CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Technical Maintenance, Inc.

12530 Telecom Drive
Temple Terrace, FL 33637
(and satellite sites as shown on the scope)

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 (s) of

CALIBRATION and DIMENSIONAL MEASUREMENT

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.

Jason Stine, Vice President

Expiry Date: 20 September 2025

Certificate Number: AC-2080

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)

Technical Maintenance, Inc.

12530 Telecom Drive
Temple Terrace, FL 33637
Wally Gynn (Branch Manager) Phone: 813-978-3054
Scott Chamberlain (Quality Manager) Phone: 321-242-0890

CALIBRATION AND DIMENSIONAL MEASUREMENT

Valid to: **September 20, 2025** Certificate Number: **AC-2080**

Satellite locations in:

Peachtree Corners, GA

Madison, AL

Rockford, IL

Windsor, CT

Hilliard, OH

Fort Lauderdale, FL

Melbourne, FL

White, GA

Colorado Springs, CO

Morrisville, NC

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CALIBRATION AND DIMENSIONAL MEASUREMENT

CALIBRATION

Acoustics and Vibration Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration (7 < 10) Hz (10 < 30) Hz (30 < 2000) Hz (2 to 10) kHz	(0.01 to 10) g	2 % of reading 1.5 % of reading 1 % of reading 2.5 % of reading	Accelerometer Calibrator

Chemical Quantities Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH meters [1,5]	4 pH 7 pH 10 pH	0.018 pH 0.036 pH 0.069 pH	pH buffer solutions
Conductivity Meters [1,5]	2 µS/cm 100 µS/cm 1 000 µS/cm 10 000 µS/cm 100 000 µS/cm 150 000 µS/cm	0.2 µS/cm 0.74 µS/cm 3.6 µS/cm 35 µS/cm 350 µS/cm 580 µS/cm	Conductivity solutions

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Angle – Generate 5 V Equal Amplitude	(0 to 360)° 1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz	 0.005° 0.01° 0.015° 0.04°	Clarke-Hess 5500-2 Phase Standard
Phase Angle – Generate 50 mV to 120 V– Unequal Amplitude	(0 to 360)° 1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz	 0.005° 0.01° 0.015° 0.04°	Clarke-Hess 5500-2 Phase Standard
Phase Angle – Measure 10 mV to 630 V	(0 to 360)° 5 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz (50 to 100) kHz (100 to 200) kHz	 0.02° 0.03° 0.04° 0.05° 0.1° 0.2°	Clarke-Hess 6000A Phase Meter
Phase Angle – Measure 50 mV to 120 V	(0 to 360) ° 1 Hz to 1 kHz (1 to 50) kHz (1 to 50) kHz (50 to 200) kHz (5 to 50) kHz (50 to 200) kHz (5 to 50) kHz (50 to 200) kHz	 0.001° 0.002° 0.002° 0.008° 0.002° 0.008° 0.002° 0.008°	Clarke-Hess 5002A Phase Meter Clarke-Hess 5002B Phase Meter Clarke-Hess 5002C Phase Meter Clarke-Hess 5002D Phase Meter
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 15 µA/A + 1 nA	Fluke 5730A Multifunction Calibrator & Fluke 5522A Multiproduct Calibrator
DC Current – Generate [1]	(10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5730A Multifunction Calibrator /5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A (20 to 100) A	77 µA/A + 761 µA 77 µA/A + 3.8 mA	Fluke 5522A Multiproduct Calibrator /52120A Transconductance Amplifier
DC Current Clamp Meters Toroidal-Wound	(0 to 1 025) A	0.21 % of output + 0.05A	Fluke 5522A Multiproduct Calibrator /Coil5500A x50
DC Current Clamp Meters Other	(0 to 1 025) A	0.39 % of output + 0.38A	Fluke 5522A Multiproduct Calibrator /Coil5500A x50
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA	19 µA/A + 0.16 pA 7.1 µA/A + 1.6 pA 6.1 µA/A + 0.016 nA 5.3 µA/A + 0.016 nA 5.3 µA/A + 0.16 nA 5.3 µA/A + 0.001 6 µA 5.3 µA/A + 0.016 µA 10 µA/A + 0.16 µA	Agilent 3458A Multimeter Option 002, 5450A Resistance Calibrator
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 2.0) A (2 to 20) A (20 to 25) A	36.5 µA/A + 21 µA 33.7 µA/A + 21 µA 28.6 µA/A + 35 µA	Agilent 3458A Multimeter, Guildline 9230A-50 Current Shunts
DC Current – Measure [1]	(25 to 100) A	0.25 % of reading + 1 mA	Agilent 3458A Multimeter Option 002, Empro 250A Current Shunt
DC Current – Measure [1]	(100 to 1 000) A	0.25 % of reading + 8 mA	Agilent 3458A Multimeter Option 002, Empro 1000A Current Shunt
DC Voltage – Generate [1]	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure [1]	(0 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6 µV/V + 100 µV + 12 µV/V x (Vin/1 000)^2	Agilent 3458A Option 002 Multimeter
DC Voltage – Measure [1]	(1 to 60) kV	0.035 % of reading	Ross VD60 High Voltage Divider, HP 3458A Multimeter
DC Voltage – Measure [1]	(12 to 120) kV	0.018 % of reading	Ross VD120 High Voltage Divider, HP 3458A Multimeter
DC Voltage – Measure [1] Fixed Points	100 mV 1 V 10 V 100 V 1 000 V	3.1 µV/V 0.46 µV/V 0.3 µV/V 0.34 µV/V 0.48 µV/V	Fluke 732B Reference Standard, 752A Divider
AC Voltage – Generate [1]	(0.22 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 (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	 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(22 to 220) mV		Fluke 5730A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 11.4 µV	
	(20 to 40) Hz	88 µV/V + 6.1 µV	
	40 Hz to 20 kHz	53 µV/V + 6.1 µV	
	(20 to 50) kHz	114 µV/V + 6.1 µV	
	(50 to 100) kHz	304 µV/V + 15.2 µV	
	(100 to 300) kHz	609 µV/V + 19 µV	
	(300 to 500) kHz	1.3 mV/V + 23 µV	
	500 kHz to 1 MHz	2.5 mV/V + 46 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	228 µV/V + 38 µV	
	(20 to 40) Hz	84 µV/V + 15 µV	
	40 Hz to 20 kHz	37 µV/V + 8 µV	
	(20 to 50) kHz	61 µV/V + 9 µV	
	(50 to 100) kHz	76 µV/V + 30 µV	
	(100 to 300) kHz	304 µV/V + 76 µV	
	(300 to 500) kHz	913 µV/V + 190 µV	
	500 kHz to 1 MHz	1.5 mV/V + 304 µV	
	(2.2 to 22) V		
	(10 to 20) Hz	228 µV/V + 380 µV	
	(20 to 40) Hz	84 µV/V + 152 µV	
	40 Hz to 20 kHz	37 µV/V + 54 µV	
	(20 to 50) kHz	61 µV/V + 91 µV	
	(50 to 100) kHz	76 µV/V + 190 µV	
	(100 to 300) kHz	228 µV/V + 609 µV	
	(300 to 500) kHz	913 µV/V + 1.9 mV	
	500 kHz to 1 MHz	1.4 mV/V + 3 mV	
	(22 to 220) V		
	(10 to 20) Hz	228 µV/V + 3.8 mV	
	(20 to 40) Hz	84 µV/V + 1.5 mV	
	40 Hz to 20 kHz	49 µV/V + 0.6 mV	
	(20 to 50) kHz	76 µV/V + 0.9 mV	
	(50 to 100) kHz	137 µV/V + 2.3 mV	
	(220 to 750) V		
	40 Hz to 1 kHz	68 µV/V + 3 mV	
	(1 to 20) kHz	126 µV/V + 5 mV	
	(20 to 50) kHz	457 µV/V + 8 mV	
	(50 to 100) kHz	1.8 mV/V + 34 mV	

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5730A Multifunction Calibrator /5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 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 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (11 to 33) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 13 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV 0.58 % of output + 6.1 µV 0.53 % of output + 6.1 µV 0.54 % of output + 8.4 µV 0.54 % of output + 8.4 µV 0.55 % of output + 8.4 µV 0.61 % of output + 8.4 µV 0.93 % of output + 8.4 µV 0.52 % of output + 12 µV 0.46 % of output + 12 µV 0.47 % of output + 14 µV 0.47 % of output + 14 µV 0.49 % of output + 14 µV 0.55 % of output + 14 µV 0.89 % of output + 14 µV	Fluke 5730A Multifunction Calibrator /5725A Amplifier

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(33 to 110) mV		Fluke 5730A Multifunction Calibrator
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.4 % of output + 33 µV	
	(1.2 to 2) MHz	0.4 % of output + 33 µV	
	(2 to 12) MHz	0.42 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	(0.33 to 1.1) V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	
	(1.1 to 3.5) V		
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	Up to 2.2 mV		Fluke 5790B AC/DC Transfer Standard
	(10 to 20) Hz	1.3 mV/V + 1.2 µV	
	(20 to 40) Hz	563 µV/V + 1.2 µV	
	40 Hz to 20 kHz	320 µV/V + 1.2 µV	
	(20 to 50) kHz	616 µV/V + 1.7 µV	
	(50 to 100) kHz	913 µV/V + 2 µV	
	(100 to 300) kHz	1.8 mV/V + 3.1 µV	
	(300 to 500) kHz	1.8 mV/V + 6.1 µV	
	500 kHz to 1 MHz	2.7 mV/V + 6.1 µV	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(2.2 to 7) mV		Fluke 5790B AC/DC Transfer Standard
	(10 to 20) Hz	647 µV/V + 1.2 µV	
	(20 to 40) Hz	282 µV/V + 1.2 µV	
	40 Hz to 20 kHz	160 µV/V + 1.2 µV	
	(20 to 50) kHz	304 µV/V + 1.7 µV	
	(50 to 100) kHz	457 µV/V + 2 µV	
	(100 to 300) kHz	913 µV/V + 3.1 µV	
	(300 to 500) kHz	989 µV/V + 6.1 µV	
	500 kHz to 1 MHz	1.8 mV/V + 6.1 µV	
	(7 to 22) mV		
	(10 to 20) Hz	221 µV/V + 1.2 µV	
	(20 to 40) Hz	145 µV/V + 1.2 µV	
	40 Hz to 20 kHz	84 µV/V + 1.2 µV	
	(20 to 50) kHz	160 µV/V + 1.7 µV	
	(50 to 100) kHz	236 µV/V + 2 µV	
	(100 to 300) kHz	616 µV/V + 3.1 µV	
	(300 to 500) kHz	677 µV/V + 6.1 µV	
	500 kHz to 1 MHz	1.3 mV/V + 6.1 µV	
	(22 to 70) mV		
	(10 to 20) Hz	183 µV/V + 1.3 µV	
	(20 to 40) Hz	91 µV/V + 1.3 µV	
	40 Hz to 20 kHz	49 µV/V + 1.3 µV	
	(20 to 50) kHz	99 µV/V + 1.7 µV	
	(50 to 100) kHz	198 µV/V + 2 µV	
	(100 to 300) kHz	388 µV/V + 3.1 µV	
	(300 to 500) kHz	510 µV/V + 6.1 µV	
	500 kHz to 1 MHz	837 µV/V + 6.1 µV	
	(70 to 220) mV		
	(10 to 20) Hz	160 µV/V + 1.3 µV	
	(20 to 40) Hz	65 µV/V + 1.3 µV	
	40 Hz to 20 kHz	29 µV/V + 1.3 µV	
	(20 to 50) kHz	53 µV/V + 1.7 µV	
	(50 to 100) kHz	122 µV/V + 2 µV	
	(100 to 300) kHz	190 µV/V + 3.1 µV	
	(300 to 500) kHz	289 µV/V + 6.1 µV	
	500 kHz to 1 MHz	761 µV/V + 6.1 µV	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(220 to 700) mV		Fluke 5790B AC/DC Transfer Standard
	(10 to 20) Hz	160 µV/V + 1.3 µV	
	(20 to 40) Hz	58 µV/V + 1.3 µV	
	40 Hz to 20 kHz	25 µV/V + 1.3 µV	
	(20 to 50) kHz	39 µV/V + 1.7 µV	
	(50 to 100) kHz	60 µV/V + 2 µV	
	(100 to 300) kHz	137 µV/V + 3.1 µV	
	(300 to 500) kHz	228 µV/V + 6.1 µV	
	500 kHz to 1 MHz	730 µV/V + 6.1 µV	
	700 mV to 2.2 V		
	(10 to 20) Hz	152 µV/V + 0.7 µV	
	(20 to 40) Hz	50 µV/V + 0.7 µV	
	40 Hz to 20 kHz	18 µV/V + 0.7 µV	
	(20 to 50) kHz	35 µV/V + 0.7 µV	
	(50 to 100) kHz	54 µV/V + 0.7 µV	
	(100 to 300) kHz	122 µV/V + 0.7 µV	
	(300 to 500) kHz	198 µV/V + 0.7 µV	
	500 kHz to 1 MHz	685 µV/V + 0.7 µV	
	(2.2 to 7) V		
	(10 to 20) Hz	152 µV/V + 0.9 µV	
	(20 to 40) Hz	51 µV/V + 0.9 µV	
	40 Hz to 20 kHz	18 µV/V + 0.9 µV	
	(20 to 50) kHz	37 µV/V + 0.9 µV	
	(50 to 100) kHz	62 µV/V + 0.9 µV	
	(100 to 300) kHz	145 µV/V + 0.9 µV	
	(300 to 500) kHz	304 µV/V + 0.9 µV	
	500 kHz to 1 MHz	913 µV/V + 0.9 µV	
	(7 to 22) V		
	(10 to 20) Hz	152 µV/V + 0.9 µV	
	(20 to 40) Hz	51 µV/V + 0.9 µV	
	40 Hz to 20 kHz	21 µV/V + 0.9 µV	
	(20 to 50) kHz	37 µV/V + 0.9 µV	
	(50 to 100) kHz	62 µV/V + 0.9 µV	
	(100 to 300) kHz	145 µV/V + 0.9 µV	
	(300 to 500) kHz	304 µV/V + 0.9 µV	
	500 kHz to 1 MHz	913 µV/V + 0.9 µV	

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(22 to 70) V (10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (70 to 220) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (220 to 700) V 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (700 to 1 000) V 40 Hz to 20 kHz (20 to 30) kHz	 152 µV/V + 5.7 µV 52 µV/V + 5.7 µV 24 µV/V + 5.7 µV 43 µV/V + 5.7 µV 72 µV/V + 5.7 µV 152 µV/V + 5.7 µV 152 µV/V + 5.7 µV 52 µV/V + 5.7 µV 24 µV/V + 5.7 µV 53 µV/V + 5.7 µV 75 µV/V + 5.7 µV 31 µV/V + 57 µV 99 µV/V + 57 µV 380 µV/V + 57 µV 29 µV/V + 57 µV 99 µV/V + 57 µV	Fluke 5790B AC/DC Transfer Standard
AC Voltage – Measure [1]	60 Hz (1 to 10) kV (10 to 42) kV	 0.5 % of reading + 0.002 kV 0.5 % of reading + 0.02 kV	Ross VD60 High Voltage Divider, HP 34401A Multimeter
AC Voltage – Measure [1]	60 Hz (1 to 10) kV (10 to 85) kV	 0.5 % of reading + 0.002 kV 0.5 % of reading + 0.02 kV	Ross VD120 High Voltage Divider, HP 34401A Multimeter
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 91 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA	Fluke 5730A/03 Multifunction Calibrator

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(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 (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	 228 µA/A + 385 nA 152 µA/A + 310 nA 91 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 µA 228 µA/A + 4 µA 152 µA/A + 3 µA 91 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA	Fluke 5730A/03 Multifunction Calibrator
AC Current – Generate [1]	(0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5730A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA/A + 141 µA 723 µA/A + 295 µA 2.7 mA/A + 573 µA	Fluke 5730A Multifunction Calibrator /5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.3 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current – Generate [1]	(11 to 20) A (10 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	 255 µA/A + 10 mA 769 µA/A + 11 mA 0.23 % of output + 31 mA 0.76 % of output + 62 mA 2.3 % of output + 92 mA	Fluke 5522A Multiproduct Calibrator / 52120A Transconductance Amplifier
AC Current – Generate [1]	(20 to 120) A (10 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	 255 µA/A + 28 mA 769 µA/A + 92 mA 0.23 % of output + 228 mA 0.76 % of output + 411 mA 3 % of output + 685 mA	Fluke 5522A Multiproduct Calibrator / 52120A Transconductance Amplifier
AC Current Clamps – Toroidal-Wound	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.23 % of output + 0.069 A 0.64 % of output + 0.076 A	Fluke 5522A Multiproduct Calibrator /x50 Coil

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Clamps – Other	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	0.44 % of output +0.53 A 0.79 % of output +0.69 A	Fluke 5522A Multiproduct Calibrator /x50 Coil
AC Current Clamps – Rogowski	(10 to 100) A (10 to 1 000) Hz (1 to 3) kHz (100 to 1000) A (10 to 1 000) Hz (1 to 3) kHz	0.53 % of output +0.011 A 0.61 % of output +0.015 A 0.53 % of output +0.11 A 0.61 % of output +0.15 A	Fluke 52120 Transconductance Amplifier, Coil 6KA Current Coil
AC Current Clamps – Rogowski	(1 000 to 6 000) A (10 to 1 000) Hz (1 000 to 3 500) A (1 to 3) kHz	0.53 % of output +0.69 A 0.61 % of output +0.95 A	Fluke 52120 Transconductance Amplifier, Coil 6KA Current Coil
AC Current – Measure [1]	(2 to 200) µA 10 Hz to 10 kHz 200 µA to 2 mA 10 Hz to 10 kHz	0.047 % of reading + 0.018 µA 0.028 % of reading + 0.18 µA	Fluke 8508A Multimeter
AC Current – Measure [1]	(0.19 to 1) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	 306 µA/A 306 µA/A 259 µA/A 419 µA/A	Agilent 3458A Multimeter / Fluke A40 Current Shunts

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(1 to 10) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (10 to 50) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 500) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (0.5 to 2) A (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	 163 µA/A 70 µA/A 40 µA/A 65 µA/A 165 µA/A 69 µA/A 39 µA/A 66 µA/A 167 µA/A 70 µA/A 40 µA/A 72 µA/A 170 µA/A 77 µA/A 62 µA/A 112 µA/A	Fluke 5790B AC/DC Transfer Standard / Holt HCS-1 Current Shunts
AC Current – Measure [1]	(2 to 10) A (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	 181 µA/A 94 µA/A 79 µA/A 130 µA/A	Fluke 5790B AC/DC Transfer Standard / Holt HCS-1 Current Shunts
AC Current – Measure [1]	(10 to 20) A (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz	 368 µA/A 368 µA/A 302 µA/A 424 µA/A	Agilent 3458A Multimeter / Fluke Y5020 Current Shunt
AC Current – Measure [1]	(100 to 1 000) A (10 to 100) Hz (100 to 500) Hz	 1.6 % of reading + 0.5A 1.9 % of reading+ 0.5A	Fluke 376 Clamp Meter
AC Current – Measure [1]	(200 to 600) A (10 to 500) Hz (600 to 2 500) A (10 to 500) Hz	 2.3 % of reading + 0.5A 2.3 % of reading + 5A	Fluke 376 Clamp Meter W/i2500 flex probe
Resistance – Generate [1] Fixed Points	0.001 Ω 0.01 Ω 0.1 Ω	10 µΩ/Ω 6.6 µΩ/Ω 25.3 µΩ/Ω	LN 422x Resistance Standards

