CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Angel's Instrumentation, A Transcat Company
928 Canal Drive
Chesapeake, VA 23323

Fulfills the requirements of

ISO/IEC 17025:2017

and national standards

ANSI/NCSL Z540-1-1994 (R2002) AND

ANSI/NCSL Z540.3-2006 (R2013)

In the field of

CALIBRATION

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org.

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 07 September 2023
Certificate Number: AC-2489.21

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. 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 April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

AND

ANSI/NCSL Z540-1-1994 (R2002)

ANSI/NCSL Z540.3-2006 (R2013)

ANGEL'S INSTRUMENTATION, A TRANSCAT COMPANY

928 Canal Drive
Chesapeake, VA 23323
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CALIBRATION

Valid to: **September 7, 2023** Certificate Number: **AC-2489.21**

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Vibration – Measure			
Voltage Sensitivity	100 Hz 10 mV/g	1.5 % of reading	Reference Accelerometer w/ Calibrator
Frequency Response	(0.8 to 20) g		
	(5 to 20) Hz	2.1 % of reading	
	(20 to 100) Hz	1.9 % of reading	
	(100 to 2 500) Hz	1.5 % of reading	
	(2 500 to 10 000) Hz	2.8 % of reading	
	(0.8 to 20) g pk		Vibration Calibrator
	(7 to 10) Hz	7 % of reading	
	(10 to 30) Hz	6 % of reading	
	(300 to 2 000) Hz	4.5 % of reading	
	(2 000 to 10 000) Hz	7 % of reading	
Sound – Generate	1 kHz 110 dB	0.42 dB	SPL Calibrator
Sound – Measure	20 Hz to 10 kHz (50 to 120) dB	0.5 dB	Sound Level Meter

