $\Omega$  (10 to 100) $\Omega$ (0.1 to 1) k $\Omega$ (1 to 10) k $\Omega$ (10 to 100) k $\Omega$ (0.1 to 1) M $\Omega$ (1 to 10) M $\Omega$ (10 to 100) M $\Omega$ 100 M $\Omega$ to 1 G $\Omega$	81 $\mu\Omega/\Omega$ + 2.7 $\mu\Omega$ 77 $\mu\Omega/\Omega$ + 36 $\mu\Omega$  15 $\mu\Omega/\Omega$ + 500 $\mu\Omega$ 13 $\mu\Omega/\Omega$ + 500 $\mu\Omega$ 13 $\mu\Omega/\Omega$ + 5 m $\Omega$ 13 $\mu\Omega/\Omega$ + 50 m $\Omega$ 18 $\mu\Omega/\Omega$ + 2 $\Omega$ 53 $\mu\Omega/\Omega$ + 100 $\Omega$ 0.058 % + 1.5 k $\Omega$ 0.57 % + 19 k $\Omega$	HP 34420A  HP 3458A
DC Power <sup>3</sup> –  (0.33 to 330) mA (0.33 to 3) A (3 to 20.5) A	(0.033 to 1020) V (0.033 to 1020) V (0.033 to 1020) V	0.018 % 0.017 % 0.05 %	Fluke 5520A
Electrical Calibration of Thermocouple Indicators <sup>3</sup> –  Type B  Type C	(600 to 800) $^{\circ}\text{C}$ (800 to 1000) $^{\circ}\text{C}$ (1000 to 1550) $^{\circ}\text{C}$ (1550 to 1820) $^{\circ}\text{C}$  (0 to 150) $^{\circ}\text{C}$ (150 to 650) $^{\circ}\text{C}$ (650 to 1000) $^{\circ}\text{C}$ (1000 to 1800) $^{\circ}\text{C}$ (1800 to 2316) $^{\circ}\text{C}$	0.53 $^{\circ}\text{C}$ 0.42 $^{\circ}\text{C}$ 0.38 $^{\circ}\text{C}$ 0.41 $^{\circ}\text{C}$  0.37 $^{\circ}\text{C}$ 0.33 $^{\circ}\text{C}$ 0.38 $^{\circ}\text{C}$ 0.59 $^{\circ}\text{C}$ 0.98 $^{\circ}\text{C}$	Fluke 5520A

Parameter/Equipment	Range	Best Uncertainty <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouple Indicators <sup>3</sup> (cont.) –			
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.59 °C 0.23 °C 0.21 °C 0.23 °C 0.27 °C	Fluke 5520A
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.34 °C 0.23 °C 0.21 °C 0.24 °C 0.30 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.40 °C 0.24 °C 0.23 °C 0.33 °C 0.48 °C	
Type L	(-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.43 °C 0.32 °C 0.23 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.48 °C 0.28 °C 0.25 °C 0.25 °C 0.34 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.67 °C 0.43 °C 0.41 °C 0.48 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.56 °C 0.44 °C 0.45 °C 0.55 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.74 °C 0.31 °C 0.23 °C 0.21 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.56 °C 0.27 °C	

Parameter/Equipment	Range	Best Uncertainty <sup>2</sup> (±)	Comments
Electrical Calibration of RTD <sup>3</sup> –			
Pt 385, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.05 °C 0.07 °C 0.09 °C 0.10 °C 0.12 °C 0.23 °C	Fluke 5520A
Pt 3926, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.05 °C 0.07 °C 0.09 °C 0.10 °C 0.12 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.25 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.09 °C 0.10 °C 0.23 °C	
Pt 385, 200 Ω	(-200 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.04 °C 0.05 °C 0.12 °C 0.13 °C 0.14 °C 0.16 °C	
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 to 630) °C	0.04 °C 0.05 °C 0.06 °C 0.08 °C 0.09 °C 0.11 °C	
Pt 385, 1000 Ω	(-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.03 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.23 °C	
PtNi 385, 120 Ω	(-80 to 100) °C (100 to 260) °C	0.08 °C 0.14 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.30 °C	