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1] Fixed Points	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ	1 μΩ/Ω 2 μΩ/Ω 0.44 μΩ/Ω 0.67 μΩ/Ω 0.86 μΩ/Ω 1.2 μΩ/Ω 2 μΩ/Ω 2.5 μΩ/Ω 19 μΩ/Ω 84 μΩ/Ω	Fluke 742A, IET SRL Resistance Standards
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 μΩ/Ω + 0.1 μΩ 21 μΩ/Ω + 1 μΩ 9.1 μΩ/Ω + 6 μΩ 6.1 μΩ/Ω + 60 μΩ 6.1 μΩ/Ω + 0.6 mΩ 7.6 μΩ/Ω + 6 mΩ 9.1 μΩ/Ω + 6 mΩ 11 μΩ/Ω + 60 mΩ 16 μΩ/Ω + 60 mΩ 35 μΩ/Ω + 0.6 Ω 42 μΩ/Ω + 0.6 Ω 91 μΩ/Ω + 6 Ω	Fluke 5730A Multifunction Calibrator
Resistance – Generate [1]	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω 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	30 μΩ/Ω + 0.001 Ω 23 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.2 Ω 21 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 2 Ω 24 μΩ/Ω + 2 Ω 46 μΩ/Ω + 23 Ω 99 μΩ/Ω + 38 Ω 190 μΩ/Ω + 1.9 kΩ 380 μΩ/Ω + 2.3 kΩ 0.23 % of reading + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1] Fixed Points	100 V 100 kΩ (100 to 1 000) V 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ 100 GΩ	 1 % of output 1 % of output 1 % of output 1 % of output 1 % of output 1.2 % of output 3.2 % of output	TMI RB Resistance Standard
Resistance – Measure [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ (100, 190) kΩ (1, 1.9) MΩ (10, 19) MΩ 100 MΩ 1 GΩ	4.8 μΩ/Ω 2.6 μΩ/Ω 0.7 μΩ/Ω 0.9 μΩ/Ω 1 μΩ/Ω 1.3 μΩ/Ω 2.3 μΩ/Ω 2.9 μΩ/Ω 22 μΩ/Ω 123 μΩ/Ω	Fluke 8508A Multimeter, Fluke 742A, IET SRL Resistance Standards
Resistance – Measure [1]	Up to 2 Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 kΩ (2 to 20) kΩ (20 to 200) kΩ 200 kΩ to 2 MΩ (2 to 20) MΩ (20 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ	15 μΩ/Ω + 3.8 μΩ 8.8 μΩ/Ω + 14 μΩ 7.2 μΩ/Ω + 46 μΩ 7.2 μΩ/Ω + 457 μΩ 7.2 μΩ/Ω + 4.6 mΩ 7.2 μΩ/Ω + 46 mΩ 8 μΩ/Ω + 0.9 Ω 15 μΩ/Ω + 9 Ω 57 μΩ/Ω + 0.9 kΩ 148 μΩ/Ω + 91 kΩ 514 μΩ/Ω + 9.1 MΩ	Fluke 8508A Multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1]	100 V 100 kΩ (100, 1 000) V 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ (500, 1 000) V 100 GΩ 1 000 V 1 TΩ 10 TΩ	 0.53 % of reading 0.5 % of reading 0.5 % of reading 0.5 % of reading 0.5 % of reading 0.52 % of reading 0.59 % of reading 0.7 % of reading 2.5 % of reading	Quadtech 1865 Megohmeter
Resistance – Measure [1]	50 Hz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ 100/120 Hz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ 1 000 Hz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ	 0.17 % of reading + 0.003 Ω 0.062 % of reading + 0.006 Ω 0.051 % of reading + 0.06 Ω 0.05 % of reading + 0.000 6 kΩ 0.054 % of reading + 0.006 kΩ 0.09 % of reading + 0.000 06 MΩ 0.45% of reading + 0.000 6 MΩ 0.13 % of reading + 0.003 Ω 0.049 % of reading + 0.006 Ω 0.041 % of reading + 0.06 Ω 0.04 % of reading + 0.000 6 kΩ 0.043 % of reading + 0.006 kΩ 0.07 % of reading + 0.000 06 MΩ 0.34 % of reading + 0.000 6 MΩ 0.05 % of reading + 0.003 Ω 0.023 % of reading + 0.006 Ω 0.02 % of reading + 0.06 Ω 0.02 % of reading + 0.000 6 kΩ 0.021 % of reading + 0.006 kΩ 0.03 % of reading + 0.000 06 MΩ 0.12 % of reading + 0.000 6 MΩ	IET 1693 RLC Meter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1]	10 kHz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 25.6) kΩ (25.6 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ 100 kHz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) kΩ	 0.17 % of reading + 0.003 Ω 0.062 % of reading + 0.006 Ω 0.051 % of reading + 0.06 Ω 0.05 % of reading + 0.000 6 KΩ 0.051 % of reading + 0.006 KΩ 0.186 % of reading + 0.006 KΩ 0.33 % of reading + 0.000 06 MΩ 1.8 % of reading + 0.0006 MΩ 0.77 % of reading + 0.003 Ω 0.257 % of reading + 0.006 Ω 0.21 % of reading + 0.06 Ω 0.23 % of reading + 0.000 6 kΩ 0.52 % of reading + 0.006 kΩ 3.4 % of reading + 0.000 06 MΩ	IET 1693 RLC Meter
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) µF (1.1 to 3.299 99) µF (3.3 to 10.999 9) µF (11 to 32.999 9) µF (33 to 109.999) µF (110 to 329.999) µF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.38 % of output + 7.6 pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF 0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 µF 0.34 % of output + 2.3 µF 0.34 % of output + 7.6 µF 0.57 % of output + 23 µF 0.84 % of output + 76 µF	Fluke 5522A Multiproduct Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure 12 Hz to 200 kHz	50 Hz		IET 1693 LCR Meter
	(50 to 100) pF	2.6 % of reading + 0.015 pF	
	(100 to 400) pF	1.3 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.37 % of reading + 0.06 pF	
	(1 to 10) nF	0.18 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.063 % of reading + 0.006 nF	
	(100 to 1000) nF	0.051 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.051 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.05% of reading + 0.000 6 µF	
	(10 to 100) µF	0.054 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.09 % of reading + 0.06 µF	
	100 Hz		
	(20 to 100) pF	2.4 % of reading + 0.015 pF	
	(100 to 400) pF	0.52 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.16 % of reading + 0.06 pF	
	(1 to 10) nF	0.088 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.045 % of reading + 0.006 nF	
	(100 to 1000) nF	0.041 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.041 % of reading + 0.000 06 µF	
	(10 to 100) µF	0.046 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.1 % of reading + 0.06 µF	
	120 Hz		
	(20 to 100) pF	2 % of reading + 0.01 5pF	
	(100 to 400) pF	0.44 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.14 % of reading + 0.06 pF	
	(1 to 10) nF	0.08 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.044 % of reading + 0.006 nF	
	(100 to 1000) nF	0.04 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.04 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.041 % of reading + 0.000 6 µF	
	(10 to 100) µF	0.047 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.11 % of reading + 0.06 µF	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure 12 Hz to 200 kHz	1 000 Hz		IET 1693 LCR Meter
	(1 to 10) pF	1.6 % of reading + 0.014 pF	
	(10 to 20) pF	0.18 % of reading + 0.015 pF	
	(20 to 100) pF	0.1 % of reading + 0.015 pF	
	(100 to 400) pF	0.036 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.024 % of reading + 0.06 pF	
	(1 to 10) nF	0.022 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.02 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.02 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.02 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.020 % of reading + 0.000 6 µF	
	(10 to 100) µF	0.04 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.22 % of reading + 0.06 µF	
	10 kHz		
	(20 to 100) pF	0.3 % of reading + 0.015 pF	
	(100 to 622) pF	0.2 % of reading + 0.06 pF	
	(622 to 1 000) pF	0.051 % of reading + 0.06 pF	
	(1 to 10) nF	0.051 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.051 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.058 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.058 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.13 % of reading + 0.000 6 µF	
	(10 to 100) µF	0.85 % of reading + 0.006 µF	
	(100 to 500) µF	4.1 % of reading + 0.06 µF	
	100 kHz		
	(20 to 100) pF	0.49 % of reading + 0.015 pF	
	(100 to 400) pF	0.26 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.21 % of reading + 0.06 pF	
	(1 to 10) nF	0.21 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.24 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.58 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.58 % of reading + 0.000 06 µF	
	(1 to 10) µF	4 % of reading + 0.000 6 µF	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate [1] Fixed Points	1 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.028 % of output 0.028 % of output 0.034 % of output 0.047 % of output 0.069 % of output 0.096 % of output 0.31 % of output 0.5 % of output	Agilent 16381A Capacitor Set
Capacitance – Generate [1] Fixed Points	10 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.019 % of output 0.019 % of output 0.019 % of output 0.019 % of output 0.019 % of output 0.019 % of output 0.022 % of output 0.024 % of output	Agilent 16382A Standard Air Capacitor
Capacitance – Generate [1] Fixed Points	100 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.017 % of output 0.017 % of output 0.018 % of output 0.018 % of output 0.02 % of output 0.024 % of output 0.053 % of output 0.083 % of output	Agilent 16383A Standard Air Capacitor
Capacitance – Generate [1] Fixed Points	1 000 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.018 % of output 0.019 % of output 0.024 % of output 0.035 % of output 0.051 % of output 0.069 % of output 0.22 % of output 0.32 % of output	Agilent 16384A Standard Air Capacitor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure [1] 12 Hz to 200 kHz	100 Hz		IET 1693 LCR Meter
	(40 to 100) µH	3.8 % of reading + 0.006 µH	
	(0.1 to 0.4) mH	1.6 % of reading + 0.000 06 mH	
	(0.4 to 1) mH	0.42 % of reading + 0.000 06 mH	
	(1 to 10) mH	0.19 % of reading + 0.000 6 mH	
	(10 to 100) mH	0.056 % of reading + 0.006 mH	
	(0.1 to 1) H	0.042 % of reading + 0.000 06 H	
	(1 to 10) H	0.041 % of reading + 0.000 6 H	
	(10 to 100) H	0.042 % of reading + 0.006 H	
	1 000 Hz		
	(4 to 10) µH	1.3 % of reading + 0.003 µH	
	(10 to 40) µH	0.53 % of reading + 0.006 µH	
	(40 to 100) µH	0.15 % of reading + 0.006 µH	
	(0.1 to 0.4) mH	0.071 % of reading + 0.000 06 mH	
	(0.4 to 1) mH	0.033 % of reading + 0.000 06 mH	
	(1 to 10) mH	0.025 % of reading + 0.000 6 mH	
	(10 to 100) mH	0.021 % of reading + 0.006 mH	
	(0.1 to 1) H	0.02 % of reading + 0.000 06 H	
	(1 to 10) H	0.021 % of reading + 0.000 6 H	
	(10 to 100) H	0.026 % of reading + 0.006 H	
	10 kHz		
	(1 to 4) µH	2.1 % of reading + 0.003 µH	
	(4 to 10) µH	0.56 % of reading + 0.003 µH	
	(10 to 40) µH	0.25 % of reading + 0.006 µH	
	(40 to 100) µH	0.1 % of reading + 0.006 µH	
	(0.1 to 0.4) mH	0.071 % of reading + 0.000 06 mH	
	(0.4 to 1) mH	0.056 % of reading + 0.000 06 mH	
	(1 to 10) mH	0.052 % of reading + 0.000 6 mH	
	(10 to 100) mH	0.051 % of reading + 0.006 mH	
	(0.1 to 0.407) H	0.051 % of reading + 0.000 06 H	
	(0.407 to 1) H	0.18 % of reading + 0.000 6 H	
	(1 to 10) H	0.27 % of reading + 0.000 6 H	
	(10 to 100) H	1.2 % of reading + 0.006 H	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure [1] 12 Hz to 200 kHz	100 kHz (1 to 4) µH (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H	 1.2 % of reading + 0.003 µH 0.44 % of reading + 0.003 µH 0.3 % of reading + 0.006 µH 0.23 % of reading + 0.006 µH 0.21 % of reading + 0.000 06 mH 0.21 % of reading + 0.000 06 mH 0.22 % of reading + 0.000 6 mH 0.39 % of reading + 0.006 mH 2.1 % of reading + 0.000 06 H	IET 1693 LCR Meter
Inductance – Generate [1] Fixed Point	50 mH 100 Hz 1 kHz	 0.028 mH 0.021 mH	GR 1482-K Standard Inductor
	100 mH 100 Hz 1 kHz	 0.069 mH 0.063 mH	GR 1481-G Standard Inductor
	200 mH 100 Hz 1 kHz	 0.09 mH 0.06 mH	GR 1482-M Standard Inductor
	500 mH 100 Hz 1 kHz	 0.23 mH 0.15 mH	GR 1482-N Standard Inductor
	5 H 100 Hz 1 kHz	 0.021 H 0.021 H	GR 1482-R Standard Inductor
Oscilloscopes Calibration [1] Generate Voltage DC - 50Ω	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
DC - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6 mV	
Square Wave 10Hz to 10kHz - 50Ω	(1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.1999) Vpp (2.2 to 6.6) Vpp	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration [1] Generate			Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Square Wave 10 Hz to 1 kHz – 1 MΩ	(1 to 24.999) mV	0.038 % of reading + 4 µV	
	(25 to 109.99) mV	0.038 % of reading + 9 µV	
	(110mV to 2.199 9) V	0.038 % of reading + 60 µV	
	(2.2 to 10.999) V	0.038 % of reading + 0.6 mV	
	(11 to 130) V	0.038 % of reading + 6 mV	
Square Wave 1 to 10 kHz - 1MΩ	(1 to 24.999) mV	0.19 % of reading + 31 µV	
	(25 to 109.99) mV	0.19 % of reading + 36 µV	
	(110mV to 2.199 9) V	0.19 % of reading + 87 µV	
	(2.2 to 10.999) V	0.19 % of reading + 0.6 mV	
	(11 to 130) V	0.19 % of reading + 6 mV	
Oscilloscopes Calibration– Generate [1]	3 dB Bandwidth		Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Leveled Sine Flatness 50 kHz to 10 MHz Reference	(5 to 50 mV) Vpp		
	50 kHz to 100 MHz	0.34 dB	
	(100 to 300) MHz	0.36 dB	
	(300 to 500) MHz	0.42 dB	
	(500 to 600) MHz	0.46 dB	
	(600 to 16 00) MHz	0.5 dB	
	(1 600 to 2 100) MHz	0.56 dB	
Oscilloscopes Calibration Generate [1]	3 dB Bandwidth		Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Leveled Sine Flatness 50 kHz to 10 MHz Reference	50 mVpp to 3.5 Vpp		
	50 kHz to 100) MHz	0.24 dB	
	(100 to 300) MHz	0.24 dB	
	(300 to 500) MHz	0.32 dB	
	(500 to 600) MHz	0.34 dB	
	(600 to 16 00) MHz	0.4 dB	
	(1 600 to 2 100) MHz	0.44 dB	
	(3.5 to 5) Vpp		
	50 kHz to 100 MHz	0.24 dB	
	(100 to 300) MHz	0.24 dB	
	(300 to 500) MHz	0.32 dB	
	(500 to 600) MHz	0.34 dB	
Oscilloscopes Calibration Generate [1] Leveled Sine Flatness	3 dB Bandwidth		EPM Power Meter w/ E Series Power Sensors
	50 mV to 3.5Vpp		
	(2 100 to 4 000) MHz	0.25 dB	
	(4 000 to 8 000) MHz	0.35 dB	
	(8 000 to 18 000) MHz	0.46 dB	

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration Generate [1] Time Marker Rise Time Input Impedance Resistance Capacitance Leakage	 500 ps to 20 ms 50 ms to 5 s < 150 ps (40 to 60) Ω 500 kΩ to 1.5MΩ (5 to 50) pF (0 to 5.99) V	 0.25 µs/s 1.9 µs/s + 3.8 µHz +0 / -50 ps 0.08 % of reading 0.08 % of reading 3.8 % of reading + 0.4pF 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration [1] Generate Voltage DC - 50Ω DC - 1MΩ Square Wave 10Hz to 10kHz – 1MΩ	 (1mV to 5V) (1mV to 200V) (1mV to 200Vpp)	 0.025 % of output + 25 µV 0.025 % of output + 25 µV 0.1 % of output + 10 µV	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration [1] Generate Leveled Sine Flatness 50 kHz to 10 MHz Reference	5 mV to 5 Vpp (0.1 Hz to 300) MHz (300 to 550) MHz (5 mV to 3Vpp) (550 to 1 100) MHz	 0.18 dB 0.22 dB 0.3 dB	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration [1] Generate Time Marker	 9 ns to 55 s	 0.25 µs/s	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration [1] Measure Input Impedance Resistance	 (10 to 40) Ω (40 to 90) Ω (90 to 150) Ω (50 to 800) KΩ (0.8 to 1.2) MΩ (1.2 to 12) MΩ	 0.5 % of reading 0.1 % of reading 0.5 % of reading 0.5 % of reading 0.1 % of reading 0.5 % of reading	Fluke 9500B with 9510 Active Head

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type B		Fluke 7526A Process Calibrator
	(600 to 800) °C	0.27 °C	
	(800 to 1 550) °C	0.22 °C	
	(1 550 to 1 820) °C	0.17 °C	
	Type C		
	(0 to 1000) °C	0.13 °C	
	(1 000 to 1 800) °C	0.18 °C	
	(1 800 to 2 000) °C	0.2 °C	
	(2 000 to 2 316) °C	0.27 °C	
	Type E		
	(-250 to -200) °C	0.19 °C	
	(-200 to -100) °C	0.1 °C	
	(-100 to 0) °C	0.07 °C	
	(0 to 600) °C	0.07 °C	
	(600 to 1 000) °C	0.08 °C	
	Type J		
	(-210 to -100) °C	0.11 °C	
	(-100 to 800) °C	0.07 °C	
	(800 to 1 200) °C	0.08 °C	
	Type K		
	(-250 to -200) °C	0.35 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 800) °C	0.08 °C	
	(800 to 1 372) °C	0.1 °C	
	Type L		
	(-200 to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type R		Fluke 7526A Process Calibrator
	(-50 to -25) °C	0.42 °C	
	(-25 to 0) °C	0.34 °C	
	(0 to 100) °C	0.3 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.17 °C	
	(600 to 1 000) °C	0.16 °C	
	(1 000 to 1 600) °C	0.15 °C	
	(1 600 to 1 767) °C	0.18 °C	
	Type S		
	(50 to -25) °C	0.39 °C	
	(-25 to 0) °C	0.33 °C	
	(0 to 100) °C	0.29 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.18 °C	
	(600 to 1 600) °C	0.17 °C	
	(1 600 to 1 767) °C	0.2 °C	
	Type T		
	(-250 to -200) °C	0.26 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 0) °C	0.09 °C	
	(0 to 400) °C	0.07 °C	
	Type U		
	(-200 to 0) °C	0.13 °C	
	(0 to 600) °C	0.08 °C	
Electrical Calibration of RTD Indicating Devices [1]	Pt 385, 100 Ω		Fluke 7526A Process Calibrator
	(-200 to 800) °C	0.05 °C	
	Pt 3926, 100 Ω		
	(-200 to 630) °C	0.05 °C	
	Pt 3916, 100 Ω		
	(-200 to 630) °C	0.05 °C	
	Pt 385, 200 Ω		
	(-200 to 400) °C	0.4 °C	
	(400 to 630) °C	0.5 °C	
	Pt 385, 500 Ω		
	(-200 to 630) °C	0.17 °C	
	Pt 385, 1 000 Ω		
	(-200 to 630) °C	0.09 °C	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure Wideband Flatness Relative to 1 kHz	(0.6 to 2.2) mV		Fluke 5790B AC/DC Measurement Standard
	(10 to 30) Hz	0.08 % of reading + 0.1 µV	
	30 Hz to 120 kHz	0.04 % of reading + 0.1 µV	
	120 kHz 2 MHz	0.05 % of reading + 0.8 µV	
	(2 to 10) MHz	0.13 % of reading + 0.8 µV	
	(10 to 20) MHz	0.23 % of reading + 0.8 µV	
	(20 to 30) MHz	0.53 % of reading + 1.6 µV	
	(2.2 to 7) mV		
	(10 to 30) Hz	0.08 % of reading + 0.1 µV	
	30 Hz to 120 kHz	0.04 % of reading + 0.1 µV	
	120 kHz 2 MHz	0.05 % of reading + 0.8 µV	
	(2 to 10) MHz	0.08 % of reading + 0.8 µV	
	(10 to 20) MHz	0.13 % of reading + 0.8 µV	
	(20 to 30) MHz	0.28 % of reading + 0.8 µV	
	(7 to 22) mV		
	(10 to 30) Hz	0.08 % of reading + 0.1 µV	
	30 Hz to 120 kHz	0.04 % of reading + 0.1 µV	
	120 kHz 2 MHz	0.05 % of reading + 0.1 µV	
	(2 to 10) MHz	0.08 % of reading + 0.1 µV	
	(10 to 20) MHz	0.13 % of reading + 0.1 µV	
	(20 to 30) MHz	0.28 % of reading + 0.1 µV	
	(22 to 70) mV		
	(10 to 30) Hz	0.08 % of reading + 0.6 µV	
	30 Hz to 2 MHz	0.04 % of reading + 0.6 µV	
	(2 to 10) MHz	0.08 % of reading + 0.6 µV	
	(10 to 20) MHz	0.11 % of reading + 0.6 µV	
	(20 to 30) MHz	0.27 % of reading + 0.6 µV	
	(70 to 220) mV		
	(10 to 30) Hz	0.08 % of reading	
	30 Hz to 500 kHz	0.03 % of reading	
	500 kHz to 2 MHz	0.04 % of reading	
	(2 to 10) MHz	0.08 % of reading	
	(10 to 20) MHz	0.11 % of reading	
	(20 to 30) MHz	0.27 % of reading	
	(220 to 700) mV		
	(10 to 30) Hz	0.08 % of reading	
	30 Hz to 500 kHz	0.02 % of reading	
	500 kHz to 2 MHz	0.04 % of reading	
	(2 to 10) MHz	0.08 % of reading	
	(10 to 20) MHz	0.11 % of reading	
	(20 to 30 MHz)	0.27 % of reading	

Electrical – DC/Low Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure Wideband Flatness Relative to 1 kHz	(0.7 to 2) V (10 to 30) Hz 30 Hz to 500 kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (2.2 to 7) V (10 to 30) Hz 30 Hz to 500 kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 0.08 % of reading 0.02 % of reading 0.04 % of reading 0.08 % of reading 0.11 % of reading 0.27 % of reading 0.08 % of reading 0.02 % of reading 0.04 % of reading 0.08 % of reading 0.11 % of reading 0.27 % of reading	Fluke 5790B AC/DC Measurement Standard
Power Meter Range Calibration [1]	3 µW to 100 mW	0.25 % of reading	HP 11683A Power Meter Calibrator

Electrical – RF/Microwave Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Flatness – Measure	9 kHz to 2 000 MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thermal Noise – Measure ENR	5 dB, 15 dB, or 21 dB 0.1 GHz 1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz 7 GHz 8 GHz 9 GHz 10 GHz 11 GHz 12 GHz 13 GHz 14 GHz 15 GHz 16 GHz	 0.21 dB 0.21 dB 0.22 dB 0.23 dB 0.24 dB 0.25 dB 0.26 dB 0.27 dB 0.28 dB 0.29 dB 0.3 dB 0.31 dB 0.32 dB 0.33 dB 0.34 dB 0.35 dB 0.36 dB	Agilent 346C Noise Source Option H13
Thermal Noise – Measure ENR	5 dB, 15 dB, or 21 dB 17 GHz 18 GHz 19 GHz 20 GHz 21 GHz 22 GHz 23 GHz 24 GHz 25 GHz 26 GHz 26.5 GHz	 0.37 dB 0.38 dB 0.39 dB 0.4 dB 0.41 dB 0.42 dB 0.43 dB 0.44 dB 0.45 dB 0.46 dB 0.47 dB	Agilent 346C Noise Source Option H13

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(30 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.13 dB	
	(3 050 to 6 600) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.19 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.25 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(13 200 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.31 dB	
	(19 200 to 26 500) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.14 dB	
	(90 to 100) dB	0.36 dB	
	(100 to 110) dB	0.82 dB	
	(26 500 to 31 150) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.13 dB	
	(90 to 100) dB	0.33 dB	
	(100 to 110) dB	0.77 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(31 150 to 41 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.14 dB	
	(80 to 90) dB	0.36 dB	
	(41 000 to 45 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.11 dB	
	(70 to 80) dB	0.24 dB	
	(80 to 90) dB	0.6 dB	
	(45 000 to 50 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.11 dB	
	(60 to 70) dB	0.29 dB	
	(70 to 80) dB	0.7 dB	
	(80 to 90) dB	1.4 dB	
RF Power – Measure [1]	9 kHz to 14 000 MHz		Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
	(20 to 0) dB	0.13 dB	
	(0 to -40) dB	0.15 dB	
	(-40 to -50) dB	0.35 dB	
	(-50 to -55) dB	0.93 dB	
	(14 000 to 18 000) MHz		
	(20 to 0) dB	0.12 dB	
	(0 to -40) dB	0.16 dB	
	(-40 to -50) dB	0.35 dB	
	(-50 to -55) dB	0.93 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(50 to 100) MHz		Agilent EPM Series Power Meter RF Power / Keysight N8487A Power Sensor
	(20 to 10) dB	0.07 dB	
	(10 to 0) dB	0.07 dB	
	(0 to -10) dB	0.06 dB	
	(-10 to -20) dB	0.07 dB	
	(-20 to -25) dB	0.11 dB	
	(100 to 6 000) MHz		
	(20 to 10) dB	0.07 dB	
	(10 to 0) dB	0.07 dB	
	(0 to -10) dB	0.07 dB	
	(-10 to -20) dB	0.07 dB	
	(-20 to -25) dB	0.11 dB	
	(6 000 to 12 400) MHz		
	(20 to 10) dB	0.08 dB	
	(10 to 0) dB	0.08 dB	
	(0 to -10) dB	0.07 dB	
	(-10 to -20) dB	0.08 dB	
	(-20 to -25) dB	0.12 dB	
	(12 400 to 18 000) MHz		
	(20 to 10) dB	0.09 dB	
	(10 to 0) dB	0.08 dB	
	(0 to -10) dB	0.08 dB	
	(-10 to -20) dB	0.08 dB	
	(-20 to -25) dB	0.12 dB	
	(18 000 to 26 500) MHz		
	(20 to 10) dB	0.11 dB	
	(10 to 0) dB	0.1 dB	
	(0 to -10) dB	0.1 dB	
	(-10 to -20) dB	0.1 dB	
	(-20 to -25) dB	0.13 dB	
	(26 5000 to 33 000) MHz		
	(20 to 10) dB	0.12 dB	
	(10 to 0) dB	0.12 dB	
	(0 to -10) dB	0.11 dB	
	(-10 to -20) dB	0.12 dB	
	(-20 to -25) dB	0.14 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(33 000 to 40 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (40 000 to 50 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.13 dB 0.12 dB 0.12 dB 0.13 dB 0.15 dB 0.18 dB 0.18 dB 0.18 dB 0.18 dB 0.2 dB	Agilent EPM Series Power Meter RF Power / Keysight N8487A Power Sensor
RF Power – Measure [1]	100 kHz to 2 000 MHz (44 to 35) dB (35 to 30) dB (30 to 20) dB (20 to 10) dB (10 to 5) dB (2 000 to 4 200) MHz (44 to 35) dB (35 to 30) dB (30 to 20) dB (20 to 10) dB (10 to 5) dB	 0.18 dB 0.07 dB 0.07 dB 0.08 dB 0.15 dB 0.18 dB 0.07 dB 0.07 dB 0.08 dB 0.15 dB	Agilent EPM Series Power Meter RF Power / HP 8482B Power Sensor
RF Power – Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.26 dB	
	(-110 to -115) dB	0.28 dB	
	(-115 to -120) dB	0.34 dB	
	(-120 to -125) dB	0.7 dB	
	(3 050 to 6 600) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.29 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.53 dB	
	(6 600 to 13 200) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.46 dB	
	(-115 to -120) dB	0.65 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -90) dB	0.26 dB	
	(-90 to -95) dB	0.26 dB	
	(-95 to -100) dB	0.26 dB	
	(-100 to -105) dB	0.29 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(18 000 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.27 dB	
	(-90 to -95) dB	0.27 dB	
	(-95 to -100) dB	0.27 dB	
	(-100 to -105) dB	0.3 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.28 dB	
	(-90 to -95) dB	0.33 dB	
	(-95 to -100) dB	0.43 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.85 dB	
	(-110 to -115) dB	1.2 dB	
	(-115 to -120) dB	1.5 dB	
	(26 500 to 31 150) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.34 dB	
	(-78 to - 90) dB	0.36 dB	
	(-90 to -95) dB	0.39 dB	
	(-95 to -100) dB	0.46 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.82 dB	
	(-110 to -115) dB	1.1 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(31 150 to 41 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB (41 000 to 45 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (45 000 to 50 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.42 dB 0.3 dB 0.34 dB 0.35 dB 0.48 dB 0.64 dB 0.87 dB 1.2 dB 1.5 dB 0.42 dB 0.3 dB 0.34 dB 0.38 dB 0.68 dB 0.93 dB 1.2 dB 1.6 dB 0.42 dB 0.3 dB 0.34 dB 0.67 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (26.5 to 31.15) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 6.8 % of reading + 0.4 digits 1.9 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure [1]	(31.15 to 50) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 26 % of reading + 0.4 digits 6 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 26.5) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 31.15) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (31.15 to 50) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.20 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 – 8.5 % of reading + 17 Hz β > 16 - 1 % of reading + 17 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad (26.5 to 31.15) GHz Deviations: > 1.3 rad Deviations > 4.0 rad (31.15 to 50) GHz Deviations: > 2.4 rad Deviations > 8.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.018 rad 1 % of reading + 0.018 rad	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1 % (0 to -20) dB (-20 to -30) dB AM Depth > 3 % (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1 % (0 to -20) dB (-20 to -30) dB AM Depth > 3 % (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (26.5 MHz to 50.0 GHz) AM Depth > 3 % (0 to -20) dB AM Depth > 5% (0 to -20) dB (-20 to -30) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB 1.8 dB 1.5 dB 3.5 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(6.6 to 13.2) GHz Dev > 4.5 K kHz Hz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (31.15 to 50.0) GHz Dev > 4 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (31.15 to 50.0) GHz Dev > 12.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver
PM Distortion Measure [1]	(1 to 6 600) MHz Rate (20 to 500) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(1 to 6 600) MHz		Agilent N5531S Measuring Receiver
	Rate (500 to 1 000) Hz		
	Dev > 0.4 rad	0.26 dB	
	(0 to -20) dB	0.79 dB	
	(-20 to -30) dB	2.3 dB	
	(-30 to -40) dB		
	Dev > 1.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(6.6 to 13.2) GHz		
	Rate (20 to 500) Hz		
	Dev > 1.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 5.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(6.6 to 13.2) GHz		
	Rate (500 to 1 000) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	

Electrical – RF/Microwave Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(13.2 to 31.15) GHz Rate (20 to 500) Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 1.2 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
Harmonics Measure [1]	(-10 to -80) dB 2nd through 5th Harmonic 1kHz to 600MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (5 300 to 10 000) MHz 2nd through 4th Harmonic (10 000 to 12 500) MHz 2nd through 3rd Harmonic (12 500 to 16 667) MHz 2nd Harmonic (16 667 to 25 000) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB 2.3 dB	Agilent E4448A Measuring Receiver
Attenuation Generate @ 30 MHz	10 dB 20 dB 30 dB 40 dB 50 dB	5.6 mdB 7.6 mdB 6.4 mdB 7.4 mdB 8.6 mdB	HP 11812A Calibration Kit