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters	4 pH 7 pH 10 pH	0.44 % of reading 0.37 % of reading 0.35 % of reading	pH Reference Solutions
Conductivity Meters	25 µS/cm 75 µS/cm 1 015 µS/cm 1 408 µS/cm	5.6 % of reading 2 % of reading 0.9 % of reading 0.8 % of reading	Conductivity Reference Solutions
Gas Detection Equipment [1] CO (Carbon Monoxide)	 0.002 % CO 0.006 % CO 0.01 % CO 0.1 % CO 0.5 % CO	 0.82 % CO 1.1 % CO 0.84 % CO 0.87 % CO 0.6 % CO	Certified Gas Mixtures
CH_4 (Methane LEL)	50 % LEL	0.66 % LEL	
C_5H_{12} (Pentane LEL)	58 % LEL	1.1 % LEL	
H_2S (Hydrogen Sulfide)	0.002 5 % H_2S 0.002 % H_2S	1.7 % H_2S 2 % H_2S	
O_2 (Oxygen)	15 % O_2 18 % O_2	0.81 % O_2 0.6 % O_2	
C_4H_8 (Isobutylene)	0.01 % C_4H_8	1.1 % C_4H_8	
CO_2 (Carbon Dioxide)	0.5 % CO_2 5 % CO_2	0.8 % CO_2 0.8 % CO_2	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1]	(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 1 100) V	7.5 µV/V + 0.4 µV 5 µV/V + 0.7 µV 3.5 µV/V + 2.5 µV 3.5 µV/V + 4 µV 5 µV/V + 40 µV 6 µV/V + 0.4 mV	Fluke 5730A/03 Multiproduct Calibrator
DC Voltage – Measure [1]	Up to 200 mV 200 mV to 20 V (20 to 200) V (200 to 1 000) V	5 µV/V + 0.5 µV 3.5 µV/V + 0.2 µV 5.5 µV/V + 0.2 µV 5.5 µV/V + 0.5 µV	Fluke 8508A opt 001 8.5 Digit Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC High Voltage – Measure [1]	Up to 40 kV	2 % of reading	Fluke 80K40HV Probe, Fluke 8508A opt 001 8.5 Digit Multimeter
DC Current – Source [1]	(0 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	40 µA/A + 6 nA 35 µA/A + 7 nA 35 µA/A + 40 nA 45 µA/A + 0.7 µA 80 µA/A + 12 µA	Fluke 5730A/03 Multiproduct Calibrator
	(2.2 to 3) A (3 to 11) A (11 to 20.5) A	0.038 % of reading + 40 µA 0.05 % of reading + 0.5 mA 0.1 % of reading + 0.75 mA	Fluke 5522A/11 Multiproduct Calibrator
	(20 to 100) A	0.04 % of reading	Current Source, SR-100 Current Shunt, Fluke 8508 8.5 Digit Multimeter
DC Clamp-on Meters – Source [1]	(20 to 1 000) A	0.5 % of reading + 0.5 A	Fluke 5522A/11 Multiproduct Calibrator, 50-turn Coil
DC Current – Measure [1]	Up to 2 mA (2 to 20) mA	12 µA/A + 2 µA 14 µA/A + 2 µA	Fluke 8508A opt 001 8.5 Digit Multimeter
	(20 to 100) mA (0.1 to 1) A (1 to 15) A (15 to 100) A	8.5 µA/A 8.5 µA/A + 6 µA 40 µA/A + 8 µA 0.04 % of reading + 24 µA	Current Shunts, Fluke 8508A opt 001 8.5 Digit Multimeter
Resistance – Source [1] (Simulated)	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.33 to 1.1) kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ (0.33 to 1.1) MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (0.33 to 1.1) GΩ	40 µΩ/Ω + 1 mΩ 30 µΩ/Ω + 1.5 mΩ 28 µΩ/Ω + 1.4 mΩ 28 µΩ/Ω + 2 mΩ 28 µΩ/Ω + 2 mΩ 28 µΩ/Ω + 20 mΩ 28 µΩ/Ω + 20 mΩ 28 µΩ/Ω + 0.2 Ω 28 µΩ/Ω + 0.2 Ω 32 µΩ/Ω + 2 Ω 32 µΩ/Ω + 2 Ω 60 µΩ/Ω + 30 Ω 0.013 % of reading + 50 Ω 0.025 % of reading + 2.5 kΩ 0.05 % of reading + 3 kΩ 0.3 % of reading + 0.1 MΩ 1.5 % of reading + 0.5 MΩ	Fluke 5522A/11 Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source [1] (Simulated)	0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	40 μΩ 95 μΩ/Ω 95 μΩ/Ω 23 μΩ/Ω 23 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 8.5 μΩ/Ω 8.5 μΩ/Ω 13 μΩ/Ω 18 μΩ/Ω 40 μΩ/Ω 47 μΩ/Ω 0.1 mΩ/Ω	Fluke 5730A/03 Multiproduct Calibrator
Resistance – Source [1] (Artifact)	1 Ω 10 kΩ	7.1 μΩ 43 mΩ	Fluke 742A-1 Fluke 742A-10k Resistance Standards
High Resistance – Source [1] (Artifact)	(1 to 1 000) MΩ (1 to 100) GΩ	0.2 % of reading 1 % of reading	Biddle 72-6346-1 Decade Resistor
	1 GΩ	110 kΩ	Precision Resistor w/ Fluke 8508A opt 001 8.5 Digit Multimeter
Resistance – Measure [1]	Up to 2 Ω (2 to 20) Ω 20 Ω to 200 kΩ (0.2 to 2) MΩ (2 to 20) MΩ (20 to 200) MΩ (0.2 to 2) GΩ	17 μΩ/Ω + 2 μΩ 9.5 μΩ/Ω + 0.7 μΩ 8 μΩ/Ω + 0.25 μΩ 9 μΩ/Ω + 0.5 μΩ 20 μΩ/Ω + 5 μΩ 0.012 % of reading + 50 μΩ 0.15 % of reading + 2 μΩ	Fluke 8508A opt 001 8.5 Digit Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source [1]	(0.22 to 0.4) nF	0.39 % of reading + 7.7 pF	Fluke 5522A/11 Multiproduct Calibrator
	(0.4 to 1.1) nF	0.39 % of reading + 7.7 pF	
	(1.1 to 3.3) nF	0.39 % of reading + 7.7 pF	
	(3.3 to 11) nF	0.19 % of reading + 7.7 pF	
	(11 to 33) nF	0.19 % of reading + 77 pF	
	(33 to 110) nF	0.19 % of reading + 77 pF	
	(110 to 330) nF	0.19 % of reading + 0.23 nF	
	(0.33 to 1.1) µF	0.19 % of reading + 0.77 nF	
	(1.1 to 3.3) µF	0.19 % of reading + 2.3 nF	
	(3.3 to 11) µF	0.19 % of reading + 7.7 nF	
	(11 to 33) µF	0.31 % of reading + 23 nF	
	(33 to 110) µF	0.35 % of reading + 77 nF	
	(110 to 330) µF	0.35 % of reading + 0.23 µF	
	(0.33 to 1.1) mF	0.35 % of reading + 0.77 µF	
	(1.1 to 3.3) mF	0.35 % of reading + 2.3 µF	
	(3.3 to 11) mF	0.35 % of reading + 7.7 µF	
	(11 to 33) mF	0.58 % of reading + 23 µF	
	(33 to 110) mF	0.85 % of reading + 77 µF	
Capacitance – Measure [1]	1 kHz		General Radio 1689 RLC Digibridge
	400 pF to 25 µF	0.02 % of reading + 1 digit	
	(25 to 100) µF	0.05 % of reading + 1 digit	
	(100 to 500) µF	0.05 % of reading + 1 digit	
	(0.5 to 1) mF	0.09 % of reading + 1 digit	
Inductance – Measure [1]	1 kHz		General Radio 1689 RLC Digibridge
	1 mH to 10 H	0.02 % of reading + 1 digit	
AC Voltage – Source [1]	Up to 2.2 mV		Fluke 5730A/03 Multiproduct Calibrator
	(10 to 20) Hz	0.024 % of reading + 4 µV	
	(20 to 40) Hz	0.009 % of reading + 4 µV	
	(0.04 to 20) kHz	0.008 % of reading + 4 µV	
	(20 to 50) kHz	0.02 % of reading + 4 µV	
	(50 to 100) kHz	0.05 % of reading + 5 µV	
	(100 to 300) kHz	0.11 % of reading + 10 µV	
	(300 to 500) kHz	0.14 % of reading + 20 µV	
	(0.5 to 1) MHz	0.27 % of reading + 20 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	(2.2 to 22) mV		Fluke 5730A/03 Multiproduct Calibrator
	(10 to 20) Hz	0.024 % of reading + 4 µV	
	(20 to 40) Hz	0.009 % of reading + 4 µV	
	(0.04 to 20) kHz	0.008 % of reading + 4 µV	
	(20 to 50) kHz	0.02 % of reading + 4 µV	
	(50 to 100) kHz	0.05 % of reading + 5 µV	
	(100 to 300) kHz	0.11 % of reading + 10 µV	
	(300 to 500) kHz	0.14 % of reading + 20 µV	
	(0.5 to 1) MHz	0.27 % of reading + 20 µV	
	(22 to 220) mV		
	(10 to 20) Hz	0.024 % of reading + 12 µV	
	(20 to 40) Hz	0.009 % of reading + 7 µV	
	40 Hz to 20 kHz	0.005 7 % of reading + 7 µV	
	(20 to 50) kHz	0.012 % of reading + 7 µV	
	(50 to 100) kHz	0.031 % of reading + 17 µV	
	(100 to 300) kHz	0.066 % of reading + 20 µV	
	(300 to 500) kHz	0.14 % of reading + 25 µV	
	500 kHz to 1 MHz	0.27 % of reading + 45 µV	
	(0.22 to 2.2) V		
	(10 to 20) Hz	0.024 % of reading + 40 µV	
	(20 to 40) Hz	0.009 % of reading + 15 µV	
	40 Hz to 20 kHz	0.004 2 % of reading + 8 µV	
	(20 to 50) kHz	0.006 7 % of reading + 10 µV	
	(50 to 100) kHz	0.008 5 % of reading + 30 µV	
	(100 to 300) kHz	0.034 % of reading + 80 µV	
	(300 to 500) kHz	0.1 % of reading + 0.2 mV	
	500 kHz to 1 MHz	0.17 % of reading + 0.3 mV	
	(2.2 to 22) V		
	(10 to 20) Hz	0.024 % of reading + 0.4 mV	
	(20 to 40) Hz	0.009 % of reading + 0.15 mV	
	40 Hz to 20 kHz	0.004 2 % of reading + 0.05 mV	
	(20 to 50) kHz	0.006 7 % of reading + 0.1 mV	
	(50 to 100) kHz	0.008 3 % of reading + 0.2 mV	
	(100 to 300) kHz	0.026 % of reading + 0.6 mV	
	(300 to 500) kHz	0.1 % of reading + 2 mV	
	500 kHz to 1 MHz	0.15 % of reading + 3.2 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	(22 to 220) V		Fluke 5730A/03 Multiproduct Calibrator
	(10 to 20) Hz	0.024 % of reading + 4 mV	
	(20 to 40) Hz	0.009 % of reading + 1.5 mV	
	40 Hz to 20 kHz	0.005 2 % of reading + 0.6 mV	
	(20 to 50) kHz	0.008 % of reading + 1 mV	
	(50 to 100) kHz	0.015 % of reading + 2.5 mV	
	(100 to 300) kHz	0.09 % of reading + 16 mV	
	(300 to 500) kHz	0.44 % of reading + 40 mV	
	500 kHz to 1 MHz	0.8 % of reading + 80 mV	
	(220 to 1 100) V		
	(15 to 50) Hz	0.03 % of reading + 16 mV	
	50 Hz to 1 kHz	0.007 % of reading + 3.5 mV	
AC Voltage – Source [1]	(220 to 330) V		Fluke 5522A/11 Multiproduct Calibrator
	(1 to 10) kHz	0.02 % of reading + 6 mV	
	(10 to 20) kHz	0.025 % of reading + 6 mV	
	(20 to 50) kHz	0.03 % of reading + 6 mV	
	(50 to 100) kHz	0.2 % of reading + 50 mV	
	(330 to 1 020) V		
	(1 to 5) kHz	0.025 % of reading + 10 mV	
	(5 to 10) kHz	0.03 % of reading + 10 mV	
AC Voltage – Source [1] (Wideband Amplitude)	30 Hz to 500 kHz		Fluke 5730A/03 Multiproduct Calibrator
	(0.3 to 1.1) mV	0.8 % of reading + 2 µV	
	(1.1 to 3) mV	0.7 % of reading + 3 µV	
	(3 to 11) mV	0.7 % of reading + 8 µV	
	(11 to 33) mV	0.6 % of reading + 16 µV	
	(33 to 110) mV	0.6 % of reading + 40 µV	
	(110 to 330) mV	0.5 % of reading + 0.1 mV	
	(0.33 to 1.1) V	0.5 % of reading + 0.4 mV	
	(1.1 to 3.5) V	0.4 % of reading + 0.5 mV	
Wideband Amplitude Flatness – Source [1] (1 kHz reference)	Up to 1.1 mV		Fluke 5730A/03 Multiproduct Calibrator
	(10 to 30) Hz	0.3 % of reading	
	(30 to 120) Hz	0.1 % of reading	
	120 Hz to 1.2 kHz	0.1 % of reading	
	(1.2 to 12) kHz	0.1 % of reading	
	(12 to 120) kHz	0.1 % of reading	
	120 kHz to 1.2 MHz	0.2 % of reading + 3 µV	
	(1.2 to 2) MHz	0.2 % of reading + 3 µV	
	(2 to 12) MHz	0.4 % of reading + 3 µV	
	(12 to 20) MHz	0.6 % of reading + 3 µV	
	(20 to 30) MHz	1.5 % of reading + 15 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Wideband Amplitude Flatness – Source [1] (1 kHz reference)	(1.1 to 3.3) mV (10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 12) kHz (12 to 120) kHz 120 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (3.3 to 11) mV (10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 12) kHz (12 to 120) kHz 120 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.3 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading + 3 µV 0.1 % of reading + 3 µV 0.3 % of reading + 3 µV 0.5 % of reading + 3 µV 1.5 % of reading + 3 µV 0.3 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading + 3 µV 0.1 % of reading + 3 µV 0.2 % of reading + 3 µV 0.4 % of reading + 3 µV 1 % of reading + 3 µV	Fluke 5730A/03 Multiproduct Calibrator
AC Voltage – Measure [1]	Up to 220 mV (1 to 10) Hz (0.22 to 220) V (1 to 10) Hz (220 to 1 000) V (1 to 10) Hz	 0.017 % of reading + 70 µV 0.015 % of reading + 60 µV 0.015 % of reading + 70 µV	Fluke 8508A opt 001 8.5 Digit Multimeter
	(0.6 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	 0.17 % of reading + 1.3 µV 0.074 % of reading + 1.3 µV 0.042 % of reading + 1.3 µV 0.081 % of reading + 2 µV 0.12 % of reading + 2.5 µV 0.23 % of reading + 4 µV 0.24 % of reading + 8 µV 0.35 % of reading + 8 µV	Fluke 5790A-03 AC Measurement Standard