Parameter/Range	Frequency	Best Uncertainty <sup>2, 4, 8</sup> (±)	Comments
Oscilloscope <sup>3</sup> –			
50 Ω load	DC	0.25 % of output + 40 μV	Fluke 5520A/SC1100
1 MΩ load	DC	0.05 % of output + 40 μV	
Squarewave Signal			
50 Ω at 1 kHz	1.0 mV to 6.6 V <sub>p-p</sub>	0.25 % of output + 40 μV	
1 MΩ			
10 Hz to 1 kHz	1.0 mV to 130 V <sub>p-p</sub>	0.1 % of output + 40 μV	
(1 to 10) kHz	1.0 mV to 130 V <sub>p-p</sub>	0.25 % of output + 40 μV	
Level Sine Wave			
Amplitude (50 kHz reference)	50 kHz	2.0 % + 300 μV	
	50 kHz to 100 MHz	3.5 % + 300 μV	
	(100 to 300) MHz	4.0 % + 300 μV	
	(300 to 600) MHz	6.0 % + 300 mV	
	(600 to 1100) MHz	7.0 % + 300 mV	
Flatness (50 kHz reference)	50 kHz to 100 MHz	1.5 % + 100 μV	<i>t</i> = time in seconds
	(100 to 300) MHz	2.0 % + 100 μV	
	(300 to 600) MHz	4.0 % + 100 μV	
	(600 to 1100) MHz	5.0 % + 100 μV	
Time Markers – Source and Period into a 50 Ω load	5 s to 50 ms	(25 + 1000 <i>t</i> ) μs/s	
	20 ms to 2 ns	2.5 μs/s	
Rise Time			
≤ 2 MHz	≤300 ps	+ 0 ps / -100 ps	
> 2 MHz	≤350 ps	+ 0 ps / -100 ps	
Wave Generator			
Amplitude			
1 MΩ	1.8 mV to 55 V <sub>pk-pk</sub>	3.0 % of output + 100 μV	
50 Ω	1.8 mV to 2.5 V <sub>pk-pk</sub>	3.0 % of output + 100 μV	

Parameter/Equipment	Range	Best Uncertainty <sup>2,4,8</sup> (±)	Comments
AC Power <sup>3</sup> – (45 to 65) Hz			
(3.3 to 9) mA	(33 to 330) mV (0.33 to 1020) V	0.11 % 0.09 %	Fluke 5520A
(9 to 33) mA	(33 to 330) mV (0.33 to 1020) V	0.1 % 0.06 %	
(33 to 90) mA	(33 to 330) mV (0.33 to 1020) V	0.11 % 0.09 %	
(90 to 330) mA	(33 to 330) mV (0.33 to 1020) V	0.1 % 0.06 %	
(0.33 to 0.9) A	(33 to 330) mV (0.33 to 1020) V	0.1 % 0.09 %	
(0.9 to 2.2) A	(33 to 330) mV (0.33 to 1020) V	0.09 % 0.07 %	
(2.2 to 4.5) A	(33 to 330) mV (0.33 to 1020) V	0.1 % 0.09 %	
(4.5 to 20.5) A	(33 to 330) mV (0.33 to 1020) V	0.09 % 0.1 %	
AC Voltage <sup>3</sup> – Generate			
(0.1 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.063 % + 5.2 μV 0.024 % + 5.2 μV 0.013 % + 5.2 μV 0.043 % + 5.2 μV 0.099 % + 8.1 μV 0.13 % + 15 μV 0.2 % + 29 μV 0.4 % + 29 μV	Fluke 5700A
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.063 % + 5.8 μV 0.024 % + 5.8 μV 0.013 % + 5.8 μV 0.043 % + 5.8 μV 0.099 % + 8.1 μV 0.13 % + 14 μV 0.2 % + 29 μV 0.39 % + 29 μV	

