



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Transcat - Chesapeake
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.

A handwritten signature in black ink, appearing to read 'R. Douglas Leonard Jr.', is positioned above a horizontal line.

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)**

TRANSCAT - CHESAPEAKE

928 Canal Drive
Chesapeake, VA 23323
Kevin Sampsel 757-558-2550

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 (20 to 100) Hz (100 to 2 500) Hz (2 500 to 10 000) Hz (0.8 to 20) g pk (7 to 10) Hz (10 to 30) Hz (300 to 2 000) Hz (2 000 to 10 000) Hz	2.1 % of reading 1.9 % of reading 1.5 % of reading 2.8 % of reading 7 % of reading 6 % of reading 4.5 % of reading 7 % of reading	Vibration Calibrator
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



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Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters	4 pH	0.38 % of reading	Accredited pH Solutions
	7 pH	0.21 % of reading	
	10 pH	0.15 % of reading	
Conductivity Meters	25 μ S/cm	7.4 % of reading	Accredited Conductivity Solutions
	75 μ S/cm	1.8 % of reading	
	1 015 μ S/cm	0.54 % of reading	
	1 408 μ S/cm	0.53 % of reading	
Gas Detection Equipment ¹ CO (Carbon Monoxide)	0.002 % CO 0.006 % CO 0.01 % CO 0.1 % CO 0.5 % CO	0.92 % CO 1.1 % CO 1.1 % CO 0.72 % CO 0.6 % CO	Certified Gas Mixtures
CH ₄ (Methane LEL)	50 % LEL	1.1 % LEL	
C ₅ H ₁₂ (Pentane LEL)	58 % LEL	1.1 % LEL	
H ₂ S (Hydrogen Sulfide)	0.002 5 % H ₂ S	1.1 % H ₂ S	
	0.002 % H ₂ S	2 % H ₂ S	
O ₂ (Oxygen)	0.5 % O ₂	1.1 % O ₂	
	5 % O ₂	0.73 O ₂	
	15 % O ₂	0.82 % O ₂	
	18 % O ₂	1.1 % O ₂	
C ₄ H ₈ (Isobutylene)	0.01 % C ₄ H ₈	2.1 % C ₄ H ₈	
CO ₂ (Carbon Dioxide)	0.5 % CO ₂	1 % CO ₂	
	5 % 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	7.5 μ V/V + 0.4 μ V	Fluke 5730A/03 Multiproduct Calibrator
	(0.22 to 2.2) V	5 μ V/V + 0.7 μ V	
	(2.2 to 11) V	3.5 μ V/V + 2.5 μ V	
	(11 to 22) V	3.5 μ V/V + 4 μ V	
	(22 to 220) V	5 μ V/V + 40 μ V	
	(220 to 1 100) V	6.5 μ V/V + 0.4 mV	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure ¹	Up to 200 mV 200 mV to 20 V (20 to 200) V (200 to 1 000) V	5 μ V/V + 0.5 μ V 3.5 μ V/V + 0.2 μ V 5.5 μ V/V + 0.2 μ V 5.5 μ V/V + 0.5 μ V	Fluke 8508A opt 001 8.5 Digit Multimeter
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) μ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	40 μ A/A + 6 nA 35 μ A/A + 7 nA 35 μ A/A + 40 nA 45 μ A/A + 0.7 μ A 80 μ A/A + 12 μ A	Fluke 5730A/03 Multiproduct Calibrator
	(2.2 to 3) A (3 to 11) A (11 to 20.5) A	0.038 % of reading + 40 μ A 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 μ A/A + 2 μ A 14 μ A/A + 2 μ A	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 μ A/A 8.5 μ A/A + 6 μ A 40 μ A/A + 8 μ A 0.04 % of reading + 24 μ A	Current Shunts, 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
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
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