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1] 50 MHz	1.0 mW	0.37 % of reading	HP 478A/Opt H76 Power Meter
RF Power – Generate	10 Hz to 100 kHz (24 to -48) dBm 100 kHz to 9.99 MHz (-48 to 24) dBm (-48 to -74) dBm (-74 to -94) dBm (10 MHz to 128) MHz (24 to -48) dBm (-48 to -84) dBm (-84 to -94) dBm (-94 to -124) dBm (128 to 300) MHz (20 to -48) dBm (-48 to -74) dBm (-74 to -84) dBm (-84 to -94) dBm (-94 to -124) dBm (300 to 1 400) MHz (20 to -48) dBm (-48 to -74) dBm (-74 to -84) dBm (-84 to -94) dBm (-94 to -124) dBm (1.4 to 3.0) GHz (14 to -48) dBm (-48 to -74) dBm (-74 to -94) dBm (-94 to -124) dBm	 0.06 dB 0.07 dB 0.16 dB 0.39 dB 0.07 dB 0.09 dB 0.24 dB 0.54 dB 0.08 dB 0.09 dB 0.24 dB 0.39 dB 1.2 dB 0.16 dB 0.31 dB 0.39 dB 0.77 dB 1.2 dB 0.24 dB 0.39 dB 0.77 dB 1.2 dB	Fluke 9640A-LPNX RF Reference Source
RF Power – Generate [1]	(30 to 2 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB	 0.29 dB 0.3 dB 0.31 dB 0.32 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(3 050 to 6 600) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(6 600 to 13 200) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.42 dB	
	(13 200 to 18 000) MHz		
	(15 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.46 dB	
	(18 000 to 19 200) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.5 dB	
	(19 200 to 26 500) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.9 dB	
	(26 500 to 31 150) MHz		
	(15 to 0) dB	0.62 dB	
	(0 to -58) dB	0.63 dB	
	(-58 to -78) dB	0.64 dB	
	(-78 to -110) dB	0.96 dB	
	(31 150 to 41 000) MHz		
	(10 to 0) dB	0.82 dB	
	(0 to -58) dB	0.83 dB	
	(-58 to -78) dB	0.84 dB	
	(-78 to -100) dB	1.1 dB	

Electrical – RF/Microwave Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(41 000 to 45 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -100) dB (45 000 to 50 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.82 dB 0.83 dB 0.85 dB 1.4 dB 0.82 dB 0.83 dB 1 dB 1.5 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
RF Power – Power Sensor (Cal Factor)	Type-N (50 Ω) 0.1 MHz 0.3 MHz 0.5 MHz 1 MHz 3 MHz 5 MHz 10 MHz 30 MHz 50 MHz 100 MHz 300 MHz 500 MHz 1 000 MHz 1 500 MHz 2 000 MHz 2 500 MHz 3 000 MHz 3 500 MHz 3 700 MHz 4 000 MHz 4 200 MHz	 1.1 % of reading + M 0.94 % of reading + M 0.93 % of reading + M 0.93 % of reading + M 0.9 % of reading + M 0.9 % of reading + M 0.89 % of reading + M 0.89 % of reading + M 0.91 % of reading + M 0.89 % of reading + M 0.94 % of reading + M 0.94 % of reading + M 0.96 % of reading + M 0.96 % of reading + M 0.96 % of reading + M 1.1 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.4 % of reading + M 1.4 % of reading + M	M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight 8482A H84 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Power Sensor (Cal Factor)	Type-N (50 Ω) 100 MHz 500 MHz 1 000 MHz 2 000 MHz 3 000 MHz 4 000 MHz 5 000 MHz 6 000 MHz 7 000 MHz 8 000 MHz 9 000 MHz 10 000 MHz 11 000 MHz 12 000 MHz 13 000 MHz 14 000 MHz 15 000 MHz 16 000 MHz 17 000 MHz 18 000 MHz	 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.5 % of reading + M 1.5 % of reading + M 1.5 % of reading + M 1.5 % of reading + M 1.7 % of reading + M 1.7 % of reading + M 1.7 % of reading + M 1.8 % of reading + M 1.8 % of reading + M 1.9 % of reading + M	M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight 8481A H84 Power Sensor
RF Power – Power Sensor (Cal Factor)	3.5 mm (50Ω) 50 MHz 100 MHz 300 MHz 500 MHz 1 000 MHz 1 500 MHz 2 000 MHz 3 000 MHz 4 000 MHz 5 000 MHz 6 000 MHz 7 000 MHz	 1.3 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.2 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.4 % of reading + M 1.4 % of reading + M	M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight 8485A H84 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Power Sensor (Cal Factor)	3.5 mm (50Ω)		M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight 8485A H84 Power Sensor
	8 000 MHz	1.5 % of reading + M	
	9 000 MHz	1.6 % of reading + M	
	10 000 MHz	1.6 % of reading + M	
	11 000 MHz	1.5 % of reading + M	
	12 000 MHz	1.5 % of reading + M	
	12 400 MHz	1.6 % of reading + M	
	13 000 MHz	1.6 % of reading + M	
	14 000 MHz	1.9 % of reading + M	
	15 000 MHz	1.7 % of reading + M	
	16 000 MHz	1.6 % of reading + M	
	17 000 MHz	1.8 % of reading + M	
	18 000 MHz	1.7 % of reading + M	
	19 000 MHz	2 % of reading + M	
	20 000 MHz	2.2 % of reading + M	
	21 000 MHz	2.1 % of reading + M	
	22 000 MHz	2.5 % of reading + M	
	23 000 MHz	2.7 % of reading + M	
	24 000 MHz	2.3 % of reading + M	
	25 000 MHz	2 % of reading + M	
	26 000 MHz	2 % of reading + M	
	26 500 MHz	2.3 % of reading + M	
RF Power – Power Sensor (Cal Factor)	2.4 mm (50 Ω)		M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight N8487A H84 Power Sensor
	50 MHz	1.1 % of reading + M	
	100 MHz	1.1 % of reading + M	
	300 MHz	1.1 % of reading + M	
	500 MHz	1.2 % of reading + M	
	1 000 MHz	1.2 % of reading + M	
	2 000 MHz	1.2 % of reading + M	
	3 000 MHz	1.2 % of reading + M	
	4 000 MHz	1.2 % of reading + M	
	5 000 MHz	1.3 % of reading + M	
	6 000 MHz	1.3 % of reading + M	
	7 000 MHz	1.3 % of reading + M	
	8 000 MHz	1.4 % of reading + M	
	9 000 MHz	1.5 % of reading + M	
	10 000 MHz	1.5 % of reading + M	
	11 000 MHz	1.5 % of reading + M	
	12 000 MHz	1.5 % of reading + M	
	13 000 MHz	1.5 % of reading + M	
	14 000 MHz	1.6 % of reading + M	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Power Sensor (Cal Factor)	2.4 mm (50 Ω)		M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight N8487A H84 Power Sensor
	15 000 MHz	1.6 % of reading + M	
	16 000 MHz	1.7 % of reading + M	
	17 000 MHz	1.7 % of reading + M	
	18 000 MHz	1.7 % of reading + M	
	19 000 MHz	1.9 % of reading + M	
	20 000 MHz	1.9 % of reading + M	
	21 000 MHz	1.9 % of reading + M	
	22 000 MHz	1.9 % of reading + M	
	23 000 MHz	1.9 % of reading + M	
	24 000 MHz	1.9 % of reading + M	
	25 000 MHz	1.9 % of reading + M	
	26 000 MHz	1.9 % of reading + M	
	27 000 MHz	2.4 % of reading + M	
	28 000 MHz	2.4 % of reading + M	
	29 000 MHz	2.4 % of reading + M	
	30 000 MHz	2.4 % of reading + M	
	31 000 MHz	2.4 % of reading + M	
	32 000 MHz	2.4 % of reading + M	
	33 000 MHz	2.4 % of reading + M	
	34 000 MHz	2.5 % of reading + M	
	34 500 MHz	2.5 % of reading + M	
	35 000 MHz	2.5 % of reading + M	
	36 000 MHz	2.6 % of reading + M	
	37 000 MHz	2.6 % of reading + M	
	38 000 MHz	2.6 % of reading + M	
	39 000 MHz	2.9 % of reading + M	
	40 000 MHz	3 % of reading + M	
	41 000 MHz	3.2 % of reading + M	
	42 000 MHz	3.2 % of reading + M	
	43 000 MHz	3.2 % of reading + M	
	44 000 MHz	3.2 % of reading + M	
	45 000 MHz	3.2 % of reading + M	
	46 000 MHz	3.2 % of reading + M	
	47 000 MHz	3.2 % of reading + M	
	48 000 MHz	3.3 % of reading + M	
	49 000 MHz	3.4 % of reading + M	
	50 000 MHz	3.4 % of reading + M	
Phase Noise [1] Offset Frequency 5 MHz < f ≤ 18 GHz	≤ 100 kHz 100 kHz to 40 MHz	2.3 dB 4.6 dB	HP 3048A Phase Noise System with 866XA Source

Electrical – RF/Microwave Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
Return Loss (VSWR) 5 Hz to 45 MHz 45 MHz to 50 GHz	 (0 to 120) dB (0 to 120) dB	 1.1 dB 0.41 dB	HP 8751A, HP 85107B Network Analyzers

Length – Dimensional Metrology Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	Up to 20 in	(3.2 + 1.2*L*) µin	Master gage blocks, P&W universal measuring machine
Micrometers [1,2]	Up to 40 in	(30 + 4.8*L*) µin	Gage blocks (grade 2)
Micrometer Standards Length Rods	Up to 40 in	(4.3 + 3.8*L*) µin	Gage blocks (grade 2), P&W universal measuring machine
Calipers [1,2]	Up to 40 in	(280 + 2*L*) µin	Gage blocks (grade 2)
Dial Indicators [1,2] Resolution: ≥ 50µin < 50µin	 Up to 10 in Up to 0.1 in	 (26 + 3.3*L*) µin 7.7 µin	Gage blocks (grade 2)
Height Gages [1,2]	Up to 40 in	(114 + 3.3*L*) µin	Gage blocks (grade 2)
Protractors [1]	(0 to 360) °	0.008 6°	Angle blocks
Rulers [1]	Up to 46 in	0.009 in	Gage blocks (grade 2)

Length – Dimensional Metrology Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Radius Gages	(0.016 to 1) in	220 µin	Optical Comparator
Tape Measures [2]	Up to 100 ft	(0.000 26*F* + 0.025) in	Standard rule
Bore Micrometers [2] 2 point 3 point	Up to 12 in	(22 + 3.6*L*) µin (8.8 + 42*L*) µin	Master gage blocks, P&W universal measuring machine, Master Ring
Feeler Gage [1]	Up to 1 in	30 µin	Pratt & Whitney Supermicrometer C
Cylindrical Gages [1,2] – Plain Pin, Plugs, Rings	(0.04 to 13) in	(5.3 + 2.3*D*) µin	Master gage blocks, P&W universal measuring machine
Cylindrical Gages [1,2] – Plain Rings	(0 to 14) in	(8.1 + 2.9*D*) µin	
Thread Plugs [1] – Major Diameter Pitch Diameter	Up to 12 in Up to 12 in	36 µin 92 µin	B & S 599-246-00, Van Keuren thread wire set Gage blocks, Pratt & Whitney Labmaster
Solid Thread Rings Pitch Diameter	Up to 12 in	107 µin	Pratt & Whitney Labmaster Measuring Machine
Adjustable Thread Rings [2,3] Pitch Diameter (Tactile Fit)	Up to 12 in	(350 + 47*D*) µin	Thread setting plug gages
Thread Wires [2]	Up to 0.5*D*	10 µin	Master gage blocks, P&W universal measuring machine
Surface Plates [1] – Overall Flatness Local Area Flatness	Up to 6 ft × 6 ft (-0.001 to 0.001) in	125 µin 68 µin	Planekator Repeat-O-Meter
Optical Comparators [1] – Angle Linearity Magnification	Up to 360 ° Up to 20 in (20 to 40) in (10 to 100) x	0.008 7 ° 210 µin 450 µin 340 µin	Gage blocks, Angle Blocks, SI Industries glass scales
Coating Thickness Gages [1,2] Eddy Current & Magnetic Induction	(0.737 to 100) mils (100 to 243) mils	26 µin 240 µin	Coating thickness standards
Ultrasonic Thickness Gauges [1]	Up to 10 in	110 µin	Gage blocks

Length – Dimensional Metrology Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Coating Thickness Shims [2]	(0 to 243) mils	56 µin	Pratt & Whitney Supermicrometer C

Mass and Mass Related Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,2,4]	1 mg to 5 000 g (0.001 to 100) lb	(0.049 + 0.003*X*) mg (3.2 E^{-6} + 3.1 E^{-6}*W*) lb	Class 1 weights
	Up to 1 000 lb	(0.000 2 + 0.000 12*W*) lb	Class F weights
Force [1] Tension and Compression	(0.5 to 750) lbf	0.09 % of reading	Class F weights
	(20 to 1 000) lbf (200 to 10 000) lbf (10 000 to 25 000) lbf (25 000 to 50 000) lbf	The greater of: 0.012 % of reading or 0.023 lbf 0.012 % of reading or 0.24 lbf 0.012 % of reading or 0.5 lbf 0.012 % of reading or 0.77 lbf	Morehouse Press with Load Cells
Pressure [1]	(0 to 24) inH_2O	0.001 5 inH_2O	Dwyer 1425-25 Hook Gage
	(-15 to 200) psi (0 to 1 000) psi	The greater of: 0.013 % of reading or 0.003 9% of reading of PPC4 Span	Fluke PPC4 Pressure Controller
	(10 to 16 000) psi	0.019 % of reading	Fluke P3125-PSI Dead Weight Tester
Pressure [1]	(16 000 to 40 000) psi	25 psi	Additel ADT672-10-GP40K Pressure Calibrator
Gas Flow	(1 to 10 000) sccm (10 to 1 000) slpm	0.2 % of reading 0.26 % of reading	Molbloc flow standards
Pipette [2]	(10 to 100) µL (100 to 1 000) µL (1 to 10) mL	(0.58 + 0.004*V*) µL (0.6 + 0.001*V*) µL (2.6 + 0.001 2*V*) µL	Mass Balance
Torque Tools [1]	(10 to 100) ozf-in	0.59 % of reading	CDI 1001 Torque Tester
	64 ozf-in to 1 000 lbf-ft	0.32 % of reading	Analyzer / CDI 5000 ST Torque Analyzer
Torque Analyzers [1]	1 lbf-in to 1 000 lbf-ft	0.075 % of reading	Torque Arm, Class F Weights

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers [1]	(< 60) HRBW (≥ 60 to < 80) HRBW (≥ 80) HRBW (< 35) HRC (≥ 35 to < 60) HRC (≥ 60) HRC (< 84) HREW (≥ 84 to < 93) HREW (≥ 93) HREW (< 81) HR15TW (≥ 81 to < 87) HR15TW (> 87) HR15TW	3 HRBW 3 HRBW 1.3 HRBW 1.3 HRC 1.2 HRC 0.7 HRC 1.3 HREW 1.3 HREW 1.3 HREW 1.8 HR15TW 1.3 HR15TW 1.3 HR15TW	Indirect verification per ASTM E18
Durometers Scale (Force) Accuracy Types A, B, C, D, DO, O Type M Types O, OO Indenter Geometry Length Diameter Angle	 (0 to 100) duros 0.1 in 0.05 in (30 to 35)°	 0.06 duros 0.07 duros 0.08 duros 130 µin 130 µin 0.12°	Direct Verification Master balance Optical comparator
Mass - Fixed Points Metric	(1, 2, 5, 10) mg (20, 50, 100, 500) mg (1, 2, 5) g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 5 kg	0.027 mg 0.027 mg 0.08 mg 0.13 mg 0.11 mg 0.22 mg 0.36 mg 0.64 mg 29 mg 30 mg 31 mg	Comparison to ASTM E617 Class 1 weights

Mass and Mass Related Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass - Fixed Points Avoirdupois	(0.001, 0.002) lb (0.005, 0.01, 0.02) lb 0.05 lb 0.1 lb 0.2 lb (0.5, 1, 2) lb 5 lb 10 lb 25 lb 50 lb	0.18 mg 0.19 mg 0.24 mg 0.29 mg 0.39 mg 27 mg 28 mg 28 mg 0.23 g 0.23 g	Comparison to ASTM E617 Class 1 weights

Thermodynamic Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber
Relative Humidity Measure	(0 to 90) %RH (90 to 100) %RH	1.2 %RH 2 %RH	Vaisala MI70/HMP76 Humidity Indicator and Probe
Temperature – Measure [1]	(-196 to 230) °C (-321 to 446) °F (230 to 420) °C (446 to 788) °F (420 to 660) °C (788 to 1 220) °F	0.023 °C 0.042 °F 0.04 °C 0.072 °F 0.056 °C 0.1 °F	Hart 1502A Indicator with 5616 & 5609 PRT
	(800 to 1 550) ºC	2 ºC	Type B Thermocouple
Temperature Uniformity Surveys [1]	Type J (100 to 900) °F Type K (100 to 1 000) °F (1 000 to 2 000) °F (2 000 to 2 200) °F	 1.8 °F 2 °F 2.1 °F 2.7 °F	Datalogger and Thermocouples
Infrared (IR) Thermometry [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 Infrared Calibrator λ = (8 to 14) µm, ε = 0.95

Time and Frequency Temple Terrace, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure	10 MHz	1×10^{-12} Hz/Hz	58503A/B GPS Receiver
Frequency – Generate [1]	1 to 10 Hz 10 to 100 Hz 100 to 1 000 Hz 1 to 10 kHz 10 to 100 kHz 0.1 to 1 MHz 1 to 10 MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 µHz $1 \times 1^{e-12}$ Hz/Hz + 5.7 µHz $1 \times 1^{e-12}$ Hz/Hz + 57 µHz $1 \times 1^{e-12}$ Hz/Hz + 0.57 mHz $1 \times 1^{e-12}$ Hz/Hz + 5.7 mHz $1 \times 1^{e-12}$ Hz/Hz + 57 mHz $1 \times 1^{e-12}$ Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	10 to 50 000 MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57mHz	Agilent E8257D Opt 550 Signal Generator / HP 58503A GPS Receiver
Frequency – Measure [1]	1 to 10 Hz 10 to 100 Hz 100 to 1 000 Hz 1 to 10 kHz 10 to 100 kHz 100 to 200 kHz 0.2 to 3 000 MHz	$1.82 \times 1^{e-9}$ Hz/Hz $0.59 \times 1^{e-9}$ Hz/Hz $0.20 \times 1^{e-9}$ Hz/Hz $74 \times 1^{e-10}$ Hz/Hz $35 \times 1^{e-10}$ Hz/Hz $23 \times 1^{e-10}$ Hz/Hz $20 \times 1^{e-10}$ Hz/Hz	Agilent 53132A Opt 030 Frequency Counter / HP 58503A GPS Receiver
	50 to 46 000 MHz	$1 \times 1^{e-12}$ Hz/Hz + 1.6 Hz	Agilent 53152A Frequency Counter / HP 58503A GPS Receiver
	10 to 50 000 MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.1 Hz	Agilent E4448A Spectrum Analyzer / HP 58503A GPS Receiver
Time – Generate	1 pps	$1 \times 1^{e-12}$ s/s + 750 ps	HP 58503A GPS Receiver
Type I (digital) Timers	(0 to19.99) sec/day (0 to 599) sec/month	0.031 sec/day 1.1 sec/month	Helmut Klein Timometer 4500
Type II (mechanical) Timers	(0 to 320) sec/day	0.6 sec/day	
Tachometers – RPM [1,2]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 33250A Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional **Temple Terrace, FL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length	X Axis (0.01 to 10) in Y Axis (0.01 to 6) in	162 µin 123 µin	Optical comparator

2 Dimensional **Temple Terrace, FL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle	Up to 360 °	0.004 °	Optical comparator

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Services performed at satellite laboratory

Technical Maintenance, Inc.
3000 Northwoods Parkway, Suite 270
Peachtree Corners, GA 30071
Milt Mosher (Branch Manager) Phone: 770-409-8348
Scott Chamberlain (Quality Manager) Phone: 321-242-0890

CALIBRATION AND DIMENSIONAL MEASUREMENT

CALIBRATION

Acoustics and Vibration — Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration [1]	(0.01 to 10) g (7 < 10) Hz (10 < 30) Hz (30 < 2 000) Hz (2 to 10) kHz	4 % of reading 3 % of reading 1.5 % of reading 4 % of reading	The Modal Shop 9100D Portable Vibration Calibrator
Sound Pressure Level – Generate [1]	114dB @ 251.2 Hz	0.26 dB	Larson Davis CAL250 Sound Level Calibrator

Chemical Quantities — Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,5]	(4, 7, 10) pH	0.02 pH	Standard pH buffers

Electrical – DC/Low Frequency — Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate [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	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure [1]	Up to 100 mV (0.1to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	3.3 µV/V + 1 µV 2.6 µV/V + 1 µV 2.6 µV/V + 1.5 µV 3.9 µV/V + 20 µV 3.9 µV/V + 66 µV + 12 µV/V x (Vin/1 000)^2	HP 3458A Opt 002 Multimeter
DC Voltage – Measure [1]	(1 to 60) kV	0.1 % of reading	Ross VD60 High Voltage Divider, HP 34401A Multimeter
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 20 µA/A + 1 nA	Fluke 5720A Multifunction Calibrator & Fluke 5522A Multifunction Calibrator
DC Current – Generate [1]	(10 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5720A Multifunction Calibrator
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5720A Multifunction Calibrator, 5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A	761 µA/A + 578 µA	Fluke 5522A Multifunction Calibrator
DC Current Clamp Meters [1] Toroidal-Wound	(0 to 1 025) A	0.21 % of output + 0.05 A	
DC Current Clamp Meters [1] Other	(0 to 1 025) A	0.39 % of output + 0.38 A	Fluke 5522A Multiproduct Calibrator / Coil x50
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.12 pA 18 µA/A + 1.2 pA 11 µA/A + 0.01 nA 9.1 µA/A + 0.12 nA	Fluke 5720A Multifunction Calibrator, Agilent 3458A Multimeter Option 002
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA 1 to 10 mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10.1 µA	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure [1]	(1 to 10) A (10 to 100) A	41 µA/A + 103 µA 53 µA/A + 103 µA	Agilent 3458A Option 002 Precision Multimeter Standard Resistor L&N 4361 Current Shunt
DC Current – Measure [1]	(1 to 500) A	0.27 % of reading	Current shunts
Resistance – Fixed Points [1]	(0.01, 0.1, 1.0) Ω	34 µΩ/Ω	Leeds & Northrup Resistor Set
	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ (100, 190) kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 µΩ/Ω + 0.1 µΩ 21 µΩ/Ω + 1 µΩ 9.1 µΩ/Ω + 6 µΩ 7.6 µΩ/Ω + 60 µΩ 7.6 µΩ/Ω + 0.6 mΩ 9.9 µΩ/Ω + 6 mΩ 17.5 µΩ/Ω + 60 mΩ 18.3 µΩ/Ω + 60 mΩ 35 µΩ/Ω + 0.6 Ω 42 µΩ/Ω + 0.6 Ω 91 µΩ/Ω + 6 Ω	Fluke 5720A Multifunction Calibrator
Resistance – Generate [1]	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	30 µΩ/Ω + 0.001 Ω 23 µΩ/Ω + 0.001 Ω 21 µΩ/Ω + 0.001 Ω 21 µΩ/Ω + 0.002 Ω 21 µΩ/Ω + 0.002 Ω 21 µΩ/Ω + 0.02 Ω 21 µΩ/Ω + 0.02 Ω 21 µΩ/Ω + 0.2 Ω 21 µΩ/Ω + 0.2 Ω 24 µΩ/Ω + 2 Ω 24 µΩ/Ω + 2 Ω 46 µΩ/Ω + 23 Ω 99 µΩ/Ω + 38 Ω 190 µΩ/Ω + 1.9 kΩ 380 µΩ/Ω + 2.3 kΩ 0.23 % of reading + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multiproduct Calibrator

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2 kΩ 1 to 12 kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 0.6 mΩ 10 μΩ/Ω + 5.6 mΩ 10 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	HP 3458A Multimeter
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) μF (1.1 to 3.299 99) μF (3.3 to 10.999 9) μF (11 to 32.999 9) μF (33 to 109.999) μF (110 to 329.999) μF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.38% of output + 7.6 pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF 0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 μF 0.34 % of output + 2.3 μF 0.34 % of output + 7.6 μF 0.57 % of output + 23 μF 0.84 % of output + 76 μF	Fluke 5522A Multiproduct Calibrator
Capacitance – Generate [1] Fixed Points	1 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	0.028 % of output 0.028 % of output 0.034 % of output 0.047 % of output 0.069 % of output 0.096 % of output 0.31 % of output 0.5 % of output	Agilent 16381A Standard Air Capacitor

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate [1] Fixed Points	10 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.019 % of output 0.019 % of output 0.019 % of output 0.019 % of output 0.019 % of output 0.019 % of output 0.022 % of output 0.024 % of output	Agilent 16382A Standard Air Capacitor
Capacitance – Generate [1] Fixed Points	100 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.017 % of output 0.017 % of output 0.018 % of output 0.018 % of output 0.02 % of output 0.024 % of output 0.053 % of output 0.083 % of output	Agilent 16383A Standard Air Capacitor
Capacitance – Generate [1] Fixed Points	1 000 pF 1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	 0.018 % of output 0.019 % of output 0.024 % of output 0.035 % of output 0.051 % of output 0.069 % of output 0.22 % of output 0.32 % of output	Agilent 16384A Standard Air Capacitor
Inductance – Generate [1] Fixed Point	500 µH 1 kHz	 0.35 µH	GR 1482-D Standard Inductor
	20 mH 1 kHz	 0.008 mH	GR 1482-J Standard Inductor
	200 mH 100 Hz	 0.11 mH	GR 1482-M Standard Inductor
	2 H 100 Hz	 0.8 mH	GR 1482-Q Standard Inductor