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(2.2 to 7) mV		Fluke 5790A-03 AC Measurement Standard
	(10 to 20) Hz	0.085 % of reading + 1.3 µV	
	(20 to 40) Hz	0.037 % of reading + 1.3 µV	
	40 Hz to 20 kHz	0.021 % of reading + 1.3 µV	
	(20 to 50) kHz	0.04 % of reading + 2 µV	
	(50 to 100) kHz	0.06 % of reading + 2.5 µV	
	(100 to 300) kHz	0.12 % of reading + 4 µV	
	(300 to 500) kHz	0.13 % of reading + 8 µV	
	500 kHz to 1 MHz	0.23% of reading + 8 µV	
	(7 to 22) mV		
	(10 to 20) Hz	0.029 % of reading + 1.3 µV	
	(20 to 40) Hz	0.019 % of reading + 1.3 µV	
	40 Hz to 20 kHz	0.011 % of reading + 1.3 µV	
	(20 to 50) kHz	0.021 % of reading + 2 µV	
	(50 to 100) kHz	0.031 % of reading + 2.5 µV	
	(100 to 300) kHz	0.081 % of reading + 4 µV	
	(300 to 500) kHz	0.089 % of reading + 8 µV	
	500 kHz to 1 MHz	0.17 % of reading + 8 µV	
	(22 to 70) mV		
	(10 to 20) Hz	0.024 % of reading + 1.5 µV	
	(20 to 40) Hz	0.012 % of reading + 1.5 µV	
	40 Hz to 20 kHz	65 µV/V + 1.5 µV	
	(20 to 50) kHz	0.013 % of reading + 2 µV	
	(50 to 100) kHz	0.026 % of reading + 2.5 µV	
	(100 to 300) kHz	0.051 % of reading + 4 µV	
	(300 to 500) kHz	0.067 % of reading + 8 µV	
	500 kHz to 1 MHz	0.11 % of reading + 8 µV	
	(70 to 220) mV		
	(10 to 20) Hz	0.021 % of reading + 1.5 µV	
	(20 to 40) Hz	85 µV/V + 1.5 µV	
	40 Hz to 20 kHz	38 µV/V + 1.5 µV	
	(20 to 50) kHz	69 µV/V + 2 µV	
	(50 to 100) kHz	0.016 % of reading + 2.5 µV	
	(100 to 300) kHz	0.025 % of reading + 4 µV	
	(300 to 500) kHz	0.038 % of reading + 8 µV	
	500 kHz to 1 MHz	0.1 % of reading + 8 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(220 to 700) mV		Fluke 5790A-03 AC Measurement Standard
	(10 to 20) Hz	0.021 % of reading + 1.5 µV	
	(20 to 40) Hz	76 µV/V + 1.5 µV	
	40 Hz to 20 kHz	33 µV/V + 1.5 µV	
	(20 to 50) kHz	51 µV/V + 2 µV	
	(50 to 100) kHz	79 µV/V + 2.5 µV	
	(100 to 300) kHz	0.018 % of reading + 4 µV	
	(300 to 500) kHz	0.03 % of reading + 8 µV	
	500 kHz to 1 MHz	0.096 % of reading + 8 µV	
	(0.7 to 2.2) V		
	(10 to 20) Hz	0.021 % of reading + 1.5 µV	
	(20 to 40) Hz	76 µV/V + 1.5 µV	
	40 Hz to 20 kHz	33 µV/V + 1.5 µV	
	(20 to 50) kHz	51 µV/V + 2 µV	
	(50 to 100) kHz	79 µV/V + 2.5 µV	
	(100 to 300) kHz	0.018 % of reading + 4 µV	
	(300 to 500) kHz	0.03 % of reading + 8 µV	
	500 kHz to 1 MHz	0.096 % of reading + 8 µV	
	(2.2 to 7) V		
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	67 µV/V	
	40 Hz to 20 kHz	24 µV/V	
	(20 to 50) kHz	48 µV/V	
	(50 to 100) kHz	81 µV/V	
	(100 to 300) kHz	0.02 % of reading	
	(300 to 500) kHz	0.04 % of reading	
	500 kHz to 1 MHz	0.12 % of reading	
	(7 to 22) V		
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	67 µV/V	
	40 Hz to 20 kHz	27 µV/V	
	(20 to 50) kHz	48 µV/V	
	(50 to 100) kHz	81 µV/V	
	(100 to 300) kHz	0.02 % of reading	
	(300 to 500) kHz	0.04 % of reading	
	500 kHz to 1 MHz	0.12 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(22 to 70) V		Fluke 5790A-03 AC Measurement Standard
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	68 µV/V	
	40 Hz to 20 kHz	32 µV/V	
	(20 to 50) kHz	57 µV/V	
	(50 to 100) kHz	94 µV/V	
	(100 to 300) kHz	0.02 % of reading	
	(300 to 500) kHz	0.04 % of reading	
	500 kHz to 1 MHz	0.12 % of reading	
	(70 to 220) V		
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	68 µV/V	
	40 Hz to 20 kHz	31 µV/V	
	(20 to 50) kHz	69 µV/V	
	(50 to 100) kHz	98 µV/V	
	(100 to 300) kHz	0.02 % of reading	
	(300 to 500) kHz	0.05 % of reading	
	(220 to 700) V		
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	99 µV/V	
	40 Hz to 20 kHz	41 µV/V	
	(20 to 50) kHz	0.01 % of reading	
	(50 to 100) kHz	0.05 % of reading	
	(700 to 1 000) V		
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	99 µV/V	
	40 Hz to 20 kHz	38 µV/V	
	(20 to 50) kHz	0.01 % of reading	
	(50 to 100) kHz	0.05 % of reading	
Wideband Amplitude Flatness – Measure [1] (1 kHz reference)	(0.6 to 2.2) mV		Fluke 5790A-03 AC Measurement Standard
	50 kHz to 1.2 MHz	0.07 % of reading + 1 µV	
	(1.2 to 2) MHz	0.07 % of reading + 1 µV	
	(2 to 10) MHz	0.17 % of reading + 1 µV	
	(10 to 20) MHz	0.3 % of reading + 1 µV	
	(20 to 30) MHz	0.7 % of reading + 2 µV	
	(2.2 to 7) mV		
	50 kHz to 1.2 MHz	0.07 % of reading + 1 µV	
	(1.2 to 2) MHz	0.07 % of reading + 1 µV	
	(2 to 10) MHz	0.1 % of reading + 1 µV	
	(10 to 20) MHz	0.17 % of reading + 1 µV	
	(20 to 30) MHz	0.37 % of reading + 1 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Wideband Amplitude Flatness – Measure [1] (1 kHz reference)	(7 to 22) mV		Fluke 5790A-03 AC Measurement Standard
	50 kHz to 1.2 MHz	0.07 % of reading	
	(1.2 to 2) MHz	0.07 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.17 % of reading	
	(20 to 30) MHz	0.37 % of reading	
	(22 to 70) mV		
	50 kHz to 1.2 MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(70 to 220) mV		
	50 kHz to 1.2 MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(220 to 700) mV		
	50 kHz to 1.2 MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(0.7 to 2.2) V		
	50 kHz to 1.2 MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(2.2 to 7) V		
	50 kHz to 1.2 MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
AC Current – Source [1]	Up to 220 µA		Fluke 5730A/03 Multiproduct Calibrator
	(10 to 20) Hz	0.025 % of reading + 16 nA	
	(20 to 40) Hz	0.016 % of reading + 10 nA	
	40 Hz to 1 kHz	0.01 % of reading + 8 nA	
	(1 to 5) kHz	0.028 % of reading + 12 nA	
	(5 to 10) kHz	0.11 % of reading + 65 nA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1]	(0.22 to 2.2) mA		Fluke 5730A/03 Multiproduct Calibrator
	(10 to 20) Hz	0.025 % of reading + 40 nA	
	(20 to 40) Hz	0.016 % of reading + 35 nA	
	40 Hz to 1 kHz	0.01 % of reading + 35 nA	
	(1 to 5) kHz	0.02 % of reading + 0.11 µA	