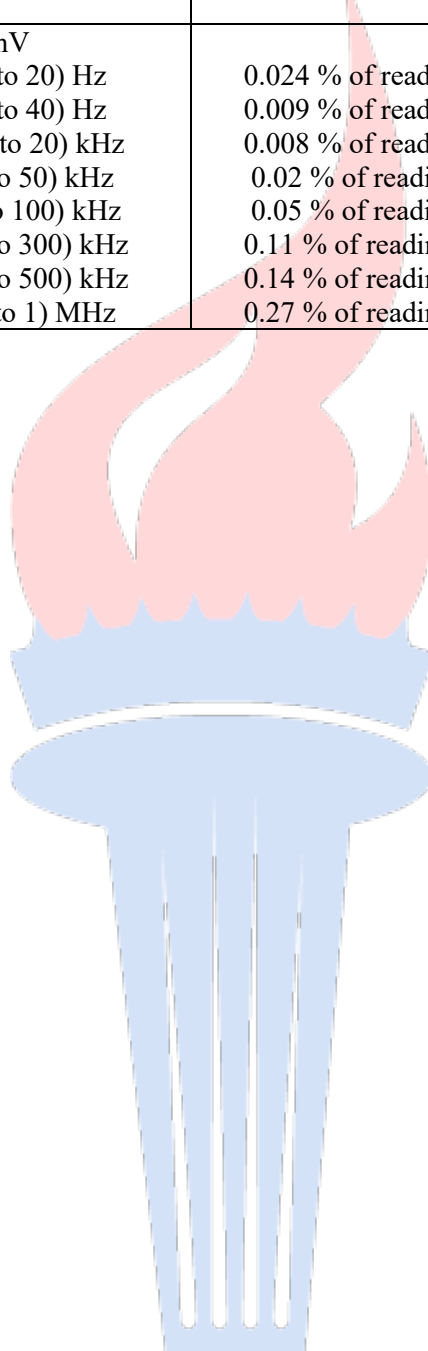
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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
	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
Capacitance – Source ¹	(0.22 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF (0.33 to 1.1) μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF (0.33 to 1.1) mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	0.39 % of reading + 7.7 pF 0.39 % of reading + 7.7 pF 0.39 % of reading + 7.7 pF 0.19 % of reading + 7.7 pF 0.19 % of reading + 77 pF 0.19 % of reading + 77 pF 0.19 % of reading + 0.23 nF 0.19 % of reading + 0.77 nF 0.19 % of reading + 2.3 nF 0.19 % of reading + 7.7 nF 0.31 % of reading + 23 nF 0.35 % of reading + 77 nF 0.35 % of reading + 0.23 μF 0.35 % of reading + 0.77 μF 0.35 % of reading + 2.3 μF 0.35 % of reading + 7.7 μF 0.58 % of reading + 23 μF 0.85 % of reading + 77 μF	Fluke 5522A/11 Multiproduct Calibrator
Capacitance – Measure ¹	1 kHz 400 pF to 25 μF (25 to 100) μF (100 to 500) μF (0.5 to 1) mF	0.02 % of reading + 1 digit 0.05 % of reading + 1 digit 0.05 % of reading + 1 digit 0.09 % of reading + 1 digit	General Radio 1689 RLC Digibridge
Inductance – Measure ¹	1 kHz 1 mH to 10 H	0.02 % of reading + 1 digit	General Radio 1689 RLC Digibridge

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source ¹	Up to 2.2 mV (10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.024 % of reading + 4 μ V 0.009 % of reading + 4 μ V 0.008 % of reading + 4 μ V 0.02 % of reading + 4 μ V 0.05 % of reading + 5 μ V 0.11 % of reading + 10 μ V 0.14 % of reading + 20 μ V 0.27 % of reading + 20 μ V	Fluke 5730A/03 Multiproduct Calibrator