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	Up to 22 mV		Fluke 5720A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	
AC Voltage – Generate [1]	(22 to 220) mV		Fluke 5720A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 11.4 µV	
	(20 to 40) Hz	88 µV/V + 6.1 µV	
	40 Hz to 20 kHz	76 µV/V + 6.1 µV	
	(20 to 50) kHz	190 µV/V + 6.1 µV	
	(50 to 100) kHz	457 µV/V + 15.2 µV	
	(100 to 300) kHz	837 µV/V + 19 µV	
	(300 to 500) kHz	1.3 mV/V + 23 µV	
	500 kHz to 1 MHz	2.5 mV/V + 46 µV	
	(0.22 to 2.2) V		
	(10 to 20) Hz	228 µV/V + 38 µV	
	(20 to 40) Hz	84 µV/V + 15 µV	
	40 Hz to 20 kHz	40 µV/V + 8 µV	
	(20 to 50) kHz	68 µV/V + 9 µV	
	(50 to 100) kHz	99 µV/V + 30 µV	
	(100 to 300) kHz	380 µV/V + 76 µV	
	(300 to 500) kHz	913 µV/V + 190 µV	
	500 kHz to 1 MHz	1.5 mV/V + 304 µV	
	(2.2 to 22) V		
	(10 to 20) Hz	228 µV/V + 380 µV	
	(20 to 40) Hz	84 µV/V + 152 µV	
	40 Hz to 20 kHz	37 µV/V + 54 µV	
	(20 to 50) kHz	61 µV/V + 91 µV	
	(50 to 100) kHz	76 µV/V + 190 µV	
	(100 to 300) kHz	228 µV/V + 609 µV	
	(300 to 500) kHz	913 µV/V + 1.9 mV	
	500 kHz to 1 MHz	1.4 mV/V + 3 mV	
	(22 to 220) V		
	(10 to 20) Hz	228 µV/V + 3.8 mV	
	(20 to 40) Hz	84 µV/V + 1.5 mV	
	40 Hz to 20 kHz	49 µV/V + 0.6 mV	
	(20 to 50) kHz	76 µV/V + 0.9 mV	
	(50 to 100) kHz	137 µV/V + 2.3 mV	

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5720A Multifunction Calibrator /5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30) Hz 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30) Hz 30 Hz to 500 kHz (0.5 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 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (11 to 33) mV (10 to 30) Hz 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 12.9 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV 0.58 % of output + 6.1 µV 0.53 % of output + 6.1 µV 0.54 % of output + 8.4 µV 0.54 % of output + 8.4 µV 0.55 % of output + 8.4 µV 0.61 % of output + 8.4 µV 0.93 % of output + 8.4 µV 0.52 % of output + 12 µV 0.46 % of output + 12 µV 0.47 % of output + 14 µV 0.47 % of output + 14 µV 0.49 % of output + 14 µV 0.55 % of output + 14 µV 0.89 % of output + 14 µV	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(33 to 110) mV		Fluke 5720A Multifunction Calibrator
	(10 to 30) Hz	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30) Hz	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	0.33 to 1.1 V		
	(10 to 30) Hz	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	
	(1.1 to 3.5) V		
	(10 to 30) Hz	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2 % of reading + 5 µV	
	(1 to 4) MHz	7 % of reading + 7 µV	
	(4 to 8) MHz	20 % of reading + 8 µV	

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	10 mV to 100 mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1.0 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.007 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.007 % of reading + 0.2 mV	
	(1 to 20) kHz	0.014 % of reading + 0.2 mV	
	(20 to 50) kHz	0.03 % of reading + 0.2 mV	
	(50 to 100) kHz	0.08 % of reading + 0.2 mV	
	(100 to 300) kHz	0.3 % of reading + 1.0 mV	
	300 kHz to 1 MHz	1 % of reading + 1 mV	
	(1 to 2) MHz	1.5 % of reading + 7 mV	
	(2 to 4) MHz	4 % of reading + 7 mV	
	(4 to 8) MHz	4 % of reading + 8 mV	
	(8 to 10) MHz	15 % of reading + 10 mV	

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.02 % of reading + 4 mV 0.02 % of reading + 2 mV 0.02 % of reading + 2 mV 0.035 % of reading + 2 mV 0.12 % of reading + 2 mV 0.4 % of reading + 10 mV 1.5 % of reading + 10 mV 0.04 % of reading + 40 mV 0.04 % of reading + 20 mV 0.06 % of reading + 20 mV 0.12 % of reading + 20 mV 0.3 % of reading + 20 mV	HP 3458A Multimeter
AC Voltage – Measure [1]	(1 to 10) kV 60 Hz (10 to 42) kV 60 Hz	 0.5 % of reading + 0.002 kV 0.5 % of reading + 0.02 kV	Ross VD60 High Voltage Divider, HP 34401A Multimeter
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 107 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 107 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 µA	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(22 to 200) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.2 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 4 µA 152 µA/A + 3 µA 107 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 243 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5720A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA/A + 141 µA 723 µA/A + 295 µA 2.7 mA/A + 573 µA	Fluke 5720A Multifunction Calibrator /5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.28 % of output + 5 mA	Fluke 5720A Multifunction Calibrator /5725A Amplifier
AC Current Clamps – Toroidal-Wound	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.23 % of output + 0.103 A 0.64 % of output + 0.085 A	Fluke 5522A Multiproduct Calibrator, 5500A/Coil x50
AC Current Clamps – Other	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.44 % of output + 0.53 A 0.79 % of output + 0.69 A	Fluke 5522A Multiproduct Calibrator, 5500A/Coil x50
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (0.1 to 1) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A Multimeter
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	 0.72 % of reading + 1.2 mA 0.23 % of reading + 1.2 mA 0.1 % of reading + 1.2 mA	Agilent 34401A Multimeter
AC Current – Measure [1]	(1 to 20) A (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz	 368 µA/A 368 µA/A 302 µA/A 424 µA/A	Agilent 3458A Multimeter / Fluke Y5020 Current Shunt
AC Current – Measure [1]	(3 to 30) A 40 Hz to 1 kHz (1 to 5) kHz	 0.3 % of reading + 0.07 A 5 % of reading + 0.14 A	Agilent 3458A Multimeter Keysight 34330A Current Shunt
AC Current – Measure [1]	(10 to 100) A (50 to 1000) Hz (100 to 600) A (50 to 1000) Hz	 2 % of reading + 0.02 A 2 % of reading+ 0.2 A	Fluke 80i-600 Clamp Meter / Agilent 3458A Multimeter
AC Current – Measure [1]	(100 to 2 000) A 55 to 65 Hz (2 000 to 6 000) A 55 to 65 Hz	 1 % of reading + 0.5A 1 % of reading + 3.9 A	PEM CWT600B Rogowski Coil / HP 34401A Multimeter
Low Frequency Power – Generate [1]	Up to 20 kW (45 to 65) Hz, 1 PF Up to 20 kW DC	 0.44 % of reading 0.13 % of reading	Fluke 5522A Multiproduct Calibrator

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type B		Fluke 5522A Multiproduct Calibrator
	(600 to 800) °C	0.34 °C	
	(800 to 1550) °C	0.26 °C	
	(800 to 1550) °C	0.23 °C	
	(1550 to 1820) °C	0.25 °C	
	Type C		
	(0 to 150) °C	0.23 °C	
	(150 to 650) °C	0.2 °C	
	(650 to 1 000) °C	0.24 °C	
	(1 000 to 1 800) °C	0.39 °C	
	(1 800 to 2 316) °C	0.64 °C	
	Type E		
	(-250 to -100) °C	0.38 °C	
	(-100 to -25) °C	0.13 °C	
	(-25 to 350) °C	0.11 °C	
	(350 to 650) °C	0.13 °C	
	(650 to 1 000) °C	0.16 °C	
	Type J		
	(-210 to -100) °C	0.21 °C	
	(-100 to -30) °C	0.13 °C	
	(-30 to 150) °C	0.11 °C	
	(150 to 760) °C	0.13 °C	
	(760 to 1 200) °C	0.18 °C	
	Type K		
	(-200 to -100) °C	0.25 °C	
	(-100 to -25) °C	0.14 °C	
	(-25 to 120) °C	0.13 °C	
	(120 to 1 000) °C	0.2 °C	
	(1 000 to 1 372) °C	0.31 °C	
	Type L		
	(-200 to -100) °C	0.28 °C	
	(-100 to 800) °C	0.2 °C	
	(800 to 900) °C	0.13 °C	
	Type N		
	(-200 to -100) °C	0.31 °C	
	(-100 to -25) °C	0.17 °C	
	(-25 to 120) °C	0.15 °C	
	(120 to 410) °C	0.14 °C	
	(410 to 1 300) °C	0.21 °C	

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type R		Fluke 5522A Multiproduct Calibrator
	(0 to 250) °C	0.43 °C	
	(250 to 1 000) °C	0.27 °C	
	(1 000 to 1 400) °C	0.25 °C	
	(1 400 to 1 767) °C	0.31 °C	
	Type S		
	(0 to 250) °C	0.36 °C	
	(250 to 1 000) °C	0.28 °C	
	(1 000 to 1 400) °C	0.28 °C	
	(1 400 to 1 767) °C	0.35 °C	
	Type T		
	(-250 to -150) °C	0.48 °C	
	(-150 to 0) °C	0.18 °C	
	(0 to 120) °C	0.13 °C	
	(120 to 400) °C	0.11 °C	
	Type U		
	(-200 to 0) °C	0.43 °C	
	(0 to 600) °C	0.21 °C	
Electrical Calibration of RTD Indicators [1]	Pt 385, 100 Ω		Fluke 5522A Multiproduct Calibrator
	(-200 to 0) °C	0.058 °C	
	(0 to 100) °C	0.081 °C	
	(100 to 300) °C	0.1 °C	
	(300 to 400) °C	0.12 °C	
	(400 to 630) °C	0.14 °C	
	(630 to 800) °C	0.27 °C	
	Pt 3926, 100 Ω		
	(-200 to 0) °C	0.07 °C	
	(0 to 100) °C	0.081 °C	
	(100 to 300) °C	0.1 °C	
	(300 to 400) °C	0.12 °C	
	(400 to 630) °C	0.14 °C	
	Pt 3916, 100 Ω		
	(-200 to -190) °C	0.29 °C	
	(-190 to -80) °C	0.047 °C	
	(-80 to 0) °C	0.058 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 260) °C	0.081 °C	
	(260 to 300) °C	0.093 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 600) °C	0.12 °C	
	(600 to 630) °C	0.27 °C	

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of RTD Indicators [1]	Pt 385, 200 Ω		Fluke 5522A Multiproduct Calibrator
	(-200 to 100) °C	0.047 °C	
	(100 to 260) °C	0.058 °C	
	(260 to 300) °C	0.14 °C	
	(300 to 400) °C	0.15 °C	
	(400 to 600) °C	0.16 °C	
	(600 to 630) °C	0.19 °C	
	Pt 385, 500 Ω		
	(-200 to -80) °C	0.048 °C	
	(-80 to 100) °C	0.059 °C	
	(100 to 260) °C	0.07 °C	
	(260 to 400) °C	0.093 °C	
	(400 to 600) °C	0.11 °C	
	(600 to 630) °C	0.13 °C	
	Pt 385, 1000 Ω		
	(-200 to 0) °C	0.037 °C	
	(0 to 100) °C	0.048 °C	
	(100 to 260) °C	0.059 °C	
	(260 to 300) °C	0.07 °C	
	(300 to 600) °C	0.082 °C	
	(600 to 630) °C	0.27 °C	
	PtNi 385, 120 Ω (Ni120)		
	(-80 to 100) °C	0.093 °C	
	(100 to 260) °C	0.16 °C	
	Cu 427, 10 Ω		
	(100 to 260) °C	0.35 °C	
Oscilloscopes Calibration – Generate [1] Voltage DC - 50Ω	(1 to 24.999) mV	0.19 % of Output + 31 µV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
	(25 to 109.99) mV	0.19 % of Output + 36 µV	
	(110mV to 2.199 9) V	0.19 % of Output + 87 µV	
	(2.2 to 6.6) V	0.19 % of Output + 0.6 mV	
DC - 1MΩ	(1 to 24.999) mV	0.019 % of reading + 20 µV	
	(25 to 109.99) mV	0.019 % of reading + 25 µV	
	(110mV to 2.199 9) V	0.019 % of reading + 76 µV	
	(2.2 to 10.999) V	0.019 % of reading + 0.6 mV	
	(11 to 130) V	0.019 % of reading + 6 mV	

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1] Square Wave 10 Hz to 10 kHz - 50Ω	(1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.199 9) Vpp (2.2 to 6.6) Vpp	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Square Wave 10 Hz to 1 kHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.199 9) V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6 mV	
Square Wave (1 to 10) kHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6 mV	
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth (5 to 50) mVpp 50 kHz to 100) MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 16 00) MHz (1 600 to 2 100) MHz 50 mV to 3.5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz	 0.34 dB 0.36 dB 0.42 dB 0.46 dB 0.5 dB 0.56 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB 0.4 dB 0.44 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness	3 dB Bandwidth 50 mV to 3.5Vpp (2 100 to 4 000) MHz (4 000 to 8 000) MHz (8 000 to 18 000) MHz	 0.25 dB 0.35 dB 0.46 dB	EPM Power Meter w/ E Series Power Sensors
Oscilloscopes Calibration – Generate [1] Time Marker	500 ps to 20 ms 50 ms to 5 s	0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration Measure [1] Input Impedance Resistance Leakage	 (40 to 60) Ω 500 kΩ to 1.5MΩ (0 to 5.99) V	 0.08 % of reading 0.08 % of reading 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Voltage DC – 50 Ω DC – 1 MΩ Square Wave 10 Hz to 10 kHz – 1 MΩ	 1 mV to 5 V 1 mV to 200 V 1 mV to 200 Vpp	 0.025 % of output + 25 µV 0.025 % of output + 25 µV 0.1 % of output + 10 µV	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	5 mV to 5 Vpp (0.1 Hz to 300) MHz (300 to 550) MHz 5 mV to 3 Vpp (550 to 1 100) MHz	 0.18 dB 0.22 dB 0.3 dB	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration – Generate [1] Time Marker	 9 ns to 55 s	 0.25 µs/s	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration – Measure [1] Input Impedance Resistance	 (10 to 40) Ω (40 to 90) Ω (90 to 150) Ω (50 to 800) KΩ (0.8 to 1.2) MΩ (1.2 to 12) MΩ	 0.5 % of reading 0.1 % of reading 0.5 % of reading 0.5 % of reading 0.1 % of reading 0.5 % of reading	Fluke 9500B with 9510 Active Head
Power Meters [1]	3 µW to 100 mW	0.3 % of reading	HP 11683A Range Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(30 to 3050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.13 dB	
	(3 050 to 6 600) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.19 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.25 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(13 200 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.31 dB	
	(19 200 to 26 500) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.14 dB	
	(90 to 100) dB	0.36 dB	
	(100 to 110) dB	0.82 dB	
	(26 500 to 31 150) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.13 dB	
	(90 to 100) dB	0.33 dB	
	(100 to 110) dB	0.77 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(31 150 to 41 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.14 dB	
	(80 to 90) dB	0.36 dB	
	(41 000 to 45 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.11 dB	
	(70 to 80) dB	0.24 dB	
	(80 to 90) dB	0.6 dB	
	(45 000 to 50 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.11 dB	
	(60 to 70) dB	0.29 dB	
	(70 to 80) dB	0.7 dB	
	(80 to 90) dB	1.4 dB	
RF Flatness – Measure [1]	9 kHz to 2 000 MHz		Agilent EPM Series Power Meter w/E9304A Power Sensor
	(20 to -10) dBm	0.1 dB	
	(-10 to -30) dBm	0.1 dB	
	(-30 to -40) dBm	0.11 dB	
	(-40 to -42) dBm	0.12 dB	
	(2 000 to 6 000) MHz		
	(20 to -10) dBm	0.1 dB	
	(-10 to -30) dBm	0.09 dB	
	(-30 to -40) dBm	0.1 dB	
	(-40 to -42) dBm	0.11 dB	

Electrical – RF/Microwave Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power – Measure [1]	(100 to 2 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.14 dB 0.06 dB 0.07 dB 0.08 dB 0.15 dB	Agilent EPM Series Power Meter 8487A Power Sensor
RF Power – Measure [1]	(2 000 to 12 400) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (12 400 to 18 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (18 000 to 26 500) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (26 5000 to 40 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.15 dB 0.07 dB 0.07 dB 0.08 dB 0.15 dB 0.15 dB 0.08 dB 0.08 dB 0.09 dB 0.15 dB 0.16 dB 0.1 dB 0.1 dB 0.11 dB 0.16 dB 0.17 dB 0.12 dB 0.12 dB 0.13 dB 0.18 dB	Agilent EPM Series Power Meter 8487A Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(40 000 to 50 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.22 dB 0.19 dB 0.19 dB 0.19 dB 0.23 dB	Agilent EPM Series Power Meter 8487A Power Sensor
RF Power – Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (2 000 to 3 050) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (3 050 to 6 600) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (6 600 to 13 200) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB 0.37 dB 0.21 dB 0.23 dB 0.24 dB 0.26 dB 0.28 dB 0.34 dB 0.7 dB 0.37 dB 0.21 dB 0.23 dB 0.24 dB 0.29 dB 0.38 dB 0.53 dB 0.37 dB 0.21 dB 0.23 dB 0.24 dB 0.34 dB 0.46 dB 0.65 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(13 200 to 18 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -90) dB	0.26 dB	
	(-90 to -95) dB	0.26 dB	
	(-95 to -100) dB	0.26 dB	
	(-100 to -105) dB	0.29 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(18 000 to 19 200) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.27 dB	
	(-90 to -95) dB	0.27 dB	
	(-95 to -100) dB	0.27 dB	
	(-100 to -105) dB	0.3 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.28 dB	
	(-90 to -95) dB	0.33 dB	
	(-95 to -100) dB	0.43 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.85 dB	
	(-110 to -115) dB	1.2 dB	
	(-115 to -120) dB	1.5 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(26 500 to 31 150) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.34 dB	
	(-78 to - 90) dB	0.36 dB	
	(-90 to -95) dB	0.39 dB	
	(-95 to -100) dB	0.46 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.82 dB	
	(-110 to -115) dB	1.1 dB	
	(31 150 to 41 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.35 dB	
	(-78 to -90) dB	0.48 dB	
	(-90 to -95) dB	0.64 dB	
	(-95 to -100) dB	0.87 dB	
	(-100 to -105) dB	1.2 dB	
	(-105 to -110) dB	1.5 dB	
	(41 000 to 45 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.38 dB	
	(-78 to -90) dB	0.68 dB	
	(-90 to -95) dB	0.93 dB	
	(-95 to -100) dB	1.2 dB	
	(-100 to -105) dB	1.6 dB	
	(45 000 to 50 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.67 dB	
	(-78 to -90) dB	1.4 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(30 to 2 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
	(20 to 0) dB	0.29 dB	
	(0 to -58) dB	0.3 dB	
	(-58 to -78) dB	0.31 dB	
	(-78 to -110) dB	0.32 dB	
	(2 000 to 3 050) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(3 050 to 6 600) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(6 600 to 13 200) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.42 dB	
	(13 200 to 18 000) MHz		
	(15 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.46 dB	
	(18 000 to 19 200) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.5 dB	
	(19 200 to 26 500) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.9 dB	
	(26 500 to 31 150) MHz		
	(15 to 0) dB	0.62 dB	
	(0 to -58) dB	0.63 dB	
	(-58 to -78) dB	0.64 dB	
	(-78 to -110) dB	0.96 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(31 150 to 41 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -100) dB (41 000 to 45 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -100) dB (45 000 to 50 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.82 dB 0.83 dB 0.84 dB 1.1 dB 0.82 dB 0.83 dB 0.85 dB 1.4 dB 0.82 dB 0.83 dB 1 dB 1.5 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (26.5 to 31.15) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (31.15 to 50) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 0.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 6.8 % of reading + 0.4 digits 1.9 % of reading + 0.4 digits 26 % of reading + 0.4 digits 6 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 31.15) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (31.15 to 50.0) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.20 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 – 8.5 % of reading + 17 Hz β > 32 - 1 % of reading + 17 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad (26.5 to 31.15) GHz Deviations: > 1.3 rad Deviations > 4.0 rad (31.15 to 50) GHz Deviations: > 2.4 rad Deviations > 8.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.018 rad 1 % of reading + 0.018 rad	
Audio Distortion	(-80 to 0) dB 400 Hz and 1 kHz	 5.8 % of reading	HP 8902A Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (26.5 MHz to 50.0 GHz) AM Depth > 3% (0 to -20) dB AM Depth > 5% (0 to -20) dB (-20 to -30) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB 1.8 dB 1.5 dB 3.5 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2KHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (31.15 to 50.0) GHz Dev > 4 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (31.15 to 50.0) GHz Dev > 12.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(1 to 6 600) MHz		Agilent N5531S Measuring Receiver
	Rate 20 to 500 Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.4 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 1.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(6.6 to 13.2) GHz		
	Rate (20 to 500) Hz		
	Dev > 1.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 5.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(6.6 to 13.2) GHz		Agilent N5531S Measuring Receiver
	Rate (500 to 1 000) Hz		
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(13.2 to 31.15) GHz		
	Rate (20 to 500) Hz		
	Dev > 3.5 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 10.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 1.2 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 4.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(31.15 to 50.0) GHz		
	Rate 20 to 500 Hz		
	Dev > 7.5 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 19.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(31.15 to 50.0) GHz Rate (500 to 1 000) Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
Harmonics Measure [1]	(-10 to -80) dB 2nd through 5th Harmonic 1kHz to 600MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (5 300 to 10 000) MHz 2nd through 4th Harmonic (10 000 to 12 500) MHz 2nd through 3rd Harmonic (12 500 to 16 667) MHz 2nd Harmonic (16 667 to 25 000) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB 2.3 dB	Agilent E4448A Measuring Receiver

Length – Dimensional Metrology Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers [1,2]	Up to 46 in	(280 + 1.8*L*) µin	Grade 2 gage blocks
Micrometers [1,2]	Up to 46 in	(31 + 4.3*L*) µin	Grade 2 gage blocks
Micrometers Standards	(1 to 12) in	(1.7 + 6.8*L*) µin	Universal measuring machine, master gage block set
Bore Micrometers	(0.125 to 3.5) in	92 µin	Master ring gages
Dial Indicators [1,2]	Up to 0.2 in Up to 6 in Up to 1 in	15 µin (81 + 1.2*L*) µin 150 µin	Grade 2 gage blocks Starrett 716 Indicator Tester
Height Gages [1,2]	Up to 46 in	(202 + 1.7*L*) µin	Grade 2 gage blocks
Scales – Rulers [1]	Up to 46 in	0.009 in	Grade 2 gage blocks
Feeler Gages [1]	Up to 1 in	44 µin	Mitutoyo 293-369 Micrometer
Surface Plates [1] – Overall Flatness Local Area Flatness	(18 x 18) in to (6×6) ft (-0.001 to 0.001) in	79 µin 68 µin	Mahr Leveling system Repeat-o-meter
Gage Blocks [2]	Up to 12 in	(3.2 + 2.7*L*) µin	Universal measuring machine, master gage block set
Protractors [1]	(0 to 360)º	0.014º	Angle blocks
Radius Gages	(0.01 to 1) in	290 µin	Optical comparator
Cylindrical Gages [1,2] – Plain Pin, Plugs Rings	(0 to 12) in (0.04 to 14) in	(5.4 + 2.2*D*) µin (17 + 2.2*D*) µin	Master gage blocks, P&W universal measuring machine
Thread Plugs – Major Pitch Diameter (6 to 80) TPI	Up to 12 in Up to 12 in	36 µin 91 µin	Gage blocks, P & W universal measuring machine, Van Keuren thread wire set
Thread Rings [2,3]	Up to 12 in	(350 + 47*D*) µin	Thread setting plug gages

Mass and Mass Related Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,2,4]	1 g to 40 kg	(0.042 + 0.0045*X*) mg	Class 1 weights
	Up to 1 100 lb Up to 500 kg	(0.0003 + 0.00012*W*) lb (0.13 + 0.00012*X*) g	Class F weights
Pressure [1] – Measure	(0 to 30) inH2O	0.01 % of reading or 0.000 75 inH2O whichever is greater	Low Pressure Controller/Calibrator Ruska 7250LP
	(-150 to 150) inH2O (0 to 30) psig	0.073 inH2O 0.008 psi	Pressure Gage Additel ADT686-DP150 Additel ADT686-GP30
	(0 to 23) psia (0 to 30) inHg	0.02 psi 0.04 inHg	High Accuracy Pressure Standard Paroscientific 760-23A Paroscientific 760-23A
	(0 to 5 000) psig (0 to 10 000) psig	1.3 psi 2.6 psi	Pressure Gage Additel ADT686-GP5K Additel ADT686-GP10K
Pressure [1] – Generate	(10 to 16 000) psi	0.019 % of reading	Fluke P3125-PSI Deadweight Tester
Vacuum Gages	(0 to 30) inHg	0.075 inHg	Paroscientific 760-23A Pressure Standard
Torque Tools [1]	(4 to 1 000) lbf·in (25 to 1 000) lbf·ft	0.4 % of reading 0.49 % of reading	CDI torque system
Torque Analyzers	1 ozf·in to 250 lbf·ft	0.11 % of reading	Weights and arm
Force Gages Tension & Compression [1]	10 mgf to 540 lbf	0.06 % of reading	Class 1 and Class F weights
Mass – Class F	(5 to 225) g (2 to 10) lb (25 to 50) lb	0.49 mg 0.028 g 0.3 g	Master balances Class 1 Weights
Rockwell Hardness Testers [1]	(20 to 69) HRA (70 to 79) HRA (80 to 86) HRA (0 to 59) HRBW (60 to 79) HRBW (80 to 100) HRBW (20 to 39) HRC (40 to 59) HRC (60 to 70) HRC	1.3 HRA 1.3 HRA 0.73 HRA 3 HRBW 2.9 HRBW 1.2 HRBW 1.2 HRC 1.2 HRC 0.69 HRC	Indirect Verification using Hardness blocks

Mass and Mass Related Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Durometers – Scale Accuracy (force)			Direct Verification
Types A, B, C, D, DO, O	(0 to 100) duros	0.06 duros	Master balance
Type M,		0.09 duros	
Types OO, OOO		0.07 duros	
Indenter Geometry			
Length	0.1 in	180 µin	Optical comparator
Diameter	0.05 in	180 µin	
Angle	(30 to 35)°	0.006°	
Mass - Fixed Points Metric	(1,2) g	0.07 mg	Comparison to ASTM E617 Class 1 weights
	10 g	0.15 mg	
	20 g	0.19 mg	
	50 g	0.3 mg	
	100 g	0.56 mg	
	200 g	1.2 mg	
	500 g	6.5 mg	
	2 kg	14 mg	
	5 kg	31 mg	
	10 kg	82 mg	
	20 kg	114 mg	