	(5 to 10) kHz	0.11 % of reading + 0.65 µA	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.025 % of reading + 0.4 µA	
	(20 to 40) Hz	0.016 % of reading + 0.35 µA	
	40 Hz to 1 kHz	0.01 % of reading + 0.35 µA	
	(1 to 5) kHz	0.02 % of reading + 0.55 µA	
	(5 to 10) kHz	0.11 % of reading + 5 µA	
	(22 to 220) mA		
	(10 to 20) Hz	0.025 % of reading + 4 µA	
	(20 to 40) Hz	0.016 % of reading + 3.5 µA	
	40 Hz to 1 kHz	0.01 % of reading + 2.5 µA	
	(1 to 5) kHz	0.02 % of reading + 3.5 µA	
	(5 to 10) kHz	0.11 % of reading + 10 µA	
	(0.22 to 2.2) A		
	20 Hz to 1 kHz	0.024 % of reading + 35 µA	
	(1 to 5) kHz	0.045 % of reading + 80 µA	
	(5 to 10) kHz	0.7 % of reading + 0.16 mA	
	(2.2 to 3) A		
	(10 to 45) Hz	0.18 % of reading + 0.1 mA	
	45 Hz to 1 kHz	0.06 % of reading + 0.1 mA	
	(1 to 5) kHz	0.6 % of reading + 1 mA	
	(5 to 10) kHz	2.5 % of reading + 5 mA	
	(3 to 11) A		Fluke 5522A/11 Multiproduct Calibrator
	(45 to 100) Hz	0.06 % of reading + 2 mA	
	(0.1 to 1) kHz	0.1 % of reading + 2 mA	
	(1 to 5) kHz	3 % of reading + 2 mA	
	(11 to 20.5) A		
	(45 to 100) Hz	0.12 % of reading + 5 mA	
	100 Hz to 1 kHz	0.15 % of reading + 5 mA	
	(1 to 5) kHz	3 % of reading + 5 mA	
AC Clamp-on Meters – Source [1]	(20 to 150) A		Fluke 5522A/11 Multiproduct Calibrator, 50-turn Coil
	(65 to 440) Hz	0.79 % of reading + 0.1 A	
	(20to 1 000) A		
	(45 to 65) Hz	0.28 % of reading + 90 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	Up to 200 µA		Fluke 8508A opt 001 8.5 Digit Multimeter
	1 Hz to 10 kHz	0.031 % of reading + 20 nA	
	(10 to 30) kHz	0.071 % of reading + 20 nA	
	(30 to 100) kHz	0.4 % of reading + 20 nA	
	(0.2 to 2) mA		
	(1 to 10) Hz	0.031 % of reading + 0.2 µA	
	10 Hz to 10 kHz	0.03 % of reading + 0.2 µA	
	(10 to 30) kHz	0.071 % of reading + 0.2 µA	
	(30 to 100) kHz	0.4 % of reading + 0.2 µA	
	(2 to 20) mA		
	(1 to 10) Hz	0.031 % of reading + 2 µA	
	10 Hz to 10 kHz	0.03 % of reading + 2 µA	
	(10 to 30) kHz	0.071 % of reading + 2 µA	
	(30 to 100) kHz	0.4 % of reading + 2 µA	
	(20 to 200) mA		
	1 Hz to 10 Hz	0.031 % of reading + 20 µA	
	10 Hz to 10 kHz	0.029 % of reading + 20 µA	
	(10 to 30) kHz	0.063 % of reading + 20 µA	
	(0.2 to 2) A		
	10 Hz to 2 kHz	0.062 % of reading + 0.2 mA	
	(2 to 10) kHz	0.074 % of reading + 0.2 mA	
	(10 to 30) kHz	0.3 % of reading + 0.2 mA	
	(2 to 20) A		
	10 Hz to 2 kHz	0.082 % of reading + 2 mA	
	(2 to 10) kHz	0.25 % of reading + 2 mA	
	(1 to 10) mA		Fluke 5790A-03 AC Measurement Standard, Fluke A40 Current Shunts
	(5 to 400) Hz	0.002 % of reading	
	400 Hz to 20 kHz	0.003 % of reading	
	(20 to 50) kHz	0.004 % of reading	
	(50 to 100) kHz	0.006 % of reading	
	(10 to 30) mA		
	(5 to 400) Hz	0.002 % of reading	
	400 Hz to 20 kHz	0.003 % of reading	
	(20 to 50) kHz	0.005 % of reading	
	(50 to 100) kHz	0.007 % of reading	
	(30 to 300) mA		
	(5 to 400) Hz	0.003 % of reading	
	400 Hz to 20 kHz	0.004 % of reading	
	(20 to 50) kHz	0.007 % of reading	
	(50 to 100) kHz	0.01 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(0.3 to 3) A (5 to 400) Hz 400 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (3 to 10) A (5 to 400) Hz 400 Hz to 20 kHz (20 to 50) kHz (10 to 20) A (5 to 400) Hz 400 Hz to 20 kHz (20 to 50) kHz	 0.002 % of reading 0.003 % of reading 0.005 % of reading 0.01 % of reading 0.002 % of reading 0.003 % of reading 0.005 % of reading 0.007 % of reading 0.012 % of reading 0.018 % of reading	Fluke 5790A-03 AC Measurement Standard, Fluke A40 Current Shunts
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	Type B (600 to 800) °C (800 to 1 000) °C (1 000 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 150) °C (150 to 650) °C (650 to 1000) °C (1 000 to 1 800) °C (1 800 to 2 316) °C Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1 000) °C Type J (-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1 200) °C Type K (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1 000) °C (1 000 to 1 372) °C	 0.44 °C 0.34 °C 0.3 °C 0.33 °C 0.3 °C 0.26 °C 0.31 °C 0.5 °C 0.84 °C 0.5 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C 0.27 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C 0.33 °C 0.18 °C 0.16 °C 0.26 °C 0.4 °C	Fluke 5522A/11 Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	Type N (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1 300) °C Type R (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (1 000 to 1 767) °C Type S (0 to 250) °C (250 to 1 000) °C (1 000 to 1 400) °C (1 400 to 1 767) °C Type T (-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.4 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C 0.57 °C 0.35 °C 0.33 °C 0.4 °C 0.47 °C 0.36 °C 0.37 °C 0.46 °C 0.63 °C 0.24 °C 0.16 °C 0.14 °C 0.56 °C 0.27 °C	Fluke 5522A/11 Multiproduct Calibrator
Electrical Simulation of RTD Indicating Devices – Source [1]	Pt 385, 100 Ω (-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C Pt 385, 200 Ω (-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	 0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.12 °C 0.23 °C 0.04 °C 0.04 °C 0.04 °C 0.05 °C 0.12 °C 0.13 °C 0.14 °C 0.16 °C	Fluke 5522A/11 Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices – Source [1]	Pt 385, 500 Ω		Fluke 5522A/11 Multiproduct Calibrator
	(-200 to -80) °C	0.04 °C	
	(-80 to 0) °C	0.05 °C	
	(0 to 100) °C	0.05 °C	
	(100 to 260) °C	0.06 °C	
	(260 to 300) °C	0.08 °C	
	(300 to 400) °C	0.08 °C	
	(400 to 600) °C	0.09 °C	
	(600 to 630) °C	0.11 °C	
	Pt 385, 1 kΩ		
	(-200 to -80) °C	0.03 °C	
	(-80 to 0) °C	0.03 °C	
	(0 to 100) °C	0.04 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 300) °C	0.06 °C	
	(300 to 400) °C	0.07 °C	
	(400 to 600) °C	0.07 °C	
	(600 to 630) °C	0.23 °C	
	Pt 3916, 100 Ω		
	(-200 to -190) °C	0.25 °C	