Parameter/Range	Frequency	Best Uncertainty <sup>2, 4, 8</sup> ( $\pm$ )	Comments
AC Voltage <sup>3</sup> – Generate (cont)			
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.064 % + 15 $\mu$ V 0.025 % + 9.2 $\mu$ V 0.013 % + 9.2 $\mu$ V 0.037 % + 9.2 $\mu$ V 0.099 % + 9.2 $\mu$ V 0.013 % + 29 $\mu$ V 0.2 % + 40 $\mu$ V 0.4 % + 92 $\mu$ V	Fluke 5700A
(0.22 to 2.2) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.058 % + 92 $\mu$ V 0.019 % + 29 $\mu$ V 0.0089 % + 6.7 $\mu$ V 0.015 % + 18 $\mu$ V 0.029 % + 81 $\mu$ V 0.05 % + 150 $\mu$ V 0.12 % + 0.4 $\mu$ V 0.25 % + 0.98 $\mu$ V	
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.058 % + 0.92 mV 0.019 % + 0.34 mV 0.0084 % + 160 $\mu$ V 0.014 % + 260 $\mu$ V 0.029 % + 0.44 mV 0.058 % + 1.7 mV 0.14 % + 5.0 mV 0.31 % + 9.8 mV	
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.058 % + 9.3 mV 0.019 % + 3.1 mV 0.0091 % + 1.4 mV 0.026 % + 4.4 mV 0.058 % + 9.3 $\mu$ V 0.17 % + 100 mV 0.54 % + 100 mV 1.4 % + 220 mV	
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.01 % + 10 mV 0.019 % + 10 mV 0.07 % + 14 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.07 % + 13 mV 0.27 % + 52 mV	

Parameter/Range	Frequency	Best Uncertainty <sup>2,4,8</sup> ( $\pm$ )	Comments
AC High Voltage <sup>3</sup> – Generate  (1 to 10) kV	50/60 Hz	0.24 % + 1.5 mV	Ross Eng VD15-50Y- A-LB-AL, HP 34401, Peschel P20Y-D
AC Current <sup>3</sup> – Generate			
10 nA to 220 $\mu$ A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.081 % + 29 nA 0.041 % + 23 nA 0.017 % + 19 nA 0.07 % + 46 nA 0.18 % + 92 nA	Fluke 5700A
220 $\mu$ A to 2.2 mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.081 % + 46 nA 0.041 % + 40 nA 0.017 % + 40 nA 0.07 % + 460 nA 0.19 % + 1 $\mu$ A	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.081 % + 460 nA 0.041 % + 400 nA 0.017 % + 400 nA 0.07 % + 4.6 $\mu$ A 0.19 % + 10 $\mu$ A	
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.081 % + 4.6 $\mu$ A 0.041 % + 4.0 $\mu$ A 0.017 % + 4.0 $\mu$ A 0.07 % + 46 $\mu$ A 0.19 % + 92 $\mu$ A	
220 mA to 2.2 A	(20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.076 % + 40 $\mu$ A 0.087 % + 92 $\mu$ A 0.98 % + 180 $\mu$ A	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.054 % + 200 $\mu$ A 0.11 % + 440 $\mu$ A 0.42 % + 870 $\mu$ A	Fluke 5700A/5725A
(11 to 20.5) A	(45 to 100) Hz (0.100 to 1) kHz (1 to 5) kHz	0.12 % of output + 5.0 mA 0.15 % of output + 5.0 mA 3.0 % of output + 5.0 mA	Fluke 5520A
(20 to 1000) A	(45 to 440) Hz	0.8 % of output	Fluke 5500A/coil