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 (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 (220 to 1 100) V (15 to 50) Hz 50 Hz to 1 kHz	0.024 % of reading + 4 mV 0.009 % of reading + 1.5 mV 0.005 2 % of reading + 0.6 mV 0.008 % of reading + 1 mV 0.015 % of reading + 2.5 mV 0.09 % of reading + 16 mV 0.44 % of reading + 40 mV 0.8 % of reading + 80 mV 0.03 % of reading + 16 mV 0.007 % of reading + 3.5 mV	Fluke 5730A/03 Multiproduct Calibrator
AC Voltage – Source ¹	(220 to 330) V (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (330 to 1 020) V (1 to 5) kHz (5 to 10) kHz	0.02 % of reading + 6 mV 0.025 % of reading + 6 mV 0.03 % of reading + 6 mV 0.2 % of reading + 50 mV 0.025 % of reading + 10 mV 0.03 % of reading + 10 mV	Fluke 5522A/11 Multiproduct Calibrator
AC Voltage – Source ¹ (Wideband Amplitude)	30 Hz to 500 kHz (0.3 to 1.1) mV (1.1 to 3) mV (3 to 11) mV (11 to 33) mV (33 to 110) mV (110 to 330) mV (0.33 to 1.1) V (1.1 to 3.5) V	0.8 % of reading + 2 μV 0.7 % of reading + 3 μV 0.7 % of reading + 8 μV 0.6 % of reading + 16 μV 0.6 % of reading + 40 μV 0.5 % of reading + 0.1 mV 0.5 % of reading + 0.4 mV 0.4 % of reading + 0.5 mV	Fluke 5730A/03 Multiproduct Calibrator
Wideband Amplitude Flatness – Source ¹ (1 kHz reference)	Up to 1.1 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 0.2 % of reading + 3 μV 0.2 % of reading + 3 μV 0.4 % of reading + 3 μV 0.6 % of reading + 3 μV 1.5 % of reading + 15 μV	Fluke 5730A/03 Multiproduct Calibrator



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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	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	Fluke 5730A/03 Multiproduct Calibrator
	(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 0.2 % of reading + 3 μV 0.4 % of reading + 3 μV 1 % of reading + 3 μV	
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 Fluke 5790A-03 AC Measurement Standard
	(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	



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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		



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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 μ V	
	(20 to 40) Hz	76 μ V/V + 1.5 μ V	
	40 Hz to 20 kHz	33 μ V/V + 1.5 μ V	
	(20 to 50) kHz	51 μ V/V + 2 μ V	
	(50 to 100) kHz	79 μ V/V + 2.5 μ V	
	(100 to 300) kHz	0.018 % of reading + 4 μ V	
	(300 to 500) kHz	0.03 % of reading + 8 μ V	
	500 kHz to 1 MHz	0.096 % of reading + 8 μ V	
	(0.7 to 2.2) V		
	(10 to 20) Hz	0.021 % of reading + 1.5 μ V	
	(20 to 40) Hz	76 μ V/V + 1.5 μ V	
	40 Hz to 20 kHz	33 μ V/V + 1.5 μ V	
	(20 to 50) kHz	51 μ V/V + 2 μ V	
	(50 to 100) kHz	79 μ V/V + 2.5 μ V	
	(100 to 300) kHz	0.018 % of reading + 4 μ V	
	(300 to 500) kHz	0.03 % of reading + 8 μ V	
	500 kHz to 1 MHz	0.096 % of reading + 8 μ V	
	(2.2 to 7) V		
	(10 to 20) Hz	0.02 % of reading	
	(20 to 40) Hz	67 μ V/V	
	40 Hz to 20 kHz	24 μ V/V	
	(20 to 50) kHz	48 μ V/V	
	(50 to 100) kHz	81 μ V/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 μ V/V		
40 Hz to 20 kHz	27 μ V/V		
(20 to 50) kHz	48 μ V/V		
(50 to 100) kHz	81 μ V/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 μ A		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		
AC Clamp-on Meters – Source ¹	(0.22 to 2.2) A		Fluke 5522A/11 Multiproduct Calibrator, 50-turn Coil
	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		
	(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		