Thermodynamic Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	(-196 to 200) °C	0.027 °C	Hart 1502 Indicator with Fluke 5615 PRT
	(200 to 420) ºC	0.038 °C	
Temperature – Measuring Equipment	(-40 to 160) °C	0.056 °C	Hart 1502 Indicator with Fluke 5615 PRT and Additel Dry Well
	(160 to 420) ºC	0.067 °C	
	(420 to 660) ºC	0.31 °C	Additel Dry Well
Humidity – Measure [1]	(0 to 90) % RH	1.7 % RH	Vaisala HM141/HMP46 Humidity Indicator and Probe
Humidity - Generate	(10 to 95) %RH	0.5 % RH	Thunder Scientific 2500

Thermodynamic Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Infrared (IR) Thermometry [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 Infrared Calibrator Ɛ= 0.95, λ = (8 to 14) µm

Time and Frequency Peachtree Corners, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-12} Hz/Hz	HP 58503A GPS Receiver
	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-12} Hz/Hz + 0.57 µHz 1 x 1^{e-12} Hz/Hz + 5.7 µHz 1 x 1^{e-12} Hz/Hz + 57 µHz 1 x 1^{e-12} Hz/Hz + 0.57 mHz 1 x 1^{e-12} Hz/Hz + 5.7 mHz 1 x 1^{e-12} Hz/Hz + 57 mHz 1 x 1^{e-12} Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP 58503A GPS Receiver
	(10 to 50 000) MHz	1 x 1^{e-12} Hz/Hz + 0.57 mHz	Agilent E8257D Opt 550 Signal Generator / HP 58503A GPS Receiver
Time – Generate	1 pps	1 x 1^{e-12} s/s + 750 ps	HP 58503A GPS Receiver
Frequency – Measure	1 to 10 Hz 10 to 100 Hz 100 to 1 000 Hz 1 to 10 kHz 10 to 100 kHz 100 to 200 kHz 0.2 to 3 000 MHz	4.20 x 1^{e-9} Hz/Hz 1.47 x 1^{e-9} Hz/Hz 0.60 x 1^{e-9} Hz/Hz 0.33 x 1^{e-9} Hz/Hz 0.24 x 1^{e-9} Hz/Hz 0.21 x 1^{e-9} Hz/Hz 0.21 x 1^{e-9} Hz/Hz	Agilent 53131A Opt 030 Frequency Counter / HP 58503A GPS Receiver
Frequency – Measure [1]	50 to 46 000 MHz	1 x 1^{e-12} Hz/Hz + 1.6 Hz	Agilent 53152A Frequency Counter / HP 58503A GPS Receiver
Frequency – Measure [1]	10 to 50 000 MHz	1 x 1^{e-12} Hz/Hz + 0.1 Hz	Agilent E4448A Spectrum Analyzer / HP 58503A GPS Receiver
Tachometers – RPM [1,2]	Up to 100 000 RPM	0.01 of reading + 0.6*R*	HP 33250A Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional Peachtree Corners, GA

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Length (distance)	X Axis (0.01 to 8) in Y Axis (0.01 to 4) in	180 µin 180 µin	Optical comparator

2 Dimensional Peachtree Corners, GA

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Angle	Up to 360°	0.006°	Optical comparator

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Services performed at satellite laboratory

Technical Maintenance, Inc.
117 Jetplex Circle, Suite C4
Madison, AL 35758
Donny Prax (Branch Manager) Phone: 256-772-4115
Scott Chamberlain (Quality Manager Phone: 321-242-0890

CALIBRATION AND DIMENSIONAL MEASUREMENT

CALIBRATION

Acoustics and Vibration Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration [1]	(0.01 to 10) g (7 to 100) Hz (100 to 2 500) Hz (2.5 to 10) kHz	 1.5 % of reading 1.2 % of reading 2.5 % of reading	Accelerometer Calibrator
Sound Pressure Level – Generate [1]	94 dB @ 1 kHz 114 dB @ 1 kHz	0.65 dB 0.97 dB	Extech 407766 Sound Level Calibrator

Chemical Quantities Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,5]	4 pH 7 pH 10 pH	0.016 pH 0.025 pH 0.061 pH	pH buffer solutions
Conductivity Meters [1,5]	100 µS/cm 1 410 µS/cm 10 000 µS/cm	0.83 µS/cm 5.3 µS/cm 44 µS/cm	Conductivity solutions

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate [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	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5730A Multifunction Calibrator
DC Voltage – Measure [1]	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6.0 µV/V + 100 µV + 12 µV/V x (Vin/1000) ^2	Agilent 3458A Option 002 Multimeter
DC Voltage – Measure [1]	(1 to 30) kV	0.1 % of reading	Ross VD30 High Voltage Divider, Fluke 89 IV Multimeter
DC Voltage – Measure [1]	(1 to 150) kV	0.1 % of reading	Ross VD150 High Voltage Divider, HP 34401A Multimeter
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 15 µA/A + 1 nA	Fluke 5730A & 5522A Multifunction Calibrator
	(10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5730A Multifunction Calibrator
	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5730A/03 Multifunction Calibrator 5725A Amplifier
	(11 to 20.5) A	761 µA/A + 578 µA	Fluke 5522A Multiproduct Calibrator
DC Current Clamp Meters [1] Toroidal-Wound	(0 to 1 025) A	0.21 % of output + 0.05A	Fluke 5522A Multiproduct Calibrator/5500A/Coil x50
DC Current Clamp Meters [1] Other	(0 to 1 025) A	0.39 % of output + 0.38A	Fluke 5522A Multiproduct Calibrator/5500A/Coil x50

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.12 pA 13 µA/A + 1.2 pA 9.1 µA/A + 0.01 nA 7.9 µA/A + 0.12 nA	Fluke 5730A Multifunction Calibrator Agilent 3458A Option 002 Multimeter
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10.1 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 3) A (3 to 10) A	761 µA/A + 462 µA 1.1 mA/A + 614 µA	Fluke 8845A Multimeter
	(1 to 600) A	0.27 % of reading	Current Shunts
AC Voltage – Generate [1]	(0.22 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 (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 (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	 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV 228 µV/V + 11.4 µV 88 µV/V + 6.1 µV 53 µV/V + 6.1 µV 114 µV/V + 6.1 µV 304 µV/V + 15.2 µV 609 µV/V + 19 µV 1.3 mV /V + 22.8 µV 2.5 mV /V + 45.7 µV	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(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 (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 (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	 228 µV/V + 38 µV 84 µV/V + 15 µV 37 µV/V + 8 µV 61 µV/V + 9 µV 76 µV/V + 30 µV 304 µV/V + 76 µV 913 µV /V + 190 µV 1.5 mV/V + 304 µV 228 µV/V + 380 µV 84 µV/V + 152 µV 37 µV/V + 54 µV 61 µV/V + 91 µV 76 µV/V + 190 µV 228 µV/V + 609 µV 913 µV/V + 1.9 mV 1.4 mV/V + 3 mV 228 µV/V + 3.8 mV 84 µV/V + 1.5 mV 49 µV/V + 0.6 mV 76 µV/V + 0.9 mV 137 µV/V + 2.3 mV	Fluke 5730A Multifunction Calibrator
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (30 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5730A Multifunction Calibrator /5725A Amplifier

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV		Fluke 5730A Multifunction Calibrator
	(10 to 30 Hz)	0.65 % of output + 1.5 µV	
	30 Hz to 500 kHz	0.61 % of output + 1.5 µV	
	(0.5 to 1.2) MHz	0.63 % of output + 3.8 µV	
	(1.2 to 2) MHz	0.63 % of output + 3.8 µV	
	(2 to 12) MHz	0.68 % of output + 3.8 µV	
	(12 to 20) MHz	0.76 % of output + 3.8 µV	
	(20 to 30) MHz	1.3 % of output + 12.9 µV	
	(1.1 to 3.3) mV		
	(10 to 30 Hz)	0.58 % of output + 2.3 µV	
	30 Hz to 500 kHz	0.53 % of output + 2.3 µV	
	(0.5 to 1.2) MHz	0.54% of output + 4.6 µV	
	(1.2 to 2) MHz	0.54 % of output + 4.6 µV	
	(2 to 12) MHz	0.58 % of output + 4.6 µV	
	(12 to 20) MHz	0.65 % of output + 4.6 µV	
	(20 to 30) MHz	1.3 % of output + 4.6 µV	
	(3.3 to 11) mV		
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89 % of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(110 to 330) mV		Fluke 5730A Multifunction Calibrator
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	(0.33 to 1.1) V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	
	(1.1 to 3.5) V		
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2% of reading + 5 µV	
	(1 to 4) MHz	7% of reading + 7 µV	
	(4 to 8) MHz	20% of reading + 8 µV	

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	10 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.007 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.007 % of reading + 0.2 mV	
	(1 to 20) kHz	0.014 % of reading + 0.2 mV	
	(20 to 50) kHz	0.03 % of reading + 0.2 mV	
	(50 to 100) kHz	0.08 % of reading + 0.2 mV	
	(100 to 300) kHz	0.3 % of reading + 1 mV	
	300 kHz to 1 MHz	10 % of reading + 1 mV	
	(1 to 2) MHz	1.5 % of reading + 7 mV	
	(2 to 4) MHz	40 % of reading + 7 mV	
	(4 to 8) MHz	40 % of reading + 8 mV	
	(8 to 10) MHz	15 % of reading + 10 mV	

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.02 % of reading + 4 mV 0.02 % of reading + 2 mV 0.02 % of reading + 2 mV 0.035 % of reading + 2 mV 0.12 % of reading + 2 mV 0.4 % of reading + 10 mV 1.5 % of reading + 10 mV 0.04 % of reading + 40 mV 0.04 % of reading + 20 mV 0.06 % of reading + 20 mV 0.12 % of reading + 20 mV 0.3 % of reading + 20 mV	Agilent 3458A/002 Precision Multimeter
AC Voltage – Measure [1]	(1 to 21) kV 60 Hz	 0.57 % of reading + 0.002 kV	Ross VD30 High Voltage Divider, Fluke 89IV Multimeter
AC Voltage – Measure [1]	(1 to 100) kV 60 Hz	 0.5 % of reading + 0.02 kV	Ross VD150 High Voltage Divider, HP 34401A Multimeter
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 91 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 91 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 nA	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(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 (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 4 µA 152 µA/A + 3 µA 91 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 228 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5730A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA /A + 141 µA 723 µA /A + 295 µA 2.7 mA /A + 573 µA	Fluke 5730A Multifunction Calibrator /5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A 45 Hz to 100 Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.3 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current – Generate [1] Clamps – Toroidal-Wound	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.23 % of output + 0.1 A 0.64 % of output + 0.085 A	Fluke 5522A Multiproduct Calibrator, 5500A/Coil x50
AC Current – Generate [1] Clamps – Other	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.44 % of output +0.53 A 0.79 % of output +0.68 A	Fluke 5522A Multiproduct Calibrator, 5500A/Coil x50
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz 100 µA to 1 mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA	Agilent 3458A/002 Precision Multimeter

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A/002 Precision Multimeter
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	 0.72 % of reading + 1.2 mA 0.23 % of reading + 1.2 mA 0.1 % of reading + 1.2 mA	Agilent 34401A Multimeter
AC Current – Measure [1]	(3 to 30) A 40 Hz to 1 kHz (1 to 5) kHz	 0.3 % of reading + 0.07 A 5 % of reading + 0.14 A	Agilent 3458A/002 Precision Multimeter Keysight 34330A Current Shunt
AC Current – Measure [1]	(10 to 1 000) A (10 to 100) Hz (100 to 500) Hz	 1.5 % of reading + 1 A 1.9 % of reading+ 1 A	Fluke 376 Clamp Meter
AC Current – Measure [1]	(100 to 2 500) A (10 to 500) Hz	 2.3 % of reading + 5 A	Fluke 376 Clamp Meter w/i2500 flex probe
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 µΩ/Ω + 0.1 µΩ 21 µΩ/Ω + 1 µΩ 9.1 µΩ/Ω + 6 µΩ 6.1 µΩ/Ω + 60 µΩ 6.1 µΩ/Ω + 0.6 mΩ 7.6 µΩ/Ω + 6 mΩ 9.1 µΩ/Ω + 6 mΩ 11.4 µΩ/Ω + 60 mΩ 16 µΩ/Ω + 60 mΩ 35 µΩ/Ω + 0.6Ω 42 mΩ/Ω + 0.6Ω 91 mΩ/Ω + 6Ω	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1]	Up to 11 Ω	30 μΩ/Ω + 0.001 Ω	Fluke 5520A Multiproduct Calibrator
	(11 to 33) Ω	23 μΩ/Ω + 0.001 Ω	
	(33 to 110) Ω	21 μΩ/Ω + 0.001 Ω	
	(110 to 330) Ω	21 μΩ/Ω + 0.002 Ω	
	330 Ω to 1.1 kΩ	21 μΩ/Ω + 0.002 Ω	
	(1.1 to 3.3) kΩ	21 μΩ/Ω + 0.02 Ω	
	(3.3 to 11) kΩ	21 μΩ/Ω + 0.02 Ω	
	(11 to 33) kΩ	21 μΩ/Ω + 0.2 Ω	
	(33 to 110) kΩ	21 μΩ/Ω + 0.2 Ω	
	(110 to 330) kΩ	24 μΩ/Ω + 2 Ω	
	(0.33 to 1.1) MΩ	24 μΩ/Ω + 2 Ω	
	(1.1 to 3.3) MΩ	46 μΩ/Ω + 23 Ω	
	(3.3 to 11) MΩ	99 μΩ/Ω + 38 Ω	
	(11 to 33) MΩ	190 μΩ/Ω + 1.9 kΩ	
	(33 to 110) MΩ	380 μΩ/Ω + 2.3 kΩ	
	(110 to 330) MΩ	0.23 % of setting + 76 kΩ	
	330 MΩ to 1.1 GΩ	1.1 % of reading + 380 kΩ	
Resistance – Measure [1]	Up to 12 Ω	15 μΩ/Ω + 56 μΩ	Agilent 3458A Multimeter
	(10 to 120) Ω	12 μΩ/Ω + 0.5 mΩ	
	100 Ω to 1.2 kΩ	10 μΩ/Ω + 0.6 mΩ	
	(1 to 12) kΩ	10 μΩ/Ω + 5.6 mΩ	
	(10 to 120) kΩ	10 μΩ/Ω + 56 mΩ	
	100 kΩ to 1.2 MΩ	15 μΩ/Ω + 2.2 Ω	
	(1 to 12) MΩ	50 μΩ/Ω + 120 Ω	
	(10 to 120) MΩ	500 μΩ/Ω + 1.2 kΩ	
	100 MΩ to 1.2 GΩ	0.5 % of reading + 70 kΩ	
Resistance – Generate [1] Fixed Points	100 V		TMI RB Resistance Standard
	100 kΩ	1 % of output	
	(100 to 1 000) V		
	1 MΩ	1 % of output	
	10 MΩ	1 % of output	
	100 MΩ	1 % of output	
	1 GΩ	1 % of output	
	10 GΩ	1.2 % of output	
	100 GΩ	3.2 % of output	

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) µF (1.1 to 3.299 99) µF (3.3 to 10.999 9) µF (11 to 32.999 9) µF (33 to 109.999) µF (110 to 329.999) µF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.38% of output + 7.6 pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF 0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 µF 0.34 % of output + 2.3 µF 0.34 % of output + 7.6 µF 0.57 % of output + 23 µF 0.84 % of output + 76 µF	Fluke 5522A Multiproduct Calibrator
Capacitance – Measure [1]	100 Hz /120 Hz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF (0.1 to 1) mF 1 000 Hz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF (0.1 to 1) mF 10 kHz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF (0.1 to 1) mF	 2 % of reading + 0.3 pF 0.17 % of reading 0.13 % of reading 0.12 % of reading 0.18 % of reading 0.2 % of reading 0.43 % of reading + 0.3pF 0.1 % of reading 0.08 % of reading 0.07 % of reading 0.13 % of reading 0.45 % of reading 0.56 % of reading + 0.3pF 0.15 % of reading 0.12 % of reading 0.17 % of reading 0.69 % of reading 3.5 % of reading	Agilent 4263B LCR Meter

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure [1]	20 kHz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF 100 kHz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 10) µF	 2.1 % of reading + 0.3pF 0.62 % of reading 0.62 % of reading 0.43 % of reading 1.7 % of reading 1.6 % of reading + 0.3 pF 1 % of reading 0.98 % of reading 1.4 % of reading 4.1 % of reading	Agilent 4263B LCR Meter
Inductance – Measure [1]	100 Hz /120 Hz (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H 1 000 Hz (1 to 4) µH (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.01to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H	 5.2 % of reading + 0.03 µH 2.3 % of reading + 0.03 µH 0.57 % of reading + 0.03 µH 0.4 % of reading 0.32 % of reading 0.28 % of reading 0.23 % of reading 0.18 % of reading 0.22 % of reading 1 % of reading + 0.03 µH 0.46 % of reading + 0.03 µH 0.74 % of reading + 0.03 µH 0.35 % of reading + 0.03 µH 0.3 % of reading 0.11 % of reading 0.12 % of reading 0.1 % of reading 0.1 % of reading 0.12 % of reading	Agilent 4263B LCR Meter

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure [1]	10 kHz		Agilent 4263B LCR Meter
	(1 to 4) µH	0.62 % of reading + 0.03 µH	
	(4 to 10) µH	0.4 % of reading + 0.03 µH	
	(10 to 40) µH	0.32 % of reading + 0.03 µH	
	(40 to 100) µH	0.18 % of reading + 0.03 µH	
	(0.1 to 0.4) mH	0.2 % of reading	
	(0.4 to 1) mH	0.14 % of reading	
	(1 to 10) mH	0.17 % of reading	
	(10 to 100) mH	0.2 % of reading	
	(0.1 to 1) H	0.2 % of reading	
	(1 to 10) H	0.44 % of reading	
	20 kHz		
	(1 to 4) µH	1.3 % of reading + 0.03 µH	
	(4 to 10) µH	0.68 % of reading + 0.03 µH	
	(10 to 40) µH	0.63 % of reading + 0.03 µH	
	(40 to 100) µH	0.53 % of reading + 0.03 µH	
	(0.1 to 0.4) mH	0.49 % of reading	
	(0.4 to 1) mH	0.48 % of reading	
	(1 to 10) mH	0.65 % of reading	
	(10 to 100) mH	0.66 % of reading	
	(0.1 to 1) H	1.2 % of reading	
	(1 to 10) H	3.3 % of reading	
	100 kHz		
	(1 to 4) µH	2.7 % of reading + 0.03 µH	
	(4 to 10) µH	0.86 % of reading + 0.03 µH	
	(10 to 40) µH	1.2 % of reading + 0.03 µH	
	(40 to 100) µH	0.68 % of reading + 0.03 µH	
	(0.1 to 0.4) mH	0.9 % of reading	
	(0.4 to 1) mH	1.1 % of reading	
	(1 to 10) mH	1.4 % of reading	
	(10 to 100) mH	1.4 % of reading	
	(0.1 to 1) H	6.3 % of reading	
Electrical Calibration of Thermocouple Indicating Devices [1]	Type B		Fluke 7526A Process Calibrator
	(600 to 800) °C	0.27 °C	
	(800 to 1 550) °C	0.22 °C	
	(1 550 °C to 1 820) °C	0.17 °C	
	Type C		
	(0 to 1000) °C	0.13 °C	
	(1 000 to 1 800) °C	0.18 °C	
	(1 800 to 2 000) °C	0.2 °C	
	(2 000 to 2 316) °C	0.27 °C	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type E		Fluke 7526A Process Calibrator
	(-250 to -200) °C	0.19 °C	
	(-200 to -100) °C	0.1 °C	
	(-100 to 0) °C	0.07 °C	
	(0 to 600) °C	0.07 °C	
	(600 to 1 000) °C	0.08 °C	
	Type J		
	(-210 to -100) °C	0.11 °C	
	(-100 to 800) °C	0.07 °C	
	(800 to 1 200) °C	0.08 °C	
	Type K		
	(-250 to -200) °C	0.35 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 800) °C	0.08 °C	
	(800 to 1 372) °C	0.1 °C	
	Type L		
	(-200 to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	
	Type R		
	(-50 to -25) °C	0.42 °C	
	(-25 to 0) °C	0.34 °C	
	(0 to 100) °C	0.3 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.17 °C	
	(600 to 1 000) °C	0.16 °C	
	(1 000 to 1 600) °C	0.15 °C	
	(1 600 to 1 767) °C	0.18 °C	
	Type S		
	(50 to -25) °C	0.39 °C	
	(-25 to 0) °C	0.33 °C	
	(0 to 100) °C	0.29 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.18 °C	
	(600 to 1 600) °C	0.17 °C	
	(1 600 to 1 767) °C	0.2 °C	

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type T (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.26 °C 0.13 °C 0.09 °C 0.07 °C 0.13 °C 0.08 °C	Fluke 7526A Process Calibrator
Electrical Calibration of RTD Indicating Devices [1]	Pt 385, 100 Ω (-200 to 800) °C Pt 3926, 100 Ω (-200 to 630) °C Pt 3916, 100 Ω (-200 to 630) °C Pt 385, 200 Ω (-200 to 400) °C (400 to 630) °C Pt 385, 500 Ω (-200 to 630) °C Pt 385, 1000 Ω (-200 to 630) °C	 0.05 °C 0.05 °C 0.05 °C 0.4 °C 0.5 °C 0.17 °C 0.09 °C	Fluke 7526A Process Calibrator
Oscilloscopes Calibration[1] – Generate Voltage DC - 50Ω DC - 1MΩ Square Wave 10 Hz to 10 kHz - 50Ω	 (1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V (1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V (1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.1999) Vpp (2.2 to 6.6) Vpp	 0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV 0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6 mV 0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1] Square Wave 10 Hz to 1 kHz – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Square Wave 1 to 10 kHz – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6 mV	
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth (5 to 50) mVpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz 50 mV to 3.5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz (3.5 to 5) Vpp 50 kHz to 100) MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz	0.34 dB 0.36 dB 0.42 dB 0.46 dB 0.5 dB 0.56 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB 0.4 dB 0.44 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness	3 dB Bandwidth 50 mV to 3.5Vpp (2 100 to 4 000) MHz (4 000 to 8 000) MHz (8 000 to 18 000) MHz	0.25 dB 0.35 dB 0.46 dB	EPM Power Meter w/ E Series Power Sensors
Oscilloscopes Calibration – Generate [1] Time Marker	500 ps to 20 ms 50 ms to 5 s	0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Measure [1] Input Impedance Resistance Leakage	 (40 to 60) Ω 500 kΩ to 1.5MΩ (0 to 5.99) V	 0.08 % of reading 0.08 % of reading 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Low Frequency Power – Generate [1] (45 to 65) Hz 1 PF DC	Up to 20 kW	0.25 % of reading 0.21 % of reading	Fluke 5522A Multiproduct Calibrator
Power Meters [1]	3 µW to 100 mW	0.25 % of reading	HP 11683A Range Calibrator

Electrical – RF/Microwave Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Flatness – Measure [1]	9 kHz to 2 000 MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 000 to 14 000) MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 000 to 18 000) MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(30 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.13 dB	
	(3 050 to 6 600) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.19 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.25 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(13 200 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.31 dB	
	(19 200 to 26 500) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.14 dB	
	(90 to 100) dB	0.36 dB	
	(100 to 110) dB	0.82 dB	
	(26 500 to 31 150) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.13 dB	
	(90 to 100) dB	0.33 dB	
	(100 to 110) dB	0.77 dB	

Electrical – RF/Microwave Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(31 150 to 41 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (41 000 to 45 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (45 000 to 50 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.14 dB 0.36 dB 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.11 dB 0.24 dB 0.6 dB 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.11 dB 0.29 dB 0.7 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
RF Power – Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(100 to 2 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.14 dB 0.06 dB 0.07 dB 0.08 dB 0.15 dB	Agilent EPM Series Power Meter 8487A Power Sensor
RF Power – Measure [1]	(2 000 to 12 400) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (12 400 to 18 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (18 000 to 26 500) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (26 5000 to 40 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (40 000 to 50 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.15 dB 0.07 dB 0.07 dB 0.08 dB 0.15 dB 0.15 dB 0.08 dB 0.08 dB 0.09 dB 0.15 dB 0.16 dB 0.1 dB 0.1 dB 0.11 dB 0.16 dB 0.17 dB 0.12 dB 0.12 dB 0.13 dB 0.18 dB 0.22 dB 0.19 dB 0.19 dB 0.19 dB 0.23 dB	Agilent EPM Series Power Meter 8487A Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(30 to 2 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.36 dB	
	(20 to 0) dB	0.2 dB	
	(0 to -58) dB	0.22 dB	
	(-58 to -78) dB	0.23 dB	
	(-78 to -110) dB	0.25 dB	
	(-110 to -115) dB	0.27 dB	
	(-115 to -120) dB	0.33 dB	
	(-120 to -125) dB	0.46 dB	
	(2 000 to 3 050) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.26 dB	
	(-110 to -115) dB	0.28 dB	
	(-115 to -120) dB	0.34 dB	
	(-120 to -125) dB	0.7 dB	
	(3 050 to 6 600) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.29 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.53 dB	
	(6 600 to 13 200) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.46 dB	
	(-115 to -120) dB	0.65 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(13 200 to 18 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -90) dB	0.26 dB	
	(-90 to -95) dB	0.26 dB	
	(-95 to -100) dB	0.26 dB	
	(-100 to -105) dB	0.29 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(18 000 to 19 200) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.27 dB	
	(-90 to -95) dB	0.27 dB	
	(-95 to -100) dB	0.27 dB	
	(-100 to -105) dB	0.3 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.28 dB	
	(-90 to -95) dB	0.33 dB	
	(-95 to -100) dB	0.43 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.85 dB	
	(-110 to -115) dB	1.2 dB	
	(-115 to -120) dB	1.5 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(26 500 to 31 150) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to - 90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB (-110 to -115) dB (31 150 to 41 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB (41 000 to 45 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (45 000 to 50 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.42 dB 0.3 dB 0.34 dB 0.34 dB 0.36 dB 0.39 dB 0.46 dB 0.61 dB 0.82 dB 1.1 dB 0.42 dB 0.3 dB 0.34 dB 0.35 dB 0.48 dB 0.64 dB 0.87 dB 1.2 dB 1.5 dB 0.42 dB 0.3 dB 0.34 dB 0.38 dB 0.68 dB 0.93 dB 1.2 dB 1.6 dB 0.42 dB 0.3 dB 0.34 dB 0.67 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
RF Power – Measure [1] 50 MHz	1 mW	0.003 2 mW	HP 432A Power Meter & 8478B Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(30 to 2 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
	(20 to 0) dB	0.29 dB	
	(0 to -58) dB	0.3 dB	
	(-58 to -78) dB	0.31 dB	
	(-78 to -110) dB	0.32 dB	
	(2 000 to 3 050) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(3 050 to 6 600) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(6 600 to 13 200) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.42 dB	
	(13 200 to 18 000) MHz		
	(15 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.46 dB	
	(18 000 to 19 200) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.5 dB	
	(19 200 to 26 500) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.9 dB	
	(26 500 to 31 150) MHz		
	(15 to 0) dB	0.62 dB	
	(0 to -58) dB	0.63 dB	
	(-58 to -78) dB	0.64 dB	
	(-78 to -110) dB	0.96 dB	