Parameter/Range	Frequency	Best Uncertainty <sup>2, 5, 8</sup> ( $\pm$ )	Comments
AC Voltage <sup>3</sup> – Measure			
(0.1 to 0.3) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	86 $\mu$ V/V + 0.09 $\mu$ V 33 $\mu$ V/V + 0.74 $\mu$ V 81 $\mu$ V/V + 0.14 $\mu$ V 0.018 % + 0.4 $\mu$ V 0.036 % + 0.15 $\mu$ V 0.11 % + 14 $\mu$ V	Datron 4920
(0.3 to 1.0) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	86 $\mu$ V/V + 1.0 $\mu$ V 33 $\mu$ V/V + 2.9 $\mu$ V 80 $\mu$ V/V + 1.0 $\mu$ V 0.018 % + 2.4 $\mu$ V 0.35 % + 2.5 $\mu$ V 0.11 % + 30 $\mu$ V	
(1.0 to 3.0) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	86 $\mu$ V/V + 0.6 $\mu$ V 33 $\mu$ V/V + 5.4 $\mu$ V 80 $\mu$ V/V + 2.5 $\mu$ V 0.018 % + 4.5 $\mu$ V 0.035 % + 1.4 $\mu$ V 0.11 % + 37 $\mu$ V	
(3.0 to 10) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	85 $\mu$ V/V + 26 $\mu$ V 34 $\mu$ V/V + 13 $\mu$ V 81 $\mu$ V/V + 1.6 $\mu$ V 0.018 % + 30 $\mu$ V 0.035 % + 6.4 $\mu$ V 0.11 % + 240 $\mu$ V	
(10 to 30) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	86 $\mu$ V/V + 8.1 $\mu$ V 34 $\mu$ V/V + 48 $\mu$ V 80 $\mu$ V/V + 16 $\mu$ V 0.017 % + 160 $\mu$ V 0.035 % + 27 $\mu$ V 0.12 % + 250 $\mu$ V	
(30 to 100) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	86 $\mu$ V/V + 11 $\mu$ V 28 $\mu$ V/V + 1.0 mV 80 $\mu$ V/V + 120 $\mu$ V 0.016 % + 1.8 mV 0.034 % + 2.0 mV	
(100 to 300) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	92 $\mu$ V/V + 39 $\mu$ V 38 $\mu$ V/V + 1.0 mV 85 $\mu$ V/V + 0.6 mV 0.018 % + 460 $\mu$ V	
(300 to 1000) VAC	(10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	92 $\mu$ V/V + 60 $\mu$ V 40 $\mu$ V/V + 140 $\mu$ V 86 $\mu$ V/V + 270 $\mu$ V 0.018 % + 160 $\mu$ V	

Parameter/Range	Frequency	Best Uncertainty <sup>2, 5, 8</sup> ( $\pm$ )	Comments
AC Voltage <sup>3</sup> – Measure (cont)			
(1 to 10) kVrms	60 Hz	0.25 % + 2.3 V	Ross Eng VD15-50Y-A-LB-AL, HP 34401A
(15 to 90) kVrms	60 Hz	1.2 % + 28 V	Hipotronics KVM 100D
AC Current <sup>3</sup> – Measure			
(5 to 100) $\mu$ A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.4 % + 30 nA 0.15 % + 30 nA 0.06 % + 30 nA 0.06 % + 30 nA	HP 3458A
100 $\mu$ A to 1 mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.4 % + 200 nA 0.15 % + 200 nA 0.06 % + 200 nA 0.03 % + 200 nA	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.4 % + 2 $\mu$ A 0.15 % + 2 $\mu$ A 0.06 % + 2 $\mu$ A 0.03 % + 2 $\mu$ A	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.4 % + 20 $\mu$ A 0.15 % + 20 $\mu$ A 0.06 % + 20 $\mu$ A 0.03 % + 20 $\mu$ A	
100 mA to 1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.4 % + 200 $\mu$ A 0.16 % + 200 $\mu$ A 0.08 % + 200 $\mu$ A 0.1 % + 200 $\mu$ A	
Flatness <sup>3</sup> – Measure, Fixed Points	100/200 Hz 10 kHz 30 kHz 100 kHz 300 kHz 1 MHz 3 MHz 8 MHz 10 MHz 20 MHz 30 MHz 50 MHz 70 MHz 80 MHz	0.0044 V 0.0041 V 0.0042 V 0.0042 V 0.0041 V 0.0041 V 0.0042 V 0.0042 V 0.0042 V 0.0045 V 0.0048 V 0.0067 V 0.0098 V 0.012 V	1 Volt thermal converter (75 $\Omega$ )