Electrical – DC/Low Frequency

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

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		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	0.005 % of reading	
	(50 to 100) kHz	0.01 % of reading	
	(3 to 10) A		
	(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	
	(10 to 20) A		
	(5 to 400) Hz	0.007 % of reading	
	400 Hz to 20 kHz	0.012 % of reading	
(20 to 50) kHz	0.018 % of reading		
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	Type B		Fluke 5522A/11 Multiproduct Calibrator
	(600 to 800) °C	0.44 °C	
	(800 to 1 000) °C	0.34 °C	
	(1 000 to 1 550) °C	0.3 °C	
	(1 550 to 1 820) °C	0.33 °C	
	Type C		
	(0 to 150) °C	0.3 °C	
	(150 to 650) °C	0.26 °C	
	(650 to 1000) °C	0.31 °C	
	(1 000 to 1 800) °C	0.5 °C	
	(1 800 to 2 316) °C	0.84 °C	
	Type E		
	(-250 to -100) °C	0.5 °C	
	(-100 to -25) °C	0.16 °C	
	(-25 to 350) °C	0.14 °C	
	(350 to 650) °C	0.16 °C	
	(650 to 1 000) °C	0.21 °C	
	Type J		
	(-210 to -100) °C	0.27 °C	
	(-100 to -30) °C	0.16 °C	
	(-30 to 150) °C	0.14 °C	
	(150 to 760) °C	0.17 °C	
	(760 to 1 200) °C	0.23 °C	
	Type K		
(-200 to -100) °C	0.33 °C		
(-100 to -25) °C	0.18 °C		
(-25 to 120) °C	0.16 °C		
(120 to 1 000) °C	0.26 °C		
(1 000 to 1 372) °C	0.4 °C		

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		Fluke 5522A/11 Multiproduct Calibrator
	(-200 to -100) °C	0.4 °C	
	(-100 to -25) °C	0.22 °C	
	(-25 to 120) °C	0.19 °C	
	(120 to 410) °C	0.18 °C	
	(410 to 1 300) °C	0.27 °C	
	Type R		
	(0 to 250) °C	0.57 °C	
	(250 to 400) °C	0.35 °C	
	(400 to 1 000) °C	0.33 °C	
	(1 000 to 1 767) °C	0.4 °C	
	Type S		
	(0 to 250) °C	0.47 °C	
	(250 to 1 000) °C	0.36 °C	
	(1 000 to 1 400) °C	0.37 °C	
	(1 400 to 1 767) °C	0.46 °C	
	Type T		
(-250 to -150) °C	0.63 °C		
(-150 to 0) °C	0.24 °C		
(0 to 120) °C	0.16 °C		
(120 to 400) °C	0.14 °C		
Type U			
(-200 to 0) °C	0.56 °C		
(0 to 600) °C	0.27 °C		
Electrical Simulation of RTD Indicating Devices – Source ¹	Pt 385, 100 Ω		Fluke 5522A/11 Multiproduct Calibrator
	(-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	
	(630 to 800) °C	0.23 °C	
	Pt 385, 200 Ω		
	(-200 to -80) °C	0.04 °C	
	(-80 to 0) °C	0.04 °C	
	(0 to 100) °C	0.04 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 300) °C	0.12 °C	
	(300 to 400) °C	0.13 °C	
	(400 to 600) °C	0.14 °C	
	(600 to 630) °C	0.16 °C	