	(-190 to -80) °C	0.04 °C	
	(-80 to 0) °C	0.05 °C	
	(0 to 100) °C	0.06 °C	
	(100 to 260) °C	0.07 °C	
	(260 to 300) °C	0.08 °C	
	(300 to 400) °C	0.09 °C	
	(400 to 600) °C	0.1 °C	
	(600 to 630) °C	0.23 °C	
	Pt 3926, 100 Ω		
	(-200 to -80) °C	0.05 °C	
	(-80 to 0) °C	0.05 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 630) °C	0.12 °C	
	PtNi 385, 120 Ω		
	(-80 to 0) °C	0.08 °C	
	(0 to 100) °C	0.08 °C	
	(100 to 260) °C	0.14 °C	
	Cu 427, 10 Ω		
	(-100 to 260) °C	0.3 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase – Source [1]	(0 to 180)° (10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	 0.1° 0.25° 0.5° 2.5° 5° 10°	Fluke 5522A/11 Multiproduct Calibrator
Phase – Measure [1] (0 to 360)° (Sine Wave)	10 mV to 350 V (5 to 10) Hz 10 Hz to 50 kHz 10 mV to 12.5 V (50 to 100) kHz (12.5 to 350) V 10 Hz to 10 kHz	 0.23° 0.051° 0.23° 0.051°	Clarke-Hess 6000 Precision Phase Meter
Oscilloscopes [1,2]			Fluke 5522A/11 Multiproduct Calibrator
Amplitude DC			
into 50 Ω load	(-6.6 to 6.6) V	0.2 % of reading + 31 µV	
into 1 MΩ load	(-130 to 130) V	0.039 % of reading + 31 µV	
Amplitude Square Wave			
into 50 Ω load	10 Hz to 10 kHz 1 mVp-p to 6.6 Vp-p	 0.19 % of reading + 31 µV	
into 1 MΩ load	10 Hz to 1 kHz 1 mVp-p to 6.6 Vp-p (1 to 10) kHz 1 mVp-p to 6.6 Vp-p	 0.078 % of reading + 31 µV 0.19 % of reading + 31 µV	
Timing – Generate			
into 50 Ω load	1 ns to 20 ms 50 ms 0.1 s 0.2 s 0.5 s 1 s 2 s 5 s	0.000 22 % of reading 2.3 µs 7.6 µs 28 µs 0.16 ms 0.62 ms 2.4 ms 15 ms	
Edge Rise Time – Generate			
into 50 Ω Load	5 mVp-p to 2.5 Vp-p		
Rate: 1 kHz to 2 MHz	250 ps (nominal)	50 ps	
Rate: 2 MHz to 10 MHz	250 ps (nominal)	50 ps	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1,2]			Fluke 5522A/11 Multiproduct Calibrator
Leveled Sine Wave			
into 50 Ω load	5 mVp-p to 5.5 Vp-p		
	50 kHz	1.8 % of reading + 0.23 mV	
	50 kHz to 100 MHz	2.8 % of reading + 0.23 mV	
	(100 to 300) MHz	3.2 % of reading + 0.23 mV	
	(300 to 600) MHz	4 % of reading + 0.23 mV	
	5 mVp-p to 3.5 Vp-p		
	600 MHz to 1.1 GHz	5.5 % of reading + 0.23 mV	
Bandwidth/Flatness			
into 50 Ω load	5 mVp-p to 5.5 Vp-p		
(50 kHz Reference)	50 kHz to 100 MHz	1.4 % of reading + 78 µV	
	(100 to 300) MHz	1.8 % of reading + 78 µV	
	(300 to 600) MHz	3.2 % of reading + 78 µV	
	5 mVp-p to 3.5 Vp-p		
	600 MHz to 1.1 GHz	4 % of reading + 78 µV	
Input Impedance – Measure			
into 50 Ω load	(40 to 60) Ω	0.082 % of reading	
into 1 MΩ load	(0.5 to 1.5) MΩ	0.081 % of reading	
Input Capacitance – Measure	(5 to 50) pF	3.9 % of reading + 0.39 pF	
Wave Generator – Source			
Amplitude			
(Sine, Square, Triangle)	10 Hz to 10 kHz		
into 50 Ω load	1.8 mVp-p to 2.5 Vp-p	2.3 % of reading + 78 µV	
into 1 MΩ load	1.8 mVp-p to 55 Vp-p	2.3 % of reading + 78 µV	
Frequency	10 Hz to 10 kHz	0.001 9 % of reading + 12 mHz	
Pulse Characterization			Tektronix CSA803C Comm Signal Analyzer, Tektronix SD-26 Sampling Head
Rise Time – Measure	30 ps to 1 µs	21 ps	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source [1,3]	(-35 to 14) dBm 100 MHz to 2.4 GHz (2.4 to 8) GHz (8 to 18) GHz (18 to 26.5) GHz	 0.08 dB 0.11 dB 0.14 dB 0.17 dB	Fluke 96720A RF Reference Source, R&S NRP-Z55(x2) Power Sensor, Agilent 11667B Power Splitter, Sucoflex 102EA 40 GHz Test Cable
RF Absolute Power – Measure [1]	1 mW Reference, 50 MHz	0.03 % of reading	HP 8478B Power Sensor, HP 432A Power Meter
RF Absolute Power – Measure [1,3]	(-65 to -35) dBm (> 0.01 to ≤ 0.03) GHz (> 0.03 to ≤ 4.00) GHz (> 4.00 to ≤ 8.00) GHz (> 8.00 to ≤ 10.00) GHz (> 10.00 to ≤ 13.00) GHz (> 13.00 to ≤ 15.00) GHz (> 15.00 to ≤ 18.00) GHz	 2.84 % of reading 1.9 % of reading 2.34 % of reading 2.44 % of reading 2.98 % of reading 3.48 % of reading 3.84 % of reading	HP 8484A Power Sensor, Agilent E4419B Power Meter
	(-35 to 20) dBm DC to 100 MHz (> 0.1 to ≤ 2.4) GHz (> 2.4 to ≤ 8) GHz (> 8 to ≤ 12.4) GHz (> 12.4 to ≤ 18) GHz (> 18 to ≤ 26.5) GHz (> 26.5 to ≤ 33) GHz (> 33 to ≤ 40) GHz	 0.04 dB 0.048 dB 0.054 dB 0.063 dB 0.082 dB 0.086 dB 0.11 dB 0.11 dB	Fluke 96720A RF Reference Source, R&S NRP-Z55(x2) Power Sensor
Tuned RF Absolute Power – Measure [3]	2.5 MHz to 26.5 GHz (-127 to -110) dBm (-110 to -90) dBm (-90 to -80) dBm (-80 to -50) dBm (-50 to -40) dBm (-40 to -10) dBm (-10 to 0) dBm (0 to 10) dBm	 0.54 dB 0.39 dB 0.37 dB 0.34 dB 0.33 dB 0.31 dB 0.3 dB 0.3 dB	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – AM Depth Measure [1]			HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
Rate: 50 Hz to 10 kHz	150 kHz to 10 MHz (5 to 40) % Depth (40 to 99) % Depth	 0.85 % Depth 2.3 % Depth	
Rate: (20 to 50) Hz	150 kHz to 10 MHz (5 to 40) % Depth (40 to 99) % Depth	 1.3 % Depth 3.3 % Depth	
Rate: 50 Hz to 50 kHz	10 MHz to 1.3 GHz (5 to 40) % Depth (40 to 99) % Depth	 0.45 % Depth 1.3 % Depth	
Rate: 50 Hz to 50 kHz	(1.3 to 26.5) GHz (5 to 40) % Depth (40 to 99) % Depth	 0.65 % Depth 1.8 % Depth	
Rate: (20 to 50) Hz or (50 to 100) kHz	10 MHz to 26.5 GHz (5 to 40) % Depth (40 to 99) % Depth	 1.3 % Depth 3.3 % Depth	
Frequency Modulation – Measure			HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
Rate: 20 Hz to 10 kHz	250 kHz to 10 MHz Dev: ≤ 40 kHz pk	 2 % of reading + 1 digit	
Rate: 50 Hz to 100 kHz	10 MHz to 1.3 GHz Dev: ≤ 400 kHz pk 10 MHz to 26.5 GHz Dev: ≤ 400 kHz pk	 1 % of reading + 1 digit 1 % of reading + 1 digit	
Rate: 20 Hz to 200 kHz	10 MHz to 1.3 GHz Dev: ≤ 400 kHz pk 10 MHz to 26.5 GHz Dev: ≤ 400 kHz pk	 6 % of reading + 1 digit 6 % of reading + 1 digit	
Phase Modulation – Measure Rate: 200 Hz to 10 kHz	150 kHz to 10 MHz	5 % of reading + 1 digit	
Rate: 200 Hz to 20 kHz	10 MHz to 26.5 GHz	4 % of reading + 1 digit	
Power Range Accuracy – Measure	3 µW to 100 mW	0.15 µW	HP 11683A