Parameter/Range	Frequency	Best Uncertainty <sup>2, 8</sup> (±)	Comments
Flatness <sup>3</sup> – Measure, Fixed Points (cont)	10 Hz 100 Hz 10 kHz 30 kHz 100 kHz 300 kHz 1 MHz 3 MHz 8 MHz 10 MHz 20 MHz 30 MHz 50 MHz 70 MHz 80 MHz	0.0035 V 0.0036 V 0.0036 V 0.0036 V 0.0038 V 0.0037 V 0.0036 V 0.0037 V 0.0039 V 0.0039 V 0.0062 V 0.0061 V 0.0094 V 0.015 V 0.018 V	1 Volt thermal converter (50 Ω)
	10 Hz 100 Hz 10 kHz 30 kHz 100 kHz 300 kHz 1 MHz 3 MHz 8 MHz 10 MHz 20 MHz	0.021 V 0.021 V 0.021 V 0.021 V 0.021 V 0.021 V 0.1 V 0.021 V 0.022 V 0.022 V 0.12 V	3 Volt thermal converter (50 Ω)
Capacitance <sup>3</sup> – Generate			
(0.19 to 1.09) nF (1.1 to 3.29) nF (3.3 to 10.9) nF (11 to 109.9) nF (110 to 329.9) nF (0.33 to 1.09) μF (1.1 to 3.29) μF (3.29 to 10.9) μF (11 to 32.9) μF (33 to 109.9) μF (110 to 329.9) μF (0.33 to 1.09) mF	10 Hz to 10 kHz 10 Hz to 3 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz (10 to 120) Hz (10 to 80) Hz (10 to 50) Hz (10 to 20) Hz	0.5 % + 0.01 nF 0.5 % + 0.01 nF 0.25 % + 0.01 nF 0.25 % + 0.01 nF 0.25 % + 0.3 nF 0.25 % + 1 nF 0.25 % + 3 nF 0.25 % + 10 nF 0.40 % + 30 nF 0.45 % + 100 nF 0.45 % + 300 nF 0.45 % + 1 mF	Fluke 5520A
(0.01 to 0.10 ) μF (0.1 to 1.0) μF (1 to 10) pF (10 to 100) pF (100 to 1000) pF (1000 to 10 000) pF	100 Hz to 1 kHz	0.59 μF + 0.59 pF/μF 0.59 μF + 0.59 pF/μF 0.59 pF + 0.59 pF/μP 0.59 pF + 0.59 pF/pF 0.64 pF + 5.4 pF/pF 0.59 pF + 0.60 pF/pF	GR 1413
1 pF 10 pF 100 pF 1000 pF	1 kHz	0.0026 pF 0.0031 pF 0.019 pF 0.0068 pF	HP 16380A Set (4 terminal)

Parameter/Range	Frequency	Best Uncertainty <sup>2</sup> (±)	Comments
Capacitance – Measure (0 to 1100) μF	1 kHz	0.27 μF	GR 1689
Inductance – Generate 100 mH 0.1 mH 1 mH	(100 Hz, 1 kHz) (100 Hz, 1 kHz, 10 kHz) (100 Hz, 1 kHz, 10 kHz)	0.11 mH 0.00055 mH 0.0013 mH	GR, 106K GR, 106L GR, 106G
Inductance – Measure (0 to 100) mH	1 kHz	0.023 mH	GR 1689

### III. Electrical – Microwave/RF

Parameter/Range	Frequency	Best Uncertainty <sup>2</sup> (±)	Comments
RF Power <sup>3</sup> – Generate	(0 to 26.5) GHz	1.9 dB	3325B, 8340B, 8902A, 8902A, 11722A, 11792A, 11793A, 11792A, 11793A
RF Power <sup>3</sup> – Measure	(0 to 26.5) GHz  (26.5 to 40.0) GHz	1.9 dB  0.082 dBm	8902A, 11722A, 11792A, 11793A  Agilent 8487A, 437B
Attenuation <sup>3</sup> – Generate 10 dB 20 dB 30 dB	30 MHz  10 MHz to 12.4 GHz (12.4 to 18) GHz  10 MHz to 12.4 GHz (12.4 to 18) GHz  10 MHz to 12.4 GHz (12.4 to 18) GHz	0.02 dB  1.2 dBm 1.3 dBm  1.4 dBm 1.4 dBm  1.5 dBm 1.8 dBm	Weinschel PA-2  HP 8496A attenuator