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
Oscilloscopes ^{1,2} Leveled Sine Wave into 50 Ω load	5 mVp-p to 5.5 Vp-p 50 kHz 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 5 mVp-p to 3.5 Vp-p 600 MHz to 1.1 GHz	1.8 % of reading + 0.23 mV 2.8 % of reading + 0.23 mV 3.2 % of reading + 0.23 mV 4 % of reading + 0.23 mV 5.5 % of reading + 0.23 mV	Fluke 5522A/11 Multiproduct Calibrator
Bandwidth/Flatness into 50 Ω load (50 kHz Reference)	5 mVp-p to 5.5 Vp-p 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 5 mVp-p to 3.5 Vp-p 600 MHz to 1.1 GHz	1.4 % of reading + 78 μV 1.8 % of reading + 78 μV 3.2 % of reading + 78 μV 4 % of reading + 78 μV	
Input Impedance – Measure into 50 Ω load into 1 MΩ load	(40 to 60) Ω (0.5 to 1.5) MΩ	0.082 % of reading 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) into 50 Ω load into 1 MΩ load	10 Hz to 10 kHz 1.8 mVp-p to 2.5 Vp-p 1.8 mVp-p to 55 Vp-p	2.3 % of reading + 78 μV 2.3 % of reading + 78 μV	
Frequency	10 Hz to 10 kHz	0.001 9 % of reading + 12 mHz	
Pulse Characterization Rise Time – Measure	30 ps to 1 μs	21 ps	



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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 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	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
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 ¹ Rate: 20 Hz to 10 kHz	250 kHz to 10 MHz Dev: ≤ 40 kHz pk	2 % of reading + 1 digit	HP 8902A Measuring Receiver, HP 11722A Power Sensor, HP 11792A Microwave Converter, HP 11793A Microwave Converter
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 ¹ 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	0.31 % of reading	HP 11683A Power Meter