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Distortion – Measure	20 Hz to 20 kHz (-80 to 0) dB (20 to 100) kHz (-65 to 0) dB	1.2 dB 2.4 dB	HP 8903B Audio Analyzer
RF Amplitude Frequency Response – Measure	9 kHz to 2.9 GHz (2.90 to 6.46) GHz (6.46 to 13) GHz (13 to 19.7) GHz (19.7 to 22) GHz	1.1 dB 1.5 dB 2.1 dB 3.1 dB 3.1 dB	HP 8562A Spectrum Analyzer
VSWR – Measure (VWSR = 1 to 1.4)	10 MHz to 18 GHz (0 to 60) dB	0.1 dB	Gigatronics 8003 Precision Scalar Analyzer, Gigatronics 80501 Return Loss Bridge
Absolute Power – Measure (Swept Mode)	10 MHz to 1 GHz (1 to 2) GHz (2 to 4) GHz (4 to 6) GHz (6 to 8) GHz (8 to 12.4) GHz (12.4 to 18) GHz	0.082 dB 0.089 dB 0.096 dB 0.1 dB 0.11 dB 0.13 dB 0.14 dB	Gigatronics 8003 Precision Scalar Analyzer, Gigatronics 80301 Return Loss Bridge (or 80302, or 80501)
Leveled Sine Wave Output – Absolute Amplitude Accuracy Level [3]	10 Hz to 4 GHz (-130 to -94) dBm (-94 to -74) dBm (-74 to -17) dBm (-17 to 24) dBm	1.1 dB 0.68 dB 0.34 dB 0.2 dB	Fluke 96720A RF Reference Source, Fluke 96040A-50 Low Phase Noise Reference Source
	10 Hz to 4 GHz (-120 to -100) dBm (-100 to -80) dBm (-80 to 18) dBm	1.1 dB 0.67 dB 0.34 dB	Fluke 96720A RF Reference Source, Fluke 96040A-75 Low Phase Noise Reference Source