Parameter/Range	Frequency	Best Uncertainty <sup>2,8</sup> (±)	Comments
Attenuation <sup>3</sup> – Generate (cont)			
40 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	1.8 dBm 2.1 dBm	HP 8496A attenuator
50 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	2.0 dBm 2.6 dBm	
60 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	2.3 dBm 3.0 dBm	
70 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	2.7 dBm 3.4 dBm	
80 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	3.0 dBm 3.9 dBm	
90 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	3.3 dBm 4.3 dBm	
100 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	3.6 dBm 4.7 dBm	
110 dBm	10 MHz to 12.4 GHz (12.4 to 18) GHz	3.7 dBm 5.2 dBm	
Attenuation <sup>3</sup> – Measure	10 MHz to 1.3 GHz (1.3 to 26.5) GHz	0.18 dB 0.18 dB	HP 8902A, 11722A 8902A, 11722A, 11792A, 11793A
Phase Modulation – Measure			
Rate: 200 Hz to 10 kHz (0 to 100) rad	Carrier: $150 \text{ kHz} \leq f_c < 10 \text{ MHz}$	4.7 % + 1 digit	8902A, 11793A
Rate: 200 Hz to 20 kHz (0 to 100) rad	$10 \text{ MHz} \leq f_c < 1.3 \text{ GHz}$	3.6 % + 1 digit	
Amplitude Modulation Measure –			
Rate: 50 Hz to 10 kHz Depths: 5 % to 99 %	150 kHz to 10 MHz	2.4 % + 1 digit	8902A, 11793A
Rate: 20 Hz to 10 kHz Depths: to 99 %	150 kHz to 10 MHz	3.5 % + 1 digit	
Rate: 50 Hz to 50 kHz Depths: 5 % to 99 %	10 MHz to 1.3 GHz	1.2 % + 1 digit	

Parameter/Range	Frequency	Best Uncertainty <sup>2, 8</sup> (±)	Comments
Amplitude Modulation Measure – (cont)			
Rate: 20 Hz to 100 kHz Depths: to 99 %	10 MHz to 1.3 GHz	3.5 % + 1 digit	8902A, 11793A
Rate: 50 Hz to 50 kHz Depths: 5 % to 99 %	(1.3 to 26.5) GHz	1.8 % + 1 digit	
Rate: 20 Hz to 100 kHz Depths: to 99 %	(1.3 to 26.5) GHz	3.6 % + 1 digit	
Frequency Modulation – Measure			
Rate: 20 Hz to 10 kHz Dev.: ≤ 40 kHz peak	250 kHz to 10 MHz	2.3 % + 1 digit	8902A, 11793A
Rate: 50 Hz to 100 kHz Dev.: ≤ 400 kHz peak	10 MHz to 1.3 GHz	1.2 % + 1 digit	
Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	10 MHz to 1.3 GHz	5.8 % + 1 digit	
Rate: 50 Hz to 100 kHz Dev.: ≤ 400 kHz peak	(1.3 to 26.5) GHz	1.2 % + 1 digit	
Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	(1.3 to 26.5) GHz	5.8 % + 1 digit	
Distortion <sup>3</sup> – Measure			
	20 Hz to 20 kHz (20 to 100) kHz	1.2 db 2.3 db	HP 8903B
	100 kHz to 2.5 GHz (2.5 to 11) GHz	1.8 dBm 2.6 dBm	HP 8566A
Phase <sup>3</sup> – Generate			
	101 Hz to 1 kHz 100 kHz to 1 MHz (1 to 100) kHz (1 to 13) MHz	0.24 deg 0.36 deg 0.26 deg 2.4 deg	HP 3326A
Phase <sup>3</sup> – Measure Fixed Points			
	10 Hz to 100 kHz 13 MHz 1 kHz 1 MHz	0.13 deg 16 deg 0.13 deg 1.3 deg	Agilent 53131A