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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	1.2 dB	HP 8903B Audio Analyzer
	(20 to 100) kHz (-65 to 0) dB	2.4 dB	
RF Amplitude Frequency Response – Measure	9 kHz to 2.9 GHz	1.1 dB	HP 8562A Spectrum Analyzer
	(2.90 to 6.46) GHz	1.5 dB	
	(6.46 to 13) GHz	2.1 dB	
	(13 to 19.7) GHz	3.1 dB	
	(19.7 to 22) GHz	3.1 dB	
Absolute Power – Measure (Swept Mode)	10 MHz to 1 GHz	0.082 dB	Gigatronics 8003 Precision Scalar Analyzer, Gigatronics 80301 Return Loss Bridge (or 80302, or 80501)
	(1 to 2) GHz	0.089 dB	
	(2 to 4) GHz	0.096 dB	
	(4 to 6) GHz	0.1 dB	
	(6 to 8) GHz	0.11 dB	
	(8 to 12.4) GHz (12.4 to 18) GHz	0.13 dB 0.14 dB	
Leveled Sine Wave Output – Absolute Amplitude Accuracy Level ³	10 Hz to 4 GHz (-130 to -94) dBm	1.1 dB	Fluke 96720A RF Reference Source, Fluke 96040A-50 Low Phase Noise Reference Source
	(-94 to -74) dBm	0.68 dB	
	(-74 to -17) dBm	0.34 dB	
	(-17 to 24) dBm	0.2 dB	
Leveled Sine Wave Output – Absolute Amplitude Accuracy Level ³	10 Hz to 4 GHz (-120 to -100) dBm	1.1 dB	Fluke 96720A RF Reference Source, Fluke 96040A-75 Low Phase Noise Reference Source
	(-100 to -80) dBm	0.67 dB	
	(-80 to 18) dBm	0.34 dB	
S11/S22 Reflection Magnitude – Measure ^{1,6} (Linear)	50 MHz to 2 GHz ≤ 0.25 lin	0.013	HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit
	(> 0.25 to 0.5) lin	0.012	
	(> 0.5 to ≤ 0.7) lin	0.012	
	(> 0.7 to ≤ 1) lin	0.013	
	(2 to 8) GHz ≤ 0.25 lin	0.013	
	(> 0.25 to 0.5) lin	0.012	
	(> 0.5 to ≤ 0.7) lin	0.012	
	(> 0.7 to ≤ 1) lin	0.014	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
S11/S22 Reflection Magnitude – Measure ^{1,6} (Linear)	(8 to 20) GHz ≤ 0.25 lin $(> 0.25$ to $0.5)$ lin $(> 0.5$ to $\leq 0.7)$ lin $(> 0.7$ to $\leq 1)$ lin (20 to 40) GHz ≤ 0.25 lin $(> 0.25$ to $0.5)$ lin $(> 0.5$ to $\leq 0.7)$ lin $(> 0.7$ to $\leq 1)$ lin	0.013 0.012 0.012 0.014 0.022 0.022 0.023 0.026	HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit
S11/S22 Reflection Phase – Measure ^{1,6} (Linear)	50 MHz to 2 GHz ≤ 0.25 lin $(> 0.25$ to $0.5)$ lin $(> 0.5$ to $\leq 0.7)$ lin $(> 0.7$ to $\leq 1)$ lin (2 to 8) GHz ≤ 0.25 lin $(> 0.25$ to $0.5)$ lin $(> 0.5$ to $\leq 0.7)$ lin $(> 0.7$ to $\leq 1)$ lin (8 to 20) GHz ≤ 0.25 lin $(> 0.25$ to $0.5)$ lin $(> 0.5$ to $\leq 0.7)$ lin $(> 0.7$ to $\leq 1)$ lin (20 to 40) GHz ≤ 0.25 lin $(> 0.25$ to $0.5)$ lin $(> 0.5$ to $\leq 0.7)$ lin $(> 0.7$ to $\leq 1)$ lin	2.7° 1.4° 1° 0.9° 2.7° 1.4° 1.1° 1.1° 2.7° 1.4° 1.1° 1.1° 4.9° 2.6° 2.1° 2°	HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit