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers, Calipers (Outside, Inside, Depth and Step) [1]	(0.01 to 0.04) in (0.05 to 1) in (1 to 4) in (4 to 15) in (15 to 40) in	13 µin (13 + 1*L*) µin (9 + 4*L*) µin (12 + 4*L*) µin (16 + 4*L*) µin	Gage Blocks

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Anvil Flatness [1]	Up to 1 in Diameter	14 µin	Optical Flats
Spindle Parallelism	Up to 1 in Diameter	14 µin	Optical Flats
Length – OD Measurement [1,2] (Single Axis)	Up to 1 in (1 to 4) in (4 to 15) in (15 to 20) in	(19 + 2*L*) µin (15 + 4*L*) µin (17 + 4*L*) µin (5 + 5*L*) µin	Universal Length Measuring Machine
	(20 to 40) in	(64 + 4*L*) µin	Gage Amplifier/Check, Gage Blocks
Cylindrical Ring Gages [2]	Up to 16 in	(14 + 4.6*L*) µin	Universal Length Measuring Machine
Thread Ring Gages [2]	Up to 6 in	(22 + 4.7*L*) µin	Comparison to Set Plugs
Cylindrical Plug Gages [2]	Up to 16 in	(13 + 4.6*L*) µin	Universal Length Measuring Machine
Thread Plug Gages Major Diameter (OD) Pitch Diameter	 Up to 6 in Up to 6 in	 (15 + 3.7*L*) µin (23 + 3.1*L*) µin	Universal Length Measuring Machine, Thread Wires
Surface Plates [1,2] Overall Flatness Local Area Flatness	 Up to 161 in*DL* Up to 0.001 in	 95 µin 29 µin	In accordance with ASME B89.3.7 using Planekator Repeat-O-Meter
Coating Thickness Gages (Eddy Current, Magnetic Induction, Fixed Point)	Up to 3 000 µm Up to 118 mils	(0.59 + 0.03*L*) µm (0.023 + 0.001*L*) mils	Universal Length Measuring Machine, Shims, Gage Blocks
Dial Indicators	Up to 1 in (1 to 4) in	(22 + 2*L*) µin (21 + 3*L*) µin	Universal Length Measuring Machine, Gage Blocks