IV. Mechanical

Parameter/Equipment	Range	Best Uncertainty <sup>2,7,8</sup> ( $\pm$ )	Comments
Scales & Balances <sup>3</sup> –	(1 to 200) g 200 g to 1 kg (1 to 5) kg	0.15 mg 5.6 mg 58 mg	Class 1 weights
	(1 to 100) lb (100 to 500) lb (500 to 1000) lb	0.0057 lb 0.053 lb 0.57 lb	Class F weights
Pressure Gauges, Transducers & Calibrators <sup>3</sup> – Measuring Equipment and Measure	(0.1 to 1.0) psi (1 to 100) psi (100 to 500) psi (500 to 1000) psi (1000 to 10 000) psi	0.0016 psi 0.05 psi 0.26 psi 0.52 psi 0.99 psi	Fluke 700P22 Fluke 700P06 Fluke 700P07 Fluke 700P08 Fluke 700P31
	(1 to 100) psi (100 to 1000) psi (1000 to 10 000) psi	0.0032 % 0.029 % 0.032 %	Ametek T-100-1/C
Vacuum Gauges & Transducers <sup>3</sup> – Measuring Equipment & Measure	(-15 to 0) psi	0.15 psi	Fluke 700PD7, 743
Torque Wrenches <sup>3</sup>	4.0 in-lb to 250 ft-lb	0.39 %	CDI Suretest and 4 in 1 transducer
Force <sup>3</sup> – Compression & Tension	Up to 250 lbf	0.018 % + 0.6R	Class F Weights and hangers
RPM <sup>3</sup> –	(0.01 to 100) rpm (100 to 1000) rpm (1000 to 99 999) rpm	0.0059 rpm 0.059 rpm 0.73 rpm	HP 3325B
			Measure (Optical & Mechanical)

## V. Thermodynamics

Parameter/Equipment	Range	Best Uncertainty <sup>2</sup> (±)	Comments
Temperature <sup>3</sup> – Measuring Equipment  SPRT, RTD, Thermocouples	(-100 to 125) °C  (125 to 660) °C	0.031 °C  0.039 °C	Hart 7102, 1502A, 5628  Hart 9122, 1502A, 5628
IR Temperature <sup>3</sup> – Measuring Equipment  R=0.01  R=1	(35 to 400) °C  (35 to 400) °C	0.0066 °C/°C + 0.48 °C  0.0063 °C/°C + 0.64 °C	Hart 9131
Relative Humidity <sup>3</sup> – Measure	(10 to 70) % RH (70 to 90) % RH	1.0 % RH 2.0 % RH	Vaisala MI70, HMP77

## VI. Time & Frequency

Parameter/ Range	Frequency	Best Uncertainty <sup>2</sup> (±)	Comments
Frequency <sup>3</sup> – Generating Equipment	1 Hz to 26.5 GHz	0.01 nHz/Hz	GPS 58503A
Frequency – Measure	10 Hz to 3.0 GHz 3.0 GHz to 26.5 GHz 26.5 GHz to 40 GHz	0.029 Hz 0.58 Hz 0.58 Hz	58503A, 53131A-003 58503A, EIP 548 58503A, 5352B

<sup>1</sup> This laboratory offers commercial calibration service and field calibration services.

<sup>2</sup> “Best Uncertainty” is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of  $k = 2$ . The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer’s device and to influences from the circumstances of the specific calibration.

- <sup>3</sup> Field calibration service is available for this calibration and this laboratory meets A2LA *R104 – General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the uncertainties achievable on a customer's site can normally be expected to be larger than the Best Measurement Capabilities (BMC) that the accredited laboratory has been assigned as Best Uncertainty on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the calibration uncertainty being larger than the BMC.
- <sup>4</sup> The measurands stated are generated with the Fluke 5500 series of instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. Best measurement uncertainties are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.
- <sup>5</sup> The measurands stated are measured with the HP 3400 series of instruments. This capability is suitable for the calibration of the devices intended to generate the measurand in the ranges indicated. Best measurement uncertainties are expressed as either a specific value that covers the full range or as a combination of the fraction of the reading/output plus a range specification.
- <sup>6</sup> In the statement of best uncertainty,  $R$  is the numerical value of the resolution of the device in inches.
- <sup>7</sup> In the statement of best uncertainty,  $R$  is the numerical value of the resolution of the device in pounds force.
- <sup>8</sup> In the statement of best uncertainty, percentage refers to percent of reading, unless otherwise noted.