Electrical – RF/Microwave Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(31 150 to 41 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -100) dB (41 000 to 45 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -100) dB (45 000 to 50 000) MHz (0 to 10) dB (-58 to 0) dB (-78 to -58) dB (-90 to -78) dB	 0.82 dB 0.83 dB 0.84 dB 1.1 dB 0.82 dB 0.83 dB 0.85 dB 1.4 dB 0.82 dB 0.83 dB 1 dB 1.5 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (26.5 to 31.15) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (31.15 to 50) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 6.8 % of reading + 0.4 digits 1.9 % of reading + 0.4 digits 26 % of reading + 0.4 digits 6 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 31.15) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (31.15 to 50.0) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.20 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 – 8.5 % of reading + 17 Hz β > 32 - 1 % of reading + 17 Hz	Agilent N5531S Measuring Receiver
Phase Modulation [1] – Measure	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad (26.5 to 31.15) GHz Deviations: > 1.3 rad Deviations > 4.0 rad (31.15 to 50) GHz Deviations: > 2.4 rad Deviations > 8.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.018 rad 1 % of reading + 0.018 rad	Agilent N5531S Measuring Receiver
AM Distortion Measure[1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1 % (0 to -20) dB (-20 to -30) dB AM Depth > 3 % (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AM Distortion Measure[1] Rate 20 Hz to 1 kHz	10 MHz to 26.5 GHz AM Depth > 1 % (0 to -20) dB (-20 to -30) dB AM Depth > 3 % (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (26.5 MHz to 50.0 GHz) AM Depth > 3 % (0 to -20) dB AM Depth > 5% (0 to -20) dB (-20 to -30) dB	 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB 1.8 dB 1.5 dB 3.5 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(13.2 to 31.15) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (31.15 to 50.0) GHz Dev > 4 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 12.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (1 to 6 600) MHz Rate (20 to 500) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 0.4 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 1.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(6.6 to 13.2) GHz Rate (20 to 500) Hz Dev > 1.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 5.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (6.6 to 13.2) GHz Rate (500 to 1 000) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Rate (20 to 500) Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure[1]	(13.2 to 31.15) GHz Rate (500 to 1 000) Hz Dev > 1.2 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (31.15 to 50.0) GHz Rate 20 to 500 Hz Dev > 7.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 19.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Harmonic Distortion (THD)	(0 to 60) dB 20 Hz to 20 kHz (-40 to 0) dB (-50 to -40) dB (-60 to -50) dB (-65 to -60) dB (20 to 50) kHz (-40 to 0) dB (-50 to -40) dB (-60 to -50) dB (50 to 100) kHz (-40 to 0) dB (-50 to -40) dB	1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1 kHz to 600 MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (5 300 to 10 000) MHz 2nd through 4th Harmonic (10 000 to 12 500) MHz 2nd through 3rd Harmonic (12 500 to 16 667) MHz 2nd Harmonic (16 667 to 25 000) MHz	0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB 2.3 dB	Agilent E4448A Measuring Receiver

Length – Dimensional Metrology Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers [1,2]	Up to 80 in	(280 + 3.4*L*) µin	Gage blocks (Grade 2)
Micrometers [1,2]	Up to 46 in	(9.3 + 7*L*) µin	
Height Gages [1,2]	Up to 46 in	(78 + 5.3*L*) µin	

Length – Dimensional Metrology Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dial Indicators [1,2] Resolution ≥ 50µin Resolution < 50µin	Up to 10 in Up to 0.1 in	(26 + 3.7*L*) µin 9.6 µin	Gage blocks (Grade 2)
Rulers [1]	Up to 46 in	0.009 1 in	
Bore Micrometers[2] 2 point 3 point	Up to 12 in Up to 12 in	(56 + 3.2*L*) µin (64 + 3.1*L*) µin	Master gage blocks, P&W universal measuring machine, Master Ring
Spheres	Up to 2 in	30 µin	P&W Model C
Metal Tapes and Rules [1,2]	Up to 100 ft	(0.000 27*F* + 0.024) in	Standard rule
Feeler Gages [1]	Up to 1 in	36 µin	Mitutoyo 293-369 Micrometer
Cylindrical gages [1,2] – Plain Pins, Plugs Rings	Up to 10 in Up to 14 in	(10 + 2.9*D*) µin (9.8 + 3*D*) µin	P&W LabMaster gage blocks (grade 1)
Surface Plates [1] – Overall Flatness Local Area Flatness	(18 × 18) in to (6 × 6) ft (-0.001 to 0.001) in	77 µin 68 µin	Rahn Planekator Repeat-o-meter
Gage Blocks [2]	Up to 12 in	(4.1 + 2.3*L*) µin	Universal measuring machine, master gage block set
Micrometer Standards Length Rods	Up to 46 in	(1 + 7.8L) µin	Gage blocks (grade 2), P&W universal measuring Machine, MAHR Supramess Dial Comparator
Thread Plugs – Major Diameter Pitch Diameter	Up to 12 in Up to 12 in	40 µin 92 µin	Gage blocks, P&W universal measuring machine, Van Keuren thread wire set
Thread Wires	Up to 0.5 in	11 µin	Master gage blocks, P&W universal measuring machine

Length – Dimensional Metrology Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Comparators [1] – Angle Linearity Magnification	Up to 360 ° Up to 20 in (20 to 40) in 10x to 100x	0.008 7 ° 320 µin 630 µin 420 µin	Precision balls, Angle Blocks, Gage Blocks, SI Industries glass scales
Protractors [1]	(0 to 360)°	0.008°	Angle blocks
Coating Thickness Gages [1] Eddy Current & Magnetic Induction, Fixed Point	(0.48 to 38.9) mils	69 µin	Calibration foils, P&W Supermicrometer
Coating Thickness Shims [1]	(0 to 243) mils	57 µin	P&W Supermicrometer

Mass and Mass Related Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,2,4]	1 mg to 600 g	(0.014 + 0.001 5*X*) mg	Class 0 weights
	10 mg to 40 kg (0.022 to 2 000) lb	(7.7 + 0.12*X*) mg (0.000 08 + 0.000 12*W*) lb	Class F weights
Pressure [1]	(0 to 30) psia (0 to 61) inHg	0.018 psi 0.037 inHg	Fluke 700GA5 Pressure Gage
	(0 to 30) psi	0.009 psi	Additel 681-GP30 Pressure Gage
	(-15 to 100) psi	0.027 psi	Additel 681- CP100 Pressure Gage
	(0 to 300) psi	0.08 psi	Additel 681- GP300 Pressure Gage
	(0 to 1 000) psi	0.24 psi	Additel 681- GP1K Pressure Gage
	(0 to 3 000) psi	0.7 psi	Additel 681- GP3K Pressure Gage
	(0 to 10 000) psi	2.5 psi	Additel 681- GP10K Pressure Gage
	(-150 to 150) inH_2O	0.094 inH_2O	Additel 681-DP150 Pressure Gage

Mass and Mass Related Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure [1]	(-20 to 20) inH_2O	0.001 3 inH_2O	Additel 681-DP20 Pressure Gage
Torque Tools [1]	(10 to 100) ozf·in (5 to 1 000) lbf·in (25 to 250) lbf·ft (250 to 2 000) lbf·ft	0.59 % of reading 0.35 % of reading 0.35 % of reading 0.6 % of reading	CDI torque system
Torque Analyzers	(5 to 80) ozf·in (5 to 600) lbf·in (50 to 2 000) lbf·ft	0.16 % of reading 0.15 % of reading 0.14 % of reading	Weights and Wheel
Mass - Class F	(0.5 to 10) lb (10 to 50) lb	0.03 g, (0.000 066) lb 0.27 g, (0.000 6) lb	Master balance
Force [1] Tension	(10 to 200) mgf (0.2 to 1) gf (1 to 10) gf (10 to 500) gf (1 to 540) lbf	0.45 mgf 1.2 mgf 0.037 % of reading 0.024 % of reading 0.017 % of reading	Class F weights
Force [1] Tension	(1 000 to 50 000) lbf	0.021 % of reading	Morehouse Load Cells
Force [1] Compression	(200 to 10 000) lbf (500 to 25 000) lbf (1 000 to 50 000) lbf	0.014 % of reading 0.018 % of reading 0.034 % of reading	Morehouse Load Cells
Rockwell Hardness Testers [1]	(< 60) HRBW (≥ 60 to < 80) HRBW (≥ 35 to < 60) HRC (≥ 60) HRC < 70 HA > 80 HA	3.1 HRBW 3 HRBW 1.2 HRC 0.7 HRC 1.4 HRA 0.7 HRA	Indirect verification per ASTM E18
Roughness Testers [1]	Ra 117 µin Rmax 370 µin	1.3 µin	Roughness Specimen
Durometers Scale (Force) Accuracy Types A, B, C, D, DO, E, O Indenter Geometry Length Diameter Angle	(0 to 100) duros 0.1 in 0.05 in (30 to 35)°	0.06 duros 140 µin 140 µin 0.13°	Direct Verification Master balance Optical comparator

Thermodynamic Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measuring Equipment [1]	(50 to 600) °C	0.17 °C	Hart 1502A Indicator w/5626 PRT and dry block
Temperature – Measure [1]	(-196 to 600) °C	0.027 °C	Hart 1502 Indicator with 5626 PRT
Temperature Uniformity [1] Surveys	Type K (100 to 1 000) °F (1 000 to 2 000) °F (2 000 to 2 200) °F Type T (32 to 400) °F	 2 °F 2.1 °F 2.7 °F 1.6 °F	Datalogger and Thermocouples
Relative Humidity – Measure [1]	(0 to 90) % RH	1.2 %RH	Vaisala HM141/HMP46 Humidity Indicator and Probe
Infrared (IR) Thermometry [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 Infrared Calibrator ε= 0.95, λ = (8 to 14) µm

Time and Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-9} Hz/Hz	HP Z3801A GPS Receiver
	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-9} Hz/Hz + 0.57 µHz 1 x 1^{e-9} Hz/Hz + 5.7 µHz 1 x 1^{e-9} Hz/Hz + 57 µHz 1 x 1^{e-9} Hz/Hz + 0.57 mHz 1 x 1^{e-9} Hz/Hz + 5.7 mHz 1 x 1^{e-9} Hz/Hz + 57 mHz 1 x 1^{e-9} Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP Z3801A GPS Receiver
	(10 to 5 0000) MHz	1 x 1^{e-9} Hz/Hz + 0.57 mHz	Agilent E8257D Opt 550 Signal Generator / HP Z3801A GPS Receiver

Time and Frequency Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 200) kHz (0.2 to 3 000) MHz	$5.2 \times 1^{e-9}$ Hz/Hz $2.5 \times 1^{e-9}$ Hz/Hz $1.6 \times 1^{e-9}$ Hz/Hz $1.3 \times 1^{e-9}$ Hz/Hz $1.2 \times 1^{e-9}$ Hz/Hz $1.2 \times 1^{e-9}$ Hz/Hz $1.2 \times 1^{e-9}$ Hz/Hz	Agilent 53131A Frequency Counter / HP Z3801A GPS Receiver
	(500 to 46 000) MHz	$1 \times 1^{e-9}$ Hz/Hz + 1.0 Hz	Agilent 5352B Frequency Counter / HP Z3801A GPS Receiver
	(10 to 50 000) MHz	$1 \times 1^{e-9}$ Hz/Hz + 0.1 Hz	Agilent E4448A Spectrum Analyzer / HP Z3801A GPS Receiver
Type I (digital) Timers	(0 to19.99) s/day (0 to 599) s/month	0.031 s/day 1.1 s/month	Helmut Klein Timometer 4500
Type II (mechanical) Timers	(0 to 320) s/day	0.6 s/day	Helmut Klein Timometer 4500
Tachometers – RPM [1,2]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 33250A Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional Madison, AL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length	X Axis (0.01 to 5.0) in Y Axis (0.01 to 3.0) in	340 µin	Optical comparator

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Services performed at satellite laboratory

Technical Maintenance, Inc.
3248 Forest View Road
Rockford, IL 61109
Brian Schickowski (Branch Manager) Phone: 779-774-3877
Scott Chamberlain (Quality Manager) Phone: 321-242-0890

CALIBRATION AND DIMENSIONAL MEASUREMENT CALIBRATION

Acoustics and Vibration Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration [1]	(0.01 to 10) g (7 < 10) Hz (10 < 100) Hz (100 to 920) Hz (>920 to 5000) Hz (>5 to 10) kHz	 1.7 % of reading 1.2 % of reading 1 % of reading 1.4 % of reading 1.9 % of reading	Accelerometer Calibrator
Sound Pressure Level – Generate	Up to 150 dB (19 to 16 000) Hz (16 000 to 20 000) Hz	 0.25 dB 0.32 dB	TMS 9350C Acoustic Calibrator

Chemical Quantities Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,5]	4 pH 7 pH 10 pH	0.035 pH 0.025 pH 0.069 pH	Buffer Solutions
Conductivity Meters [1,5]	2 µS/cm 10 µS/cm 100 µS/cm 1 000 µS/cm 1 413 µS/cm 10 000 µS/cm	0.19 µS/cm 0.17 µS/cm 0.74 µS/cm 3.6 µS/cm 5.7 µS/cm 36 µS/cm	Conductivity Solutions

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 15 µA/A + 1 nA	Fluke 5730A/03 Multifunction Calibrator, Agilent 3458 Option 002 Precision Multimeter
DC Current – Generate [1]	(10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5730A/03 Multifunction Calibrator
	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5730A Multifunction Calibrator /5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A (20 to 100) A	77 µA/A + 761 µA 77 µA/A + 3.8 mA	Fluke 5522A Multiproduct Calibrator, 52120A Transconductance Amplifier
DC Current Clamp Meters [1] Toroidal-Wound	(0 to 1025) A	0.21 % of output + 0.05A	Fluke 5522A Multiproduct Calibrator, . 5500A/ Coil x50
DC Current Clamp Meters [1] Other	(0 to 1025) A	0.39 % of output + 0.38A	
DC Current – Measure [1]	(1 to 10 nA) (10 to 100 nA) (0.1 to 1 µA) (1 to 10 µA) (10 to 100 µA) 0.1 to 1 mA (1 to 10) mA (10 to 100) mA	18.7 µA/A + 0.16 pA 7.1 µA/A + 1.6 pA 6.1 µA/A + 0.016 nA 5.3 µA/A + 0.016 nA 5.3 µA/A + 0.16 nA 5.3 µA/A + 0.001 6 µA 5.3 µA/A + 0.016 µA 10 µA/A + 0.16 µA	Agilent 3458A Option 002 Multimeter, 5450A Resistance Calibrator
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 10) A (10 to 100) A	41 µA/A + 103 µA 53 µA/A + 103 µA	Agilent 3458A Option 002 Precision Multimeter Standard Resistor L&N 4361 Current Shunt

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure [1]	(1 to 1 000) A	0.25 % of reading	Agilent 3458A Multimeter Empro Current Shunt
DC Voltage – Generate [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	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5730A Multifunction Calibrator
DC Voltage – Measure [1]	(0 to 100) mV 100 mV to 1V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6.0 µV/V + 100 µV + 12 µV/V x (Vin/1 000) ^2	Agilent 3458A Option 002 Multimeter
DC Voltage – Measure [1]	(0 to 1) kV (1 to 10) kV	0.03 % of reading + 0.000 032 kV 0.03 % of reading + 0.000 12 kV + 1.5 µV/V x (Vin/1 000) ^2	Vitrek 4700 Digital HV Meter
DC Voltage – Measure [1]	(1 to 60) kV (1 to 120) kV	0.1 % of reading 0.1 % of reading	Ross VD60, VD120 High Voltage Divider, HP34401A Multimeter
DC Voltage – Measure [1] Fixed Points	100 mV 1 V 10 V 100 V 1 000 V	3.1 µV/V 0.61 µV/V 0.5 µV/V 0.52 µV/V 0.63 µV/V	Fluke 732B Reference Standard, 752A Divider
Phase Angle - Generate	(-180 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	 0.08° 0.19° 0.38° 1.9° 3.8° 7.6°	Fluke 5522A Multiproduct Calibrator
Phase Angle – Measure 10 mV to 350 V	(0 to 360)° 5 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz (50 to 100) kHz (100 to 200) kHz	 0.02° 0.03° 0.04° 0.05° 0.1° 0.2°	Clarke-Hess 6000A Phase Meter

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(0.22 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	 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV	Fluke 5730A Multifunction Calibrator
AC Voltage – Generate [1]	(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 (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 220 mV 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	 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV 228 µV/V + 11.4 µV 88 µV/V + 6.1 µV 53 µV/V + 6.1 µV 114 µV/V + 6.1 µV 304 µV/V + 15.2 µV 609 µV/V + 19 µV 1.3 mV /V + 22.8 µV 2.5 mV /V + 45.7 µV 228 µV/V + 38 µV 84 µV/V + 15 µV 37 µV/V + 8 µV 61 µV/V + 9 µV 76 µV/V + 30 µV 304 µV/V + 76 µV 913 µV /V + 190 µV 1.5 mV/V + 304 µV	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(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	 228 µV/V + 380 µV 84 µV/V + 152 µV 37 µV/V + 54 µV 61 µV/V + 91 µV 76 µV/V + 190 µV 228 µV/V + 609 µV 913 µV/V + 1.9 mV 1.4 mV/V + 3 mV	Fluke 5730A Multifunction Calibrator
AC Voltage – Generate [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 (220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 228 µV/V + 3.8 mV 84 µV/V + 1.5 mV 49 µV/V + 0.6 mV 76 µV/V + 0.9 mV 137 µV/V + 2.3 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5730A Multifunction Calibrator /5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 12.9 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV	Fluke 5730A Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(3.3 to 11) mV		Fluke 5730A Multifunction Calibrator
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89 % of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	(0.33 to 1.1) V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(1.1 to 3.5) V		Fluke 5730A Multifunction Calibrator
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 30 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2% of reading + 50 µV	
	(1 to 4) MHz	7% of reading + 70 µV	
	(4 to 8) MHz	20% of reading + 80 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(1 to 10) V		Agilent 3458A Multimeter
	(1 to 40) Hz	0.007 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.007 % of reading + 0.2 mV	
	(1 to 20) kHz	0.014 % of reading + 0.2 mV	
	(20 to 50) kHz	0.03 % of reading + 0.2 mV	
	(50 to 100) kHz	0.08 % of reading + 0.2 mV	
	(100 to 300) kHz	0.3 % of reading + 1 mV	
	300 kHz to 1 MHz	1 % of reading + 1 mV	
	(1 to 2) MHz	1.5 % of reading + 7 mV	
	(2 to 4) MHz	4 % of reading + 7 mV	
	(4 to 8) MHz	4 % of reading + 8 mV	
	(8 to 10) MHz	15 % of reading + 10 mV	
	(10 to 100) V		
	(1 to 40) Hz	0.02 % of reading + 4 mV	
	40 Hz to 1 kHz	0.02 % of reading + 2 mV	
	(1 to 20) kHz	0.02 % of reading + 2 mV	
	(20 to 50) kHz	0.035 % of reading + 2 mV	
	(50 to 100) kHz	0.12 % of reading + 2 mV	
	(100 to 300) kHz	0.4 % of reading + 10 mV	
	300 kHz to 1 MHz	1.5 % of reading + 10 mV	
	(100 to 700) V		
	(1 to 40) Hz	0.04 % of reading + 40 mV	
	40 Hz to 1 kHz	0.04 % of reading + 20 mV	
	(1 to 20) kHz	0.06 % of reading + 20 mV	
	(20 to 50) kHz	0.12 % of reading + 20 mV	
	(50 to 100) kHz	0.3 % of reading + 20 mV	
AC Voltage – Measure [1]	Up to 2.2 mV		Fluke 5790A AC/DC Transfer Standard
	(10 to 20) Hz	1.3 mV/V + 1.2 µV	
	(20 to 40) Hz	563 µV/V + 1.2 µV	
	40 Hz to 20 kHz	320 µV/V + 1.2 µV	
	(20 to 50) kHz	616 µV/V + 1.7 µV	
	(50 to 100) kHz	913 µV/V + 2 µV	
	(100 to 300) kHz	1.8 mV/V + 3.1 µV	
	(300 to 500) kHz	1.8 mV/V + 6.1 µV	
	500 to 1 MHz	2.7 mV/V + 6.1 µV	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(2.2 to 7) mV		Fluke 5790A AC/DC Transfer Standard
	(10 to 20) Hz	647 µV/V + 1.2 µV	
	(20 to 40) Hz	282 µV/V + 1.2 µV	
	40 Hz to 20 kHz	160 µV/V + 1.2 µV	
	(20 to 50) kHz	304 µV/V + 1.7 µV	
	(50 to 100) kHz	457 µV/V + 2.0 µV	
	(100 to 300) kHz	913 µV/V + 3.1 µV	
	(300 to 500) kHz	989 µV/V + 6.1 µV	
	500 kHz to 1 MHz	1.8 mV/V + 6.1 µV	
	(7 to 22) mV		
	(10 to 20) Hz	221 µV/V + 1.2 µV	
	(20 to 40) Hz	145 µV/V + 1.2 µV	
	40 Hz to 20 kHz	84 µV/V + 1.2 µV	
	(20 to 50) kHz	160 µV/V + 1.7 µV	
	(50 to 100) kHz	236 µV/V + 2 µV	
	(100 to 300) kHz	616 µV/V + 3.1 µV	
	(300 to 500) kHz	677 µV/V + 6.1 µV	
	500 kHz to 1 MHz	1.3 mV/V + 6.1 µV	
	(22 to 70) mV		
	(10 to 20) Hz	183 µV/V + 1.3 µV	
	(20 to 40) Hz	91 µV/V + 1.3 µV	
	40 Hz to 20 kHz	49 µV/V + 1.3 µV	
	(20 to 50) kHz	99 µV/V + 1.7 µV	
	(50 to 100) kHz	198 µV/V + 2 µV	
	(100 to 300) kHz	388 µV/V + 3.1 µV	
	(300 to 500) kHz	510 µV/V + 6.1 µV	
	500 kHz to 1 MHz	837 µV/V + 6.1 µV	
	(70 to 220) mV		
	(10 to 20) Hz	160 µV/V + 1.3 µV	
	(20 to 40) Hz	65 µV/V + 1.3 µV	
	40 Hz to 20 kHz	29 µV/V + 1.3 µV	
	(20 to 50) kHz	53 µV/V + 1.7 µV	
	(50 to 100) kHz	122 µV/V + 2 µV	
	(100 to 300) kHz	190 µV/V + 3.1 µV	
	(300 to 500) kHz	289 µV/V + 6.1 µV	
	500 kHz to 1 MHz	761 µV/V + 6.1 µV	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(220 to 700) mV		Fluke 5790A AC/DC Transfer Standard
	(10 to 20) Hz	160 µV/V + 1.3 µV	
	(20 to 40) Hz	58 µV/V + 1.3 µV	
	40 Hz to 20 kHz	25 µV/V + 1.3 µV	
	(20 to 50) kHz	39 µV/V + 1.7 µV	
	(50 to 100) kHz	60 µV/V + 2 µV	
	(100 to 300) kHz	137 µV/V + 3.1 µV	
	(300 to 500) kHz	228 µV/V + 6.1 µV	
	500 kHz to 1 MHz	730 µV/V + 6.1 µV	
	700 mV to 2.2 V		
	(10 to 20) Hz	152 µV/V + 0.7 µV	
	(20 to 40) Hz	50 µV/V + 0.7 µV	
	40 Hz to 20 kHz	18 µV/V + 0.7 µV	
	(20 to 50) kHz	35 µV/V + 0.7 µV	
	(50 to 100) kHz	54 µV/V + 0.7 µV	
	(100 to 300) kHz	122 µV/V + 0.7 µV	
	(300 to 500) kHz	198 µV/V + 0.7 µV	
	500 kHz to 1 MHz	685 µV/V + 0.7 µV	
	(2.2 to 7) V		
	(10 to 20) Hz	152 µV/V + 0.89 µV	
	(20 to 40) Hz	51 µV/V + 0.89 µV	
	40 Hz to 20 kHz	18 µV/V + 0.89µV	
	(20 to 50) kHz	37 µV/V + 0.89 µV	
	(50 to 100) kHz	62 µV/V + 0.89 µV	
	(100 to 300) kHz	145 µV/V + 0.89 µV	
	(300 to 500) kHz	304 µV/V + 0.89 µV	
	500 kHz to 1 MHz	913 µV/V + 0.89 µV	
	(7 to 22) V		
	(10 to 20) Hz	152 µV/V + 0.89 µV	
	(20 to 40) Hz	51 µV/V + 0.89 µV	
	40 Hz to 20 kHz	21 µV/V + 0.89 µV	
	(20 to 50) kHz	37 µV/V + 0.89 µV	
	(50 to 100) kHz	62 µV/V + 0.89 µV	
	(100 to 300) kHz	145 µV/V + 0.89 µV	
	(200 to 500) kHz	304 µV/V + 0.89 µV	
	500 kHz to 1 MHz	913 µV/V + 0.89 µV	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(22 to 70) V (10 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (70 to 220) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (220 to 700) V 40 to 20 kHz (20 to 50) kHz (50 to 100) kHz (700 to 1 000) V 40 Hz to 20 kHz (20 to 30) kHz	 152 µV/V + 5.7 µV 52 µV/V + 5.7 µV 24 µV/V + 5.7 µV 43 µV/V + 5.7 µV 72 µV/V + 5.7 µV 152 µV/V + 5.7 µV 152 µV/V + 5.7 µV 52 µV/V + 5.7 µV 24 µV/V + 5.7 µV 53 µV/V + 5.7 µV 75 µV/V + 5.7 µV 31 µV/V + 57 µV 99 µV/V + 57 µV 380 µV/V + 57 µV 29 µV/V + 57 µV 99 µV/V + 57 µV	Fluke 5790A AC/DC Transfer Standard
AC Voltage – Measure [1]	(0 to 1) kV 30 to 200 Hz 200 to 450 Hz (1 to 10) kV 30 to 200 Hz 200 to 450 Hz	 0.12 % of reading + 0.000 1 kV 0.12 % of reading + 0.000 15 kV + 1.5 µV/V x (Vin/1 000) ^2 0.4 % of reading + 0.000 1 kV 0.4 % of reading + 0.000 15 kV + 1.5 µV/V x (Vin/1 000) ^2	Vitrek 4700 Digital HV Meter
AC Voltage – Measure [1]	60 Hz (1 to 10) kV (1 to 85) kV	 0.5 % of reading + 0.002 kV 0.5 % of reading + 0.02 kV	Ross VD60, VD120 High Voltage Divider, HP 34401A Multimeter
AC Voltage – Measure Wideband Flatness Relative to 1 kHz	(0.6 to 2.2) mV (10 to 30) Hz 30 Hz to 120 kHz 120 kHz 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 0.08 % of reading + 0.1 µV 0.04 % of reading + 0.1 µV 0.05 % of reading + 0.8 µV 0.13 % of reading + 0.8 µV 0.23 % of reading + 0.8 µV 0.53 % of reading + 1.6 µV	Fluke 5790A Option 003 AC/DC Transfer Standard