S21/S12 Transmission Magnitude – Measure ¹ (dB)	50 MHz to 2 GHz $(-90$ to $\leq -80)$ dB $(-80$ to $\leq -70)$ dB $(-70$ to $\leq -60)$ dB $(-60$ to $\leq -50)$ dB $(-50$ to $\leq -40)$ dB $(-40$ to $\leq -30)$ dB $(-30$ to $\leq -20)$ dB $(-20$ to $\leq -10)$ dB $(-10$ to $\leq 0)$ dB	0.35 dB 0.18 dB 0.15 dB 0.15 dB 0.14 dB 0.14 dB 0.14 dB 0.14 dB 0.14 dB	HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment		
<p style="text-align: center;">S21/S12 Transmission Magnitude – Measure ¹ (dB)</p>	<p>(2 to 8) GHz</p> <p>(-90 to ≤ -80) dB</p> <p>(-80 to ≤ -70) dB</p> <p>(-70 to ≤ -60) dB</p> <p>(-60 to ≤ -50) dB</p> <p>(-50 to ≤ -40) dB</p> <p>(-40 to ≤ -30) dB</p> <p>(-30 to ≤ -20) dB</p> <p>(-20 to ≤ -10) dB</p> <p>(-10 to ≤ 0) dB</p>	<p>0.36 dB</p> <p>0.19 dB</p> <p>0.17 dB</p> <p>0.17 dB</p> <p>0.16 dB</p> <p>0.16 dB</p> <p>0.16 dB</p> <p>0.16 dB</p> <p>0.16 dB</p>	<p>HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit</p>		
	<p>(8 to 20) GHz</p> <p>(-90 to ≤ -80) dB</p> <p>(-80 to ≤ -70) dB</p> <p>(-70 to ≤ -60) dB</p> <p>(-60 to ≤ -50) dB</p> <p>(-50 to ≤ -40) dB</p> <p>(-40 to ≤ -30) dB</p> <p>(-30 to ≤ -20) dB</p> <p>(-20 to ≤ -10) dB</p> <p>(-10 to ≤ 0) dB</p>	<p>0.46 dB</p> <p>0.25 dB</p> <p>0.21 dB</p> <p>0.21 dB</p> <p>0.21 dB</p> <p>0.2 dB</p> <p>0.2 dB</p> <p>0.2 dB</p> <p>0.2 dB</p>			
	<p>(20 to 40) GHz</p> <p>(-90 to ≤ -80) dB</p> <p>(-80 to ≤ -70) dB</p> <p>(-70 to ≤ -60) dB</p> <p>(-60 to ≤ -50) dB</p> <p>(-50 to ≤ -40) dB</p> <p>(-40 to ≤ -30) dB</p> <p>(-30 to ≤ -20) dB</p> <p>(-20 to ≤ -10) dB</p> <p>(-10 to ≤ 0) dB</p>	<p>0.84 dB</p> <p>0.44 dB</p> <p>0.37 dB</p> <p>0.36 dB</p> <p>0.36 dB</p> <p>0.36 dB</p> <p>0.36 dB</p> <p>0.36 dB</p> <p>0.36 dB</p>			
	<p style="text-align: center;">S21/S12 Transmission Phase – Measure ¹</p>	<p>50 MHz to 2 GHz</p> <p>(-90 to ≤ -40) dB</p> <p>(-40 to ≤ -30) dB</p> <p>(-30 to ≤ -20) dB</p> <p>(-20 to ≤ -10) dB</p> <p>(-10 to ≤ 0) dB</p>		<p>180°</p> <p>30°</p> <p>9.2°</p> <p>2.9°</p> <p>1°</p>	<p>HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit</p>
		<p>(2 to 8) GHz</p> <p>(-80 to ≤ -40) dB</p> <p>(-40 to ≤ -30) dB</p> <p>(-30 to ≤ -20) dB</p> <p>(-20 to ≤ -10) dB</p> <p>(-10 to ≤ 0) dB</p>		<p>180°</p> <p>35°</p> <p>10°</p> <p>3.3°</p> <p>1.2°</p>	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
S21/S12 Transmission Phase – Measure ¹	(8 to 20) GHz		HP 8722ES Network Analyzer, Agilent 85056A Calibration Kit
	(-90 to ≤ -40) dB	180°	
	(-40 to ≤ -30) dB	47°	
	(-30 to ≤ -20) dB	13°	
	(-20 to ≤ -10) dB	4.2°	
	(-10 to ≤ 0) dB	1.5°	
	(20 to 40) GHz		
	(-80 to ≤ -30) dB	180°	
(-30 to ≤ -20) dB	24°		
(-20 to ≤ -10) dB	7.4°		
(-10 to ≤ 0) dB	2.6°		