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Air/Nitrogen Flow Meters	Up to 100 slm	0.73 % of reading	CME FCS Laminar Flow Elements
Liquid Flow Meters	Up to 250 gpm	0.33 % of reading	FT-32 Turbine Flow System
Air Velocity Measuring Equipment	Up to 5 800 ft/min	1.7 % of reading	Alnor RVA Anemometer, Wind Tunnel

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pneumatic Pressure Gages, Vacuum Gages [4]	-30 inHg to 1 000 psig	0.02 % of span	DHI PPC4EX-7M Pressure Controller
Pneumatic Pressure Gages, Vacuum Gages [4]	(0.1 to 1 000) psia	0.02 % of span + 0.007 psi	DHI PPC4EX-7M Pressure Controller
Pneumatic Pressure Gages	(0.2 to 718) psia (psig)	0.003 % of reading	Ruska 2465 Gas Piston Gauge
Hydraulic Pressure Gages	(100 to 50 000) psig	0.008 % of reading	DHI 5306 Liquid Piston Gauge
Pressure/Vacuum Gages [1] (Pneumatic and Hydraulic)	(0 to 900) mmHg (15 to 30) psig (30 to 300) psig (300 to 500) psig (500 to 3 000) psig (3 000 to 10 000) psig	0.23 mmHg 0.08 psi 0.15 psi 0.13 psi 1.5 psi 8 psi	Fluke PPH Calibrator
Scales and Balances [1,5]	Up to 500 mg (0.5 to 5) g (5 to 10) g (10 to 20) g (20 to 100) g (0.1 to 5) kg (5 to 10) kg	0.025 mg 0.04 mg 0.059 mg 0.089 mg 0.000 32 % of reading 0.000 59 % of reading 0.000 41 % of reading	ASTM E617 Class 1 and Class 2 Weights and internal calibration procedure utilized for the calibration of the weighing system.
	Up to 14 kg (14 to 18) kg (18 to 32) kg (32 to 40) kg	0.012 % of reading 0.01 % of reading 0.009 % of reading 0.008 % of reading	ASTM E617 Class 6 Weights and internal calibration procedure utilized for the calibration of the weighing system.
	Up to 7 g (7 to 453) g 453 g to 2.2 kg (2.2 to 227) kg	0.24 % of reading 0.025 % of reading 0.019 % of reading 0.012 % of reading	NIST Class F Weights and internal calibration procedure utilized for the calibration of the weighing system.
Scales and Balances [1,5]	Up to 30 lb (30 to 40) lb (40 to 70) lb (70 to 90) lb	0.012 % of reading 0.01 % of reading 0.009 % of reading 0.008 % of reading	ASTM E617 Class 6 Weights and internal calibration procedure utilized for the calibration of the weighing system.
	Up to 0.5 lb (0.5 to 1) lb (1 to 5) lb (5 to 500) lb	0.24 % of reading 0.025 % of reading 0.019 % of reading 0.012 % of reading	NIST Class F Weights and internal calibration procedure utilized for the calibration of the weighing system.

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Measuring Equipment [1] Compression	Up to 10 lbf (10 to 25) lbf (25 to 50) lbf (50 to 150) lbf (150 to 250) lbf (250 to 500) lbf	0.001 5 lbf 0.002 1 lbf 0.008 3 lbf 0.023 lbf 0.065 lbf 0.13 lbf	NIST Class F Weights
	(500 to 5 000) lbf	2.3 lbf	Optima OP-312 Load Cell
	(5 000 to 20 000) lbf	9.1 lbf	Transcell BSS-20K Load Cell
Force Measuring Equipment [1] Tension	Up to 10 lbf (10 to 25) lbf (25 to 50) lbf (50 to 150) lbf (150 to 250) lbf (250 to 500) lbf	0.001 5 lbf 0.002 1 lbf 0.008 3 lbf 0.023 lbf 0.065 lbf 0.13 lbf	NIST Class F Weights
	(500 to 5 000) lbf	2.3 lbf	Optima OP-312 Load Cell
	(5 000 to 10 000) lbf	6.8 lbf	Transcell BSS-10K Load Cell
	(10 000 to 20 000) lbf	9.1 lbf	Transcell BSS-20K Load Cell
	(20 000 to 50 000) lbf	23 lbf	Optima OP-351 Load Cell
	(50 000 to 100 000) lbf	42 lbf	Rinstrum TLWS-100K Load Cell
Torque Devices	2 ozf·in to 2 000 lbf·ft	0.3 % of reading	AKO TSD2050 Torque Master
Torque Transducers	20 ozf·in to 100 lbf·in 100 lbf·in to 125 lbf·ft (125 to 2 000) lbf·ft	0.05 % of reading 0.06 % of reading 0.08 % of reading	Torque Arms, Master Weights

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Illuminance – Lux Meters	(180 to 1 792) lux (1 792 to 17 000) lux	1.6 % of reading 1.7 % of reading	FEL 1000W Lamp with Power Supply Unit

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Source/Measure	(10 to 90) %RH	1.3 %RH	Comparison to Vaisala HMI-41/HMP-46 Temp/Humidity Indicator/Probe
Temperature – Source/Measure [1]	(-196 to 0) °C (0 to 100) °C	0.042 °C 0.042 °C	Hart Scientific 1521 Handheld Thermometer, Hart Scientific 5618B, Hart Scientific 5627A RTD Probes
	(100 to 420) °C (420 to 960) °C	0.06 °C 0.064 °C	Hart Scientific 1523 Handheld Thermometer, Hart Scientific 5624A RTD Probe
Infrared Measuring Devices [1]	(35 to 200) °C (200 to 350) °C (350 to 500) °C	0.95 °C 1.6 °C 2.1 °C	Black Body Source (Flat Plate) ε = (0.1 to 1), λ = (8 to 14) µm

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source [1]	1 mHz to 27 GHz	0.05 µHz/Hz	Fluke 96720A RF Reference Source
Frequency – Measure [1]	1 Hz to 160 MHz (160 to 171) MHz	3.2 µHz/Hz 5.9 µHz/Hz	Racal Dana 1992 Universal Counter
	171 MHz to 26.5 GHz	0.05 µHz/Hz + 1 count	HP 5343A Microwave Frequency Counter
Optical Rotational Speed – Source/Measure	(1 to 100 000) rpm	0.015 rpm	Agilent 33250A Function Generator
Rotational Speed – Source/Measure [1,3,6]	Up to 5 500 rpm	0.015 % of reading	Comparison to Quantum Dynamics N-11-FCS/3 Tachometer

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

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. t = time in seconds; L = length in inches; DL = diagonal length in inches.
3. CMC does not include the Mismatch value. It will be added in the Measurement Uncertainty reported on the Certificate of Calibration.
4. The span is user set on the unit. The minimum range for this unit is 10 psi.
5. The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The CMC presented here does not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
6. The Resolution of the Device Under Test (DUT) is not included in the CMC, but will be included in the Measurement Uncertainty reported on the Certificate of Calibration. This value is equal to 0.6R, where R = resolution of the DUT.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.21.

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