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure Wideband Flatness Relative to 1 kHz	(2.2 to 7) mV		Fluke 5790A Option 003 AC/DC Transfer Standard
	(10 to 30) Hz	0.08 % of reading + 0.1 µV	
	30 Hz to 120 kHz	0.04 % of reading + 0.1 µV	
	120 kHz 2 MHz	0.05 % of reading + 0.8 µV	
	(2 to 10) MHz	0.08 % of reading + 0.8 µV	
	(10 to 20) MHz	0.13 % of reading + 0.8 µV	
	(20 to 30) MHz	0.28 % of reading + 0.8 µV	
	(7 to 22) mV		
	(10 to 30) Hz	0.08 % of reading + 0.1 µV	
	30 Hz to 120 kHz	0.04 % of reading + 0.1 µV	
	120 kHz 2 MHz	0.05 % of reading + 0.1 µV	
	(2 to 10) MHz	0.08 % of reading + 0.1 µV	
	(10 to 20) MHz	0.13 % of reading + 0.1 µV	
	(20 to 30) MHz	0.28 % of reading + 0.1 µV	
	(22 to 70) mV		
	(10 to 30) Hz	0.08 % of reading + 0.6 µV	
	30 Hz to 2 MHz	0.04 % of reading + 0.6 µV	
	(2 to 10) MHz	0.08 % of reading + 0.6 µV	
	(10 to 20) MHz	0.11 % of reading + 0.6 µV	
	(20 to 30) MHz	0.27 % of reading + 0.6 µV	
	(70 to 220) mV		
	(10 to 30) Hz	0.08 % of reading	
	30 Hz to 500 kHz	0.03 % of reading	
	500 kHz to 2 MHz	0.04 % of reading	
	(2 to 10) MHz	0.08 % of reading	
	(10 to 20) MHz	0.11 % of reading	
	(20 to 30) MHz	0.27 % of reading	
	(220 to 700) mV		
	(10 to 30) Hz	0.08 % of reading	
	30 Hz to 500 kHz	0.02 % of reading	
	500 kHz to 2 MHz	0.04 % of reading	
	(2 to 10) MHz	0.08 % of reading	
	(10 to 20) MHz	0.11 % of reading	
	(20 to 30) MHz	0.27 % of reading	
	(0.7 to 2) V		
	(10 to 30) Hz	0.08 % of reading	
	30 Hz to 500 kHz	0.02 % of reading	
	500 kHz to 2 MHz	0.04 % of reading	
	(2 to 10) MHz	0.08 % of reading	
	(10 to 20) MHz	0.11 % of reading	
	(20 to 30) MHz	0.27 % of reading	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure Wideband Flatness Relative to 1 kHz	(2 to 7) V (10 to 30) Hz 30 Hz to 500 kHz 500 kHz to 2 MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 0.08 % of reading 0.02 % of reading 0.04 % of reading 0.08 % of reading 0.11 % of reading 0.27 % of reading	Fluke 5790A Option 003 AC/DC Transfer Standard
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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 (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 (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 91 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 91 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 µA 228 µA/A + 4 µA 152 µA/A + 3 µA 91 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 228 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5730A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA/A + 141 µA 723 µA/A + 295 µA 2.7 mA/A + 573 µA	Fluke 5730A Multifunction Calibrator /5725A Amplifier

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 Hz to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.3 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current – Generate [1]	(11 to 20) A (10 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz (20 to 120) A (10 to 300) Hz 300 Hz to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	 255 µA/A + 10 mA 769 µA/A + 11 mA 0.23 % of output + 31 mA 0.76 % of output + 62 mA 2.3 % of output + 92 mA 255 µA/A + 28 mA 769 µA/A + 92 mA 0.23 % of output + 228 mA 0.76 % of output + 411 mA 3 % of output + 685 mA	Fluke 5522A Multiproduct Calibrator, Fluke 52120A Transconductance Amplifier
AC Current Clamps [1] Toroidal – Wound	(16.5 to 1025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.23 % of output + 0.1 A 0.64 % of output + 0.085 A	Fluke 5522A Multiproduct Calibrator, 5500A/Coil x50
AC Current Clamps [1] Other	(16.5 to 1025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.43 % of output +0.53 A 0.76 % of output +0.68 A	Fluke 5522A Multiproduct Calibrator, 5500A/Coil x50
AC Current Clamps - Rogowski	(10 to 100) A (10 to 1000) Hz (1 to 3) kHz (100 to 1 000) A (10 to 1000) Hz (1 to 3) kHz (1 000 to 6 000) A (10 to 1000) Hz (1 000 to 3 500) A (1 to 3) kHz	 0.53 % of reading +0.011 A 0.61 % of reading +0.015 A 0.53 % of reading +0.11 A 0.61 % of reading +0.15 A 0.53 % of reading +0.69 A 0.61 % of reading +0.95 A	Fluke 52120 Transconductance Amplifier, Coil6KA Current Coil
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA	Agilent 3458A/002 Multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (0.1 to 1) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A/002 Multimeter
AC Current – Measure [1]	(0.22 to 10) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (10 to 50) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (100 to 250) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz	 189 µA/A + 0.002 µA 90 µA/A + 0.002 µA 44 µA/A + 0.002 µA 76 µA/A + 0.002 µA 190 µA/A 87 µA/A 42 µA/A 71 µA/A 190 µA/A 88 µA/A 45 µA/A 77 µA/A 191 µA/A 91 µA/A 42 µA/A 78 µA/A	Fluke 5790A AC/DC Transfer Standard / Holt HCS-1 Current Shunts

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(250 to 500) mA		Fluke 5790A AC/DC Transfer Standard / Holt HCS-1 Current Shunts
	(10 to 20) Hz	190 µA/A	
	(20 to 40) Hz	91 µA/A	
	40 Hz to 20 kHz	42 µA/A	
	(20 to 50) kHz	82 µA/A	
	(0.5 to 1) A		
	(10 to 20) Hz	190 µA/A	
	(20 to 40) Hz	92 µA/A	
	(0.5 to 1) A		
	40 Hz to 20 kHz	59 µA/A	
	(20 to 50) kHz	117 µA/A	
	(1 to 2.5) A		
	(10 to 20) Hz	196 µA/A	
	(20 to 40) Hz	107 µA/A	
	40 Hz to 20 kHz	78 µA/A	
	(20 to 50) kHz	129 µA/A	
	(2.5 to 5) A		
	(10 to 20) Hz	199 µA/A	
	(20 to 40) Hz	110 µA/A	
	40 Hz to 20 kHz	85 µA/A	
	(20 to 50) kHz	177 µA/A	
	(5 to 10) A		
	(10 to 20) Hz	205 µA/A	
	(20 to 40) Hz	132 µA/A	
	40 Hz to 20 kHz	103 µA/A	
	(20 to 50) kHz	149 µA/A	
	(10 to 20) A		
	(10 to 20) Hz	217 µA/A	
	(20 to 40) Hz	149 µA/A	
	40 Hz to 20 kHz	127 µA/A	
	(20 to 50) kHz	184 µA/A	
AC Current – Measure [1]	(1 to 3) A		Fluke 8845A Multimeter
	(3 to 5) Hz	0.84 % of reading + 1.4 mA	
	(5 to 10) Hz	0.27 % of reading + 1.4 mA	
	10 Hz to 5 kHz	0.11 % of reading + 1.4 mA	
	(5 to 10) kHz	0.27 % of reading + 16 mA	
	(3 to 10) A		
	(3 to 5) Hz	0.84 % of reading + 4.6 mA	
	(5 to 10) Hz	0.27 % of reading + 4.6 mA	
	10 Hz to 5 kHz	0.11 % of reading + 4.6 mA	
	(5 to 10) kHz	0.27 % of reading + 53 mA	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(3 to 30) A 40 Hz to 1 kHz (1 to 5) kHz	 0.3 % of reading + 0.07 A 5 % of reading + 0.14 A	Agilent 3458A Multimeter, Keysight 34330A Current Shunt
AC Current – Measure [1]	(10 to 1 000) A (10 to 100) Hz (100 to 500) Hz	 1.5 % of reading + 1A 1.9 % of reading+ 1A	Fluke 376 Clamp Meter
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 μΩ/Ω + 0.1 μΩ 21 μΩ/Ω + 1 μΩ 9.1 μΩ/Ω + 6 μΩ 6.1 μΩ/Ω + 60 μΩ 6.1 μΩ/Ω + 0.6 mΩ 7.6 μΩ/Ω + 6 mΩ 9.1 μΩ/Ω + 6 mΩ 11 μΩ/Ω + 60 mΩ 16 μΩ/Ω + 60 mΩ 35 μΩ/Ω + 0.6 Ω 42 μΩ/Ω + 0.6 Ω 91 μΩ/Ω + 6 Ω	Fluke 5730A Multifunction Calibrator
Resistance – Generate [1] Fixed Points	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	32 μΩ/Ω + 0.6 μΩ 25 μΩ/Ω + 0.6 μΩ 7.5 μΩ/Ω + 6 μΩ 6 μΩ/Ω + 6 μΩ 2.8 μΩ/Ω + 60 μΩ 2.4 μΩ/Ω + 60 μΩ 2.8 μΩ/Ω + 0.6 mΩ 2.4 μΩ/Ω + 0.6 mΩ 2.8 μΩ/Ω + 0.6 mΩ 2.4 μΩ/Ω + 6 mΩ 2.9 μΩ/Ω + 60 mΩ 2.6 μΩ/Ω + 60 mΩ 4.5 μΩ/Ω + 0.6 Ω 12 μΩ/Ω + 0.6 Ω 14 μΩ/Ω + 6 Ω 17 μΩ/Ω + 6 Ω 82 μΩ/Ω + 60 Ω	Fluke 5450A Resistance Calibrator
Resistance – Generate [1] Fixed Points	1 Ω 10 kΩ	2.6 μΩ/Ω 0.93 μΩ/Ω	Fluke 742A Resistance Standards

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1]	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω 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	30 μΩ/Ω + 0.001 Ω 23 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.2 Ω 21 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 2 Ω 24 μΩ/Ω + 2 Ω 46 μΩ/Ω + 23 Ω 99 μΩ/Ω + 38 Ω 190 μΩ/Ω + 1.9 kΩ 380 μΩ/Ω + 2.3 kΩ 0.23 % of setting + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multiproduct Calibrator
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω 100 Ω to 1.2 kΩ (1 to 12) kΩ (10 to 120) kΩ 100 kΩ to 1.2 MΩ (1 to 12) MΩ (10 to 120) MΩ 100 MΩ to 1.2 GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 0.6 mΩ 10 μΩ/Ω + 5.6 mΩ 10 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A/002 Multimeter
Resistance – Measure [1]	50 Hz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ	 0.17 % of reading + 0.003 Ω 0.062 % of reading + 0.006 Ω 0.051 % of reading + 0.06 Ω 0.05 % of reading + 0.000 6 kΩ 0.054 % of reading + 0.006 kΩ 0.09 % of reading + 0.000 06 MΩ 0.45% of reading + 0.000 6 MΩ	IET 1693 RLC Meter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1]	100/120 Hz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ 1 000 Hz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ 10 kHz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 25.6) kΩ (25.6 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ 100 kHz (1 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) kΩ	 0.13 % of reading + 0.003 Ω 0.049 % of reading + 0.006 Ω 0.041 % of reading + 0.06 Ω 0.04 % of reading + 0.000 6 kΩ 0.043 % of reading + 0.006 kΩ 0.07 % of reading + 0.000 06 MΩ 0.34 % of reading + 0.000 6 MΩ 0.05 % of reading + 0.003 Ω 0.023 % of reading + 0.006 Ω 0.02 % of reading + 0.06 Ω 0.02 % of reading + 0.000 6 kΩ 0.021 % of reading + 0.006 kΩ 0.03 % of reading + 0.000 06 MΩ 0.12 % of reading + 0.000 6 MΩ 0.17 % of reading + 0.003 Ω 0.062 % of reading + 0.006 Ω 0.051 % of reading + 0.06 Ω 0.05 % of reading + 0.000 6 KΩ 0.051 % of reading + 0.006 KΩ 0.19 % of reading + 0.006 KΩ 0.33 % of reading + 0.000 06 MΩ 1.8 % of reading + 0.000 6 MΩ 0.77 % of reading + 0.003 Ω 0.257 % of reading + 0.006 Ω 0.206 % of reading + 0.06 Ω 0.23 % of reading + 0.000 6 kΩ 0.52 % of reading + 0.006 kΩ 3.4 % of reading + 0.000 06 MΩ	IET 1693 RLC Meter
Capacitance – Generate [1] Fixed Points	1 pF 10 pF 100 pF 1 000 pF	0.17 % of reading 0.17 % of reading 0.17 % of reading 0.17 % of reading	Agilent 16380A Capacitor Set

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate [1]	(220 to 400) pF	0.38 % of output + 7.6pF	Fluke 5522A Multiproduct Calibrator
	(0.4 to 3.299 9) nF	0.38 % of output + 0.01 nF	
	(3.3 to 10.999 9) nF	0.19 % of output + 0.01 nF	
	(11 to 32.999 9) nF	0.19 % of output + 0.08 nF	
	(33 to 109.999) nF	0.19 % of output + 0.08 nF	
	(110 to 329.999) nF	0.19 % of output + 0.23 nF	
	(0.33 to 1.099 99) µF	0.19 % of output + 0.76 nF	
	(1.1 to 3.299 99) µF	0.19 % of output + 2.3 nF	
	(3.3 to 10.999 9) µF	0.19 % of output + 7.6 nF	
	(11 to 32.999 9) µF	0.3 % of output + 23 nF	
	(33 to 109.999) µF	0.34 % of output + 76 nF	
	(110 to 329.999) µF	0.34 % of output + 228 nF	
	(0.33 to 1.099 99) mF	0.34 % of output + 0.76 µF	
	(1.1 to 3.299 99) mF	0.34 % of output + 2.3 µF	
	(3.3 to 10.999 9) mF	0.34 % of output + 7.6 µF	
	(11 to 32.999 9) mF	0.57 % of output + 23 µF	
	(33 to 110) mF	0.84 % of output + 76 µF	
Capacitance – Measure [1]	50 Hz		IET 1693 LCR Meter
	(50 to 100) pF	2.6 % of reading + 0.015 pF	
	(100 to 400) pF	1.3 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.37 % of reading + 0.06 pF	
	(1 to 10) nF	0.18 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.063 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.051 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.051 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.05% of reading + 0.000 6 µF	
	(10 to 100) µF	0.054 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.09 % of reading + 0.06 µF	
	100 Hz		
	(20 to 100) pF	2.4 % of reading + 0.015 pF	
	(100 to 400) pF	0.52 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.16 % of reading + 0.06 pF	
	(1 to 10) nF	0.088 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.045 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.041 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.041 % of reading + 0.000 06 µF	
	(10 to 100) µF	0.046 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.1 % of reading + 0.06 µF	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure [1]	120 Hz		IET 1693 LCR Meter
	(20 to 100) pF	2 % of reading + 0.015 pF	
	(100 to 400) pF	0.44 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.14 % of reading + 0.06 pF	
	(1 to 10) nF	0.08 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.044 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.04 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.04 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.041 % of reading + 0.000 6 µF	
	(10 to 100) µF	0.047 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.11 % of reading + 0.06 µF	
	1 000 Hz		
	(1 to 10) pF	1.6 % of reading + 0.014 pF	
	(10 to 20) pF	0.18 % of reading + 0.015 pF	
	(20 to 100) pF	0.1 % of reading + 0.015 pF	
	(100 to 400) pF	0.036 % of reading + 0.06 pF	
	(400 to 1 000) pF	0.024 % of reading + 0.06 pF	
	(1 to 10) nF	0.022 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.02 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.02 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.02 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.022 % of reading + 0.000 6 µF	
	(10 to 100) µF	0.04 % of reading + 0.006 µF	
	(100 to 1 000) µF	0.22 % of reading + 0.06 µF	
	10 kHz		
	(20 to 100) pF	0.3 % of reading + 0.015 pF	
	(100 to 622) pF	0.2 % of reading + 0.06 pF	
	(622 to 1 000) pF	0.051 % of reading + 0.06 pF	
	(1 to 10) nF	0.051 % of reading + 0.000 6 nF	
	(10 to 100) nF	0.051 % of reading + 0.006 nF	
	(100 to 1 000) nF	0.058 % of reading + 0.06 nF	
	(0.1 to 1) µF	0.058 % of reading + 0.000 06 µF	
	(1 to 10) µF	0.13 % of reading + 0.000 6 µF	
	(10 to 100) µF	0.85 % of reading + 0.006 µF	
	(100 to 500) µF	4.1 % of reading + 0.06 µF	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure [1]	100 kHz (20 to 100) pF (100 to 400) pF (400 to 1 000) pF (1 to 10) nF (10 to 100) nF (100 to 1 000) nF (0.1 to 1) µF (1 to 10) µF	 0.49 % of reading + 0.015 pF 0.26 % of reading + 0.06 pF 0.21 % of reading + 0.06 pF 0.21 % of reading + 0.000 6 nF 0.24 % of reading + 0.006 nF 0.58 % of reading + 0.06 nF 0.58 % of reading + 0.000 06 µF 4 % of reading + 0.000 6 µF	IET 1693 LCR Meter
Inductance – Measure [1]	100 Hz (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H (10 to 100) H 1 000 Hz (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H (10 to 100) H 10 kHz (1 to 4) µH (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 0.407) H (0.407 to 1) H (1 to 10) H (10 to 100) H	 3.8 % of reading + 0.006 µH 1.6 % of reading + 0.000 06 mH 0.42 % of reading + 0.000 06 mH 0.19 % of reading + 0.0006 mH 0.056 % of reading + 0.006 mH 0.042 % of reading + 0.000 06 H 0.041 % of reading + 0.000 6 H 0.042 % of reading + 0.006 H 1.3 % of reading + 0.003 µH 0.53 % of reading + 0.006 µH 0.15 % of reading + 0.006 µH 0.071 % of reading + 0.000 06 mH 0.033 % of reading + 0.000 06 mH 0.025 % of reading + 0.000 6 mH 0.02 % of reading + 0.006 mH 0.02% of reading + 0.000 06 H 0.02 % of reading + 0.000 6 H 0.026 % of reading + 0.006 H 2.1 % of reading + 0.003 µH 0.56 % of reading + 0.003 µH 0.25 % of reading + 0.006 µH 0.1 % of reading + 0.006 µH 0.071 % of reading + 0.000 06 mH 0.056 % of reading + 0.000 06 mH 0.052 % of reading + 0.000 6 mH 0.051 % of reading + 0.006 mH 0.051 % of reading + 0.006 mH 0.18 % of reading + 0.000 06 H 0.27 % of reading + 0.000 6 H 1.2 % of reading + 0.006 H	IET 1693 LCR Meter

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure [1]	100 kHz (1 to 4) µH (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H	 1.16 % of reading + 0.003 µH 0.44 % of reading + 0.003 µH 0.3 % of reading + 0.006 µH 0.23 % of reading + 0.006 µH 0.21 % of reading + 0.000 06 mH 0.21 % of reading + 0.000 06 mH 0.22 % of reading + 0.000 6 mH 0.39 % of reading + 0.006 mH 2.1 % of reading + 0.000 06 H	IET 1693 LCR Meter
Inductance – Generate [1] Fixed Point	100 µH 10 kHz	 0.25µH	GR 1482-B Standard Inductor
Inductance – Generate [1] Fixed Point	100 mH 100 Hz	 0.047mH	GR 1482-L Standard Inductor
Low Frequency Power – Generate	1 mW to 20 kW (45 to 65) Hz, 1 PF DC	 0.28 % of reading 0.14 % of reading	Fluke 5522A Multiproduct Calibrator
Electrical Calibration of Thermocouple Indicating Devices [1]	Type B (600 to 800) °C (800 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 000) °C (2 000 to 2 316) °C Type E (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 600) °C (600 to 1 000) °C Type J (-210 to -100) °C (-100 to 800) °C (800 to 1 200) °C Type K (-250 to -200) °C (-200 to -100) °C (-100 to 800) °C (800 to 1 372) °C	 0.27 °C 0.22 °C 0.17 °C 0.13 °C 0.18 °C 0.2 °C 0.27 °C 0.19 °C 0.1 °C 0.07 °C 0.07 °C 0.08 °C 0.11 °C 0.07 °C 0.08 °C 0.35 °C 0.13 °C 0.08 °C 0.1 °C	Fluke 7526A Process Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type L		Fluke 7526A Process Calibrator
	(-200°C to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	
	Type R		
	(-50 to -25) °C	0.42 °C	
	(-25 to 0) °C	0.34 °C	
	(0 to 100) °C	0.3 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.17 °C	
	(600 to 1 000) °C	0.16 °C	
	(1 000 to 1 600) °C	0.15 °C	
	(1 600 to 1 767) °C	0.18 °C	
	Type S		
	(-50 to -25) °C	0.39 °C	
	(-25 to 0) °C	0.33 °C	
	(0 to 100) °C	0.29 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.18 °C	
	(600 to 1 600) °C	0.17 °C	
	(1 600 to 1 767) °C	0.2 °C	
	Type T		
	(-250 to -200) °C	0.26 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 0) °C	0.09 °C	
	(0 to 400) °C	0.07 °C	
	Type U		
	(-200 to 0) °C	0.13 °C	
	(0 to 600) °C	0.08 °C	
Electrical Calibration of RTD Indicators [1]	Pt 385, 100 Ω		Fluke 5522A Multiproduct Calibrator
	(-200 to 800) °C	0.05 °C	
	Pt 3926, 100 Ω		
	(-200 to 630) °C	0.05 °C	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of RTD Indicators [1]	Pt 3916, 100 Ω (-200 to 630) °C Pt 385, 200 Ω (-200 to 400) °C (400 to 630) °C Pt 385, 500 Ω (-200 to 630) °C Pt 385, 1 000 Ω (-200 to 630) °C PtNi 385, 120 Ω (Ni120) (-80 to 0) °C (0 to 100) °C (100 to 260) °C Cu 427, 10 Ω 100 °C to 260) °C	0.05 °C 0.4 °C 0.5 °C 0.17 °C 0.09 °C 0.093 °C 0.093 °C 0.16 °C 0.35 °C	Fluke 7526A Process Calibrator
Oscilloscopes Calibration – Generate [1] Voltage DC – 50 Ω	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
DC – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6.0 mV	
Square Wave 10 Hz to 10 kHz – 50 Ω	(1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.1999) Vpp (2.2 to 6.6) Vpp	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	
Square Wave 10 Hz to 1 kHz – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6 mV	

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1] Square Wave 1 to 10 kHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth (5 to 50) mVpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz 50 mV to 3.5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz 3.5 to 5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz	 0.34 dB 0.36 dB 0.42 dB 0.46 dB 0.5 dB 0.56 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB 0.4 dB 0.44 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness	3 dB Bandwidth 50 mV to 3.5Vpp (2 100 to 4 000) MHz (4 000 to 8 000) MHz (8 000 to 18 000) MHz	 0.25 dB 0.35 dB 0.46 dB	EPM Power Meter w/ E Series Power Sensors
Oscilloscopes Calibration – Generate Time Marker	500 ps to 20 ms 50 ms to 5 s	0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Measure [1] Input Impedance Resistance Leakage	 (40 to 60) Ω 500 kΩ to 1.5MΩ (0 to 5.99) V	 0.08 % of reading 0.08 % of reading 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Meter Range Calibration [1]	3 µW to 100 mW	0.3 % of reading	HP 11683A Range Calibrator