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	13 μin	Gage Blocks
	(0.05 to 1) in	(13 + 1L) μin	
	(1 to 4) in	(9 + 4L) μin	
	(4 to 15) in	(12 + 4L) μin	
	(15 to 40) in	(16 + 4L) μin	
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	(17 + 2L) μin	Universal Length Measuring Machine
	(1 to 4) in	(14 + 4L) μin	
	(4 to 15) in	(17 + 4L) μin	Gage Amplifier/Check, Gage Blocks
	(15 to 20) in	(3 + 5L) μin	
	(20 to 40) in	(64 + 4L) μin	
Cylindrical Ring Gages ²	Up to 16 in	(14 + 4.6L) μin	Universal Length Measuring Machine
Thread Ring Gages ²	Up to 6 in	(22 + 4.7L) μin	Comparison to Set Plugs
Cylindrical Plug Gages ²	Up to 16 in	(15 + 4.5L) μin	Universal Length Measuring Machine
Thread Plug Gages Major Diameter (OD)	Up to 6 in	(16 + 3.7L) μin	Universal Length Measuring Machine, Thread Wires
	Pitch Diameter	Up to 6 in	
	Up to 6 in	(24 + 3L) μin	

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Plates ^{1,2} Overall Flatness	Up to 161 inDL	95 μin	In accordance with ASME B89.3.7 using Planekator
Local Area Flatness	Up to 0.001 in	29 μin	Repeat-O-Meter
Coating Thickness Gages (Eddy Current, Magnetic Induction, Fixed Point)	Up to 3 000 μm Up to 118 mils	(0.44 + 0.03L) μm (0.017 + 0.001L) mils	Universal Length Measuring Machine, Shims, Gage Blocks
Dial Indicators	Up to 1 in (1 to 4) in	(17 + 2L) μin (14 + 4L) 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
Low Pressure Gages	(0 to 2) inH ₂ O	0.008 inH ₂ O	Dwyer 1430 Microtector
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

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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.
Force Measuring Equipment – Compression ¹	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 1 000) lbf	0.77 lbf	Optima OP-312 Load Cell
	(1 000 to 5 000) lbf	2.8 lbf	
	(5 000 to 20 000) lbf	8.1 lbf	Transcell BSS-20K Load Cell

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Measuring Equipment – Tension ¹	Up to 10 lbf	0.001 5 lbf	NIST Class F Weights
	(10 to 25) lbf	0.002 1 lbf	
	(25 to 50) lbf	0.008 3 lbf	
	(50 to 150) lbf	0.023 lbf	
	(150 to 250) lbf	0.065 lbf	
	(250 to 500) lbf	0.13 lbf	
	(500 to 1 000) lbf	0.77 lbf	Optima OP-312 Load Cell
(1 000 to 5 000) lbf	2.8 lbf	Transcell BSS-10K Load Cell	
(5 000 to 10 000) lbf	4.2 lbf	Transcell BSS-20K Load Cell	
(10 000 to 20 000) lbf	8.1 lbf	Optima OP-351 Load Cell	
(20 000 to 50 000) lbf	23 lbf	Rinstrum TLWS-100K Load Cell	
(50 000 to 100 000) lbf	44 lbf		
Torque Devices	2 ozf·in to 2 000 lbf·ft	0.31 % of reading	AKO TSD2050 Torque Master
Torque Transducers	20 ozf·in to 100 lbf·in	0.05 % of reading	Torque Arms, Master Weights
	100 lbf·in to 125 lbf·ft	0.06 % of reading	
	(125 to 2 000) lbf·ft	0.08 % of reading	

Photometry and Radiometry

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

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

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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) $\epsilon = (0.1 \text{ to } 1)$, $\lambda = (8 \text{ to } 14) \mu\text{m}$

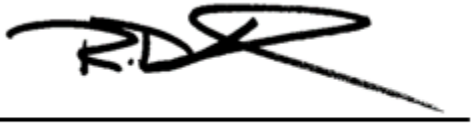
Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source/Measure ¹	1 mHz to 27 GHz	3.8 pHz/Hz	Fluke 910R GPS Rubidium Frequency Standard
Optical Rotational Speed – Source/Measure ²	(1 to 100 000) rpm	0.012 rpm	Agilent 33250A Function Generator
AC Duty Cycle – Source ¹ Square Wave: < 3.3 Vp-p Freq: 10 mHz to 100 kHz	(1 to 10) % Duty Cycle 10 μs to 100 s (10 to 49) % Duty Cycle 10 μs to 100 s 50 % Duty Cycle 10 μs to 100 s (51 to 90) % Duty Cycle 10 μs to 100 s (90 to 99) % Duty Cycle 10 μs to 100 s	0.039 % of reading + 78 ns 0.62 % of reading + 78 ns 0.001 6 % of reading + 78 ns 0.62 % of reading + 78 ns 0.039 % of reading + 78 ns	Fluke 55xxA Multiproduct Calibrator

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; rpm = revolutions per minute.
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 Measurement Uncertainty presented here is a unitless measurement.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.21.



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