Electrical – RF/Microwave Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 Hz to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 Hz to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 Hz to 400 kHz (13.2 to 26.5) GHz Rates 50 Hz to 200 kHz Peak Dev 250 Hz to 400 kHz (31.15 to 50.0) GHz Rates 50 Hz to 200 kHz Peak Dev 250 Hz to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.2 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 – 8.5 % of reading + 17 Hz β > 32 - 1 % of reading + 17 Hz	Agilent N5531S Measuring Receiver System
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (26.5 to 31.15) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (31.15 to 50) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 6.8 % of reading + 0.4 digits 1.9 % of reading + 0.4 digits 26 % of reading + 0.4 digits 6 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver System

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad (26.5 to 31.15) GHz Deviations: > 1.3 rad Deviations > 4.0 rad (31.15 to 50) GHz Deviations: > 2.4 rad Deviations > 8.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.018 rad 1 % of reading + 0.018 rad	Agilent N5531S Measuring Receiver System
RF Flatness – Measure [1]	9 kHz to 2 000MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.10 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Attenuation – Measure [1]	(30 to 3 050) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.13 dB	Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(3 050 to 6 600) MHz		Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.19 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.25 dB	
	(13 200 to 19 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.31 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(19 200 to 26 500) MHz		Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.14 dB	
	(90 to 100) dB	0.36 dB	
	(100 to 110) dB	0.82 dB	
	(26 500 to 31 150) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.13 dB	
	(90 to 100) dB	0.33 dB	
	(100 to 110) dB	0.77 dB	
	(31 150 to 41 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.14 dB	
	(80 to 90) dB	0.36 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(41 000 to 45 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (45 000 to 50 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.11 dB 0.24 dB 0.6 dB 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.11 dB 0.29 dB 0.7 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor
RF Power – Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power Measure [1]	(10 to 100) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.07 dB 0.06 dB 0.06 dB 0.06 dB 0.11 dB	Agilent EPM Series Power Meter RF Power / Keysight N8485A Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(100 to 2 000) MHz		Agilent EPM Series Power Meter RF Power / Keysight N8485A Power Sensor
	(20 to 10) dB	0.07 dB	
	(10 to 0) dB	0.07 dB	
	(0 to -10) dB	0.06 dB	
	(-10 to -20) dB	0.07 dB	
	(-20 to -25) dB	0.11 dB	
	(2 000 to 12 400) MHz		
	(20 to 10) dB	0.08 dB	
	(10 to 0) dB	0.08 dB	
	(0 to -10) dB	0.08 dB	
	(-10 to -20) dB	0.08 dB	
	(-20 to -25) dB	0.12 dB	
	(12 400 to 18 000) MHz		
	(20 to 10) dB	0.09 dB	
	(10 to 0) dB	0.08 dB	
	(0 to -10) dB	0.08 dB	
	(-10 to -20) dB	0.09 dB	
	(-20 to -25) dB	0.12 dB	
	(18 000 to 26 500) MHz		
	(20 to 10) dB	0.12 dB	
	(10 to 0) dB	0.12 dB	
	(0 to -10) dB	0.12 dB	
	(-10 to -20) dB	0.12 dB	
	(-20 to -25) dB	0.15 dB	
RF Power Measure [1]	(100 to 2 000) MHz		Agilent EPM Series Power Meter 8487A Power Sensor
	(20 to 10) dB	0.14 dB	
	(10 to 0) dB	0.06 dB	
	(0 to -10) dB	0.07 dB	
	(-10 to -20) dB	0.08 dB	
	(-20 to -25) dB	0.15 dB	
	(2 000 to 12 400) MHz		
	(20 to 10) dB	0.15 dB	
	(10 to 0) dB	0.07 dB	
	(0 to -10) dB	0.07 dB	
	(-10 to -20) dB	0.08 dB	
	(-20 to -25) dB	0.15 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(12 400 to 18 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (18 000 to 26 500) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (26 5000 to 40 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (40 000 to 50 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.15 dB 0.08 dB 0.08 dB 0.09 dB 0.15 dB 0.16 dB 0.1 dB 0.1 dB 0.11 dB 0.16 dB 0.17 dB 0.12 dB 0.12 dB 0.13 dB 0.18 dB 0.22 dB 0.19 dB 0.19 dB 0.19 dB 0.23 dB	Agilent EPM Series Power Meter 8487A Power Sensor
RF Power – Measure [1]	100 kHz to 30 MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.12 dB 0.13 dB 0.14 dB 0.18 dB 0.2 dB 0.28 dB 0.43 dB	Agilent N5531S Measuring Receiver, N1912A w/E9304A Power Sensor
RF Power – Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB	Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.26 dB	
	(-110 to -115) dB	0.28 dB	
	(-115 to -120) dB	0.34 dB	
	(-120 to -125) dB	0.7 dB	
	(3 050 to 6 600) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.29 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.53 dB	
	(-120 to -125) dB		
	(6 600 to 13 200) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.46 dB	
	(-115 to -120) dB	0.65 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -90) dB	0.26 dB	
	(-90 to -95) dB	0.26 dB	
	(-95 to -100) dB	0.26 dB	
	(-100 to -105) dB	0.29 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(18 000 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.27 dB	
	(-90 to -95) dB	0.27 dB	
	(-95 to -100) dB	0.27 dB	
	(-100 to -105) dB	0.3 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.28 dB	
	(-90 to -95) dB	0.33 dB	
	(-95 to -100) dB	0.43 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.85 dB	
	(-110 to -115) dB	1.2 dB	
	(-115 to -120) dB	1.5 dB	
	(26 500 to 31 150) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.34 dB	
	(-78 to - 90) dB	0.36 dB	
	(-90 to -95) dB	0.39 dB	
	(-95 to -100) dB	0.46 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.82 dB	
	(-110 to -115) dB	1.1 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(31 150 to 41 000) MHz		Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.35 dB	
	(-78 to -90) dB	0.48 dB	
	(-90 to -95) dB	0.64 dB	
	(-95 to -100) dB	0.87 dB	
	(-100 to -105) dB	1.2 dB	
	(-105 to -110) dB	1.5 dB	
	(41 000 to 45 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.38 dB	
	(-78 to -90) dB	0.68 dB	
	(-90 to -95) dB	0.93 dB	
	(-95 to -100) dB	1.2 dB	
	(-100 to -105) dB	1.6 dB	
	(45 000 to 50 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.67 dB	
	(-78 to -90) dB	1.4 dB	
RF Power – Generate [1]	10 Hz to 100 kHz		Fluke 9640A RF Reference Source
	(24 to -48) dBm	0.06 dB	
	100 kHz to 10 MHz		
	(24 to -48) dBm	0.07 dB	
	(-48 to -74) dBm	0.16 dB	
	(-74 to -94) dBm	0.39 dB	
	(10 to 128) MHz		
	(24 to -48) dBm	0.07 dB	
	(-48 to -84) dBm	0.09 dB	
	(-84 to -94) dBm	0.24 dB	
	(-94 to -124) dBm	0.54 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(128 to 300) MHz (20 to -48) dBm (-48 to -74) dBm (-74 to -84) dBm (-84 to -94) dBm (-94 to -124) dBm (300 to 1.4) GHz (20 to -48) dBm (-48 to -74) dBm (-74 to -84) dBm (-84 to -94) dBm (-94 to -124) dBm (1.4 to 3) GHz (14 to -48) dBm (-48 to -74) dBm (-74 to -94) dBm (-94 to -124) dBm	 0.08 dB 0.09 dB 0.24 dB 0.39 dB 1.2 dB 0.16 dB 0.31 dB 0.39 dB 0.77 dB 1.2 dB 0.24 dB 0.39 dB 0.77 dB 1.2 dB	Fluke 9640A RF Reference Source
RF Power – Generate [1]	(30 to 2 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (2 000 to 3 050) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (3 050 to 6 600) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (6 600 to 13 200) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB	 0.29 dB 0.3 dB 0.31 dB 0.32 dB 0.34 dB 0.35 dB 0.36 dB 0.39 dB 0.34 dB 0.35 dB 0.36 dB 0.39 dB 0.34 dB 0.35 dB 0.36 dB 0.42 dB	Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor, 83650B Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(13 200 to 18 000) MHz		Agilent N5531S Measuring Receiver w/N5532B Opt 550 Power Sensor, 83650B Signal Generator
	(15 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.46 dB	
	(18 000 to 19 200) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.5 dB	
	(19 200 to 26 500) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.9 dB	
	(26 500 to 31 150) MHz		
	(15 to 0) dB	0.62 dB	
	(0 to -58) dB	0.63 dB	
	(-58 to -78) dB	0.64 dB	
	(-78 to -110) dB	0.96 dB	
	(31 150 to 41 000) MHz		
	(10 to 0) dB	0.82 dB	
	(0 to -58) dB	0.83 dB	
	(-58 to -78) dB	0.84 dB	
	(-78 to -100) dB	1.1 dB	
	(41 000 to 45 000) MHz		
	(10 to 0) dB	0.82 dB	
	(0 to -58) dB	0.83 dB	
	(-58 to -78) dB	0.85 dB	
	(-78 to -100) dB	1.4 dB	
	(45 000 to 50 000) MHz		
	(10 to 0) dB	0.82 dB	
	(0 to -58) dB	0.83 dB	
	(-58 to -78) dB	1 dB	
	(-78 to -90) dB	1.5 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Power Sensor (Cal Factor)	Type-N (50 Ω) 0.1 MHz 0.3 MHz 0.5 MHz 1 MHz 3 MHz 5 MHz 10 MHz 30 MHz 50 MHz 100 MHz 300 MHz 500 MHz 1 000 MHz 1 500 MHz 2 000 MHz 2 500 MHz 3 000 MHz 3 500 MHz 3 700 MHz 4 000 MHz 4 200 MHz 5 000 MHz 6 000 MHz	 1.2 % of reading + M 1 % of reading + M 1 % of reading + M 1 % of reading + M 1 % of reading + M 1 % of reading + M 0.97 % of reading + M 0.95 % of reading + M 0.85 % of reading + M 0.85 % of reading + M 0.89 % of reading + M 0.89 % of reading + M 0.89 % of reading + M 0.89 % of reading + M 0.89 % of reading + M 0.88 % of reading + M 0.88 % of reading + M 0.9 % of reading + M 0.9 % of reading + M 0.92 % of reading + M 0.93 % of reading + M 0.93 % of reading + M 0.93 % of reading + M	M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight N8482A H84 Power Sensor
RF Power – Power Sensor (Cal Factor)	Type-N (50 Ω) 10 MHz 30 MHz 50 MHz 100 MHz 300 MHz 500 MHz 800 MHz 1 000 MHz 1 200 MHz 1 500 MHz 2 000 MHz	 1.3 % of reading + M 1.3 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M 1.2 % of reading + M	M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight N8481A H84 Power Sensor

Electrical – RF/Microwave Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Power Sensor (Cal Factor)	Type-N (50 Ω) 3 000 MHz 4 000 MHz 5 000 MHz 6 000 MHz 7 000 MHz 8 000 MHz 9 000 MHz 10 000 MHz 11 000 MHz 12 000 MHz 12 400 MHz 13 000 MHz 14 000 MHz 15 000 MHz 16 000 MHz 17 000 MHz 18 000 MHz	 1.2 % of reading + M 1.2 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.3 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.4 % of reading + M 1.5 % of reading + M 1.5 % of reading + M 1.5 % of reading + M 1.6 % of reading + M 1.6 % of reading + M 1.6 % of reading + M	M is the mismatch Uncertainty Agilent EPM Series Power Meter RF Power / Keysight N8481A H84 Power Sensor
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 26.5 MHz to 50.0 GHz AM Depth > 3% (0 to -20) dB AM Depth > 5% (0 to -20) dB (-20 to -30) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB 1.8 dB 1.5 dB 3.5 dB	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.28 dB 0.09 dB 0.27 dB 0.83 dB 2.39 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (31.15 to 50.0) GHz Dev > 4 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 12.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(1 to 6 600) MHz Rate 20 to 500 Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
PM Distortion Measure [1]	(1 to 6 600) MHz Rate (500 to 1 000) Hz Dev > 0.4 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 1.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (6.6 to 13.2) GHz Rate (20 to 500) Hz Dev > 1.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 5.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(6.6 to 13.2) GHz Rate 500 to 1 000 Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Rate 20 to 500 Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate 500 Hz to 1000 Hz Dev > 1.2 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.28 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(31.15 to 50.0) GHz Rate 20 to 500 Hz Dev > 7.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 19.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate 500 Hz to 1000 Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer

Electrical – RF/Microwave Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1 kHz to 600 MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (5 300 to 10 000) MHz 2nd through 4th Harmonic (10 000 to 12 500) MHz 2nd through 3rd Harmonic (12 500 to 16 667) MHz 2nd Harmonic (16 667 to 25 000) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB 2.3 dB	Agilent E4440A Measuring Receiver
Phase Noise – SSB Measure [1]	1 MHz to 26.5 GHz	0.45 dB	Agilent E4440A Spectrum Analyzer

Length – Dimensional Metrology Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers [2,3]	Up to 46 in	(29 + 4.5*L*) µin	Gage blocks (Grade 0)
Gage Blocks [2]	Up to 13 in	(1.2+ 2.5*L*) µin	Master gage blocks, P&W universal measuring machine
Bore Micrometers [2] 2 point 3 point	Up to 8 in	 (7 + 2L) µin (42 + 1.4L) µin	Master gage blocks, P&W universal measuring machine, Master Ring
Calipers [1,2]	Up to 46 in	(280 + 1.7*L*) µin	Gage blocks (Grade 0)
Dial Indicators [1,2] Resolution ≥ 50µin Resolution < 50µin	 Up to 10 in Up to 0.1 in	 (25 + 3.6*L*) µin 7 µin	716 Starrett Calibrator, gage blocks (Grade 0)
Micrometer Rods	Up to 40 in	(1.1 + 5.7*L*) µin	Gage blocks (grade 0)
Height Gages [1,2]	Up to 40 in	(95 + 3*L*) µin	Gage blocks (grade 0)

Length – Dimensional Metrology Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Roughness Measure	123 µin Ra 117 µin Ra 116 µin Ra 3 µm Ra	3.2 µin 2.5 µin 2.9 µin 0.06 µm	Mitutoyo SV-3200H4 Surface Measuring System and Roughness Specimens
Cylindrical Gages [2] Ring Gages Plain Plugs/Pins	 (0.04 to 14) in Up to 13 in	 (9.6 + 2.1*D*) µin (4.2 + 3.4*D*) µin	Master gage blocks, P&W universal measuring machine
Thread Wires	Up to 0.5*D*	10 µin	Master gage blocks, P&W universal measuring machine
Thread Plugs – Major Diameter Pitch Diameter	 Up to 12 in Up to 12 in	 44 µin 79 µin	P & W Model C Bench Micrometer, Van Keuren thread wire set
Solid Thread Rings	(0.625 to 12) in	106 µin	Master gage blocks, P&W universal measuring machine
Adjustable Thread Rings [2,3] Pitch Diameter (Tactile Fit)	Up to 12 in	(350 +47*D*) µin	Thread setting plug gages
Surface Plates [1,2] Overall Flatness Local Area Flatness	 Up to 6 ft × 6 ft ± 0.001 in	 77 µin 68 µin	 Planekator Repeat-O-Meter
Parallelism & Straightness	(0 to 0.01) in	13 µin	Gage Amplifier, Surface Plate
Protractors [1]	(0 to 360)°	0.075°	Angle Blocks
Radius Gages	(0.016 to 1.00) in	240 µin	Optical Comparator
Rulers [1]	Up to 72 in	0.009 in	Gage blocks (grade 0)
Tape Measures [1]	Up to 100 ft	(0.000 27*F* + 0.024) in	Standard rule
Feeler Gage [1]	Up to 1 in	31 µin	Pratt & Whitney Model C Bench Micrometer

Length – Dimensional Metrology Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Comparators [1] Angle Linearity Magnification	 (0 to 360) ° Up to 20 in (20 to 40) in (10 to 100) x	 0.042 ° 320 µin 630 µin 420 µin	Gage blocks, Angle blocks, SI Industries glass scales

Mass and Mass Related Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,2,4]	1 mg to 5 000 g (0.001 to 100) lb	(0.049 + 0.003*X*) mg (3.2 E^{-6} + 3.1 E^{-6}*W*) lb	Class 1 weights
Scales & Balances [1,2,4]	Up to 1 000 lb	(0.00 02 + 0.000 12*W*) lb	Class F weights
Mass - Measure	(1 to 200) g (200 to 2 500) g (1 to 34) kg	0.69 mg 0.026 g 0.25 g	Precision Balance
Mass - Fixed Points Metric	200 g 500 g 1 kg 5 kg	0.73 mg 29 mg 30 mg 30 mg	Comparison to ASTM E617 Class 1 weights
Pressure – Generate [1]	(10 to 16 000) psi	0.019 % of reading	Dead Weight Tester Fluke P3125
Pressure – Measure [1]	(-1 to 1) inH_2O (-5 to 5) inH_2O (-50 to 50) inH_2O (-15 to 0) psi (0 to 15) psi (0 to 30) psi (0 to 100) psi (0 to 300) psi (0 to 1 000) psi (0 to 3 000) psi (0 to 10 000) psi	0.001 5 inH_2O 0.008 inH_2O 0.061 inH_2O 0.008 9 psi 0.004 psi 0.007 8 psi 0.028 psi 0.064 psi 0.23 psi 0.97 psi 3.3 psi	Pressure Gauges ADT681-05-DP1-inH_2O ADT681-05-DP5-inH_2O ADT681-05-DP50-inH_2O Fluke 2700G-BG100K Fluke 2700G-BG100K Additel ADT681-GP30 Fluke 2700G-BG700K Fluke 2700G-BG2M Fluke 2700G-BG7M Additel ADT681-GP3K Additel ADT681-GP10K
Force [1] Tension and Compression	(0.01 to 500) lbf	0.063 % of reading	Class F weights

Mass and Mass Related Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force [1] Tension and Compression	(50 to 2 000) lbf (200 to 10 000) lbf (500 to 25 000) lbf	0.068 % of reading 0.044 % of reading 0.087 % of reading	Morehouse Press with Load Cells
Torque Tools [1]	(10 to 100) ozf-in 4 lbf·in to 1 000 lbf·ft	0.59 % of reading 0.32 % of reading	CDI 1001 Torque Tester CDI 5000 ST torque tester
Torque Tools [1]	(0.5 to 2.5) ozf-in (2 to 10) ozf-in (6 to 43) ozf-in (30 to 215) ozf-in	0.18 % of reading 0.18 % of reading 0.18 % of reading 0.18 % of reading	Waters Torque Analyzer
Torque Analyzers	0.4 ozf-in to 1 000 lbf·ft	0.065 % of reading	Class F weights and arm
Durometers Scale (Force) Accuracy Types A, B, E, O,C, D, DO Type M Types OO, OOO Indenter Geometry Length Diameter Angle	(0 to 100) duros 0.1 in 0.05 in (30 to 35) °	0.06 duros 0.07 duros 0.08 duros 130 µin 130 µin 0.085 °	Direct Verification Master balance Optical comparator
Rockwell Hardness Testers[1]	(< 60) HRBW (≥ 60 to < 80) HRBW (≥ 80) HRBW (< 35) HRC (≥ 35 to < 60) HRC (≥ 60) HRC (< 81) HR15TW (≥ 81 to < 87) HR15TW (> 87) HR15TW	3 HRBW 3 HRBW 1.4 HRBW 1.3 HRC 1.3 HRC 0.73 HRC 1.8 HR15TW 1.3 HR15TW 1.3 HR15TW	Indirect verification per ASTM E18

Thermodynamic Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity – Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 1200 Humidity Chamber

Thermodynamic Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity – Measure	(0 to 90) %RH (90 to 100) %RH	1.2 %RH 2 %RH	Vaisala MI70/HMP76 Humidity Indicator and Probe
Temperature – Measuring Equipment [1]	(-25 to 350) °C	0.087 °C	Hart 1502A Indicator with Burnes Engineering 12005 PRT and dry block
Temperature – Measure [1]	(-200 to 420) °C	0.036 °C	Hart 1502A Indicator with Burnes Engineering 12005 PRT
Infrared (IR) Thermometers	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 IR Calibrator ε = 0.95, λ = (8 to 14) µm

Time and Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	1 to 10 Hz 10 to 100 Hz 100 to 1 000 Hz 1 to 10 kHz 10 to 100 kHz 0.1 to 1 MHz 1 to 10 MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 µHz $1 \times 1^{e-12}$ Hz/Hz + 5.7 µHz $1 \times 1^{e-12}$ Hz/Hz + 57 µHz $1 \times 1^{e-12}$ Hz/Hz + 0.57 mHz $1 \times 1^{e-12}$ Hz/Hz + 5.7 mHz $1 \times 1^{e-12}$ Hz/Hz + 57 mHz $1 \times 1^{e-12}$ Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	10 to 40 000 MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 mHz	Agilent E8257D Opt 540 Signal Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	10 to 50 000 MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 kHz	HP 83650B Signal Generator / HP 58503A GPS Receiver
Frequency – Measure [1]	1 to 10 Hz 10 to 100 Hz 100 to 1 000 Hz 1 to 10 kHz 10 to 100 kHz 100 to 200 kHz 0.2 to 3 000 MHz	$4.20 \times 1^{e-9}$ Hz/Hz $1.47 \times 1^{e-9}$ Hz/Hz $0.60 \times 1^{e-9}$ Hz/Hz $0.33 \times 1^{e-9}$ Hz/Hz $0.24 \times 1^{e-9}$ Hz/Hz $0.21 \times 1^{e-9}$ Hz/Hz $0.21 \times 1^{e-9}$ Hz/Hz	Agilent 53131A Opt 030 Frequency Counter / HP 58503A GPS Receiver

Time and Frequency Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure [1]	10 to 50 000 MHz	1 x 1^{e-12} Hz/Hz + 0.1 Hz	Agilent E4448A Spectrum Analyzer / HP 58503A GPS Receiver
Time – Generate	1 pps	1 x 1^{e-12} s/s + 750 ps	HP 58503A GPS Receiver
Type I (digital) Timers	(0 to19.99) sec/day (0 to 599) sec/month	0.031 sec/day 1.1 sec/month	Helmut Klein Timometer 4500
Type II (mechanical) Timers	(0 to 320) sec/day	0.6 sec/day	Helmut Klein Timometer 4500
Timer, Stopwatch	10 s to 24 hr	34 ms	Totalize method with counter
Tachometers – RPM [1]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 33250A Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length	X Axis (0.01 to 10) in Y Axis (0.01 to 6) in	162 µin 123 µin	Optical comparator

2 Dimensional Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle	Up to 360°	0.004°	Optical comparator

3 Dimensional Rockford, IL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
General Inspection	X axis (0 to 33) in (0 to 838) mm Y axis (0 to 60) in (0 to 1 524) mm Z axis (0 to 20) in (0 to 508) mm	 (80+ 3.6*L*) µin (2.1 + 0.003 6*L*) µm (200 + 0.13*L*) µin (5.1 + 0.000 13*L*) µm (200 + 0.13L) µin (5.1 + 0.000 13*L*) µm	CMM

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Services performed at satellite laboratory

Technical Maintenance, Inc.
425 Hayden Station Road, Suite B
Windsor, CT 06095
Matt Nicewicz (Branch Manager) Phone: 860-219-0046
Scott Chamberlain (Quality Manager) Phone: 321-242-0890

CALIBRATION

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration	(0.01 to 10) g (7 < 10) Hz (10 < 30) Hz (30 < 2 000) Hz (2 to 10) kHz	 4 % of reading 3 % of reading 1.5 % of reading 4 % of reading	Accelerometer Calibrator

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,5]	4 pH 7 pH 10 pH	0.035 pH 0.025 pH 0.069 pH	pH buffer solutions

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate [1]	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 000) V	6.8 µV/V + 0.9 µV 6.1 µV/V + 0.9 µV 6.1 µV/V + 3.2 µV 6.1 µV/V + 6.2 µV 6.8 µV/V + 76 µV 8.4 µV/V + 460 µV	Fluke 5700A Multifunction Calibrator

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure [1]	(0 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6.0 µV/V + 100 µV + 12 µV/V x (Vin/1 000) ^2	Agilent 3458A Option 002 Multimeter
DC Voltage – Measure [1]	(1 to 60) kV	0.1 % of reading	Ross VD60 High Voltage Divider, HP 34401A Multimeter
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	100 µA/A + 0.007 nA 99 µA/A + 0.007 nA 99 µA/A + 0.01 nA 36 µA/A + 0.1 nA 20 µA/A + 1 nA	Fluke 5700A & 5522A Multifunction Calibrator
DC Current – Generate [1]	(10 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	46 µA/A + 8 nA 46 µA/A + 8 nA 46 µA/A + 82 nA 53 µA/A + 0.9 µA 61 µA/A + 0.9 µA 72 µA/A + 23 µA 109 µA/A + 23 µA	Fluke 5700A Multifunction Calibrator
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 371 µA	Fluke 5700A Multifunction Calibrator /5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A	761 µA/A + 631 µA	Fluke 5522A Multiproduct Calibrator
DC Current – Generate [1] Clamp Meters	(0 to 200) A	0.21 % of output + 0.028 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
DC Current – Generate [1] Clamp Meters	(0 to 1 000) A	0.21 % of output + 0.04 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil
DC Current – Measure	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.12 pA 18 µA/A + 1.2 pA 13 µA/A + 0.01 nA 12 µA/A + 0.12 nA	Fluke 5700A/03 Multifunction Calibrator Agilent 3458A Option 002 Multimeter
DC Current – Measure	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10 µA	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure	(1 to 3) A (3 to 10) A	761 µA/A + 462 µA 1.1 mA/A + 614 µA	Fluke 8845A Multimeter
DC Current – Measure	(10 to 100) A	0.25 % of reading	Agilent 3458A Option 002 Multimeter Empro Current Shunt
AC Voltage – Generate [1]	(0.22 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 (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 (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	 457 µV/V + 3.9 µV 183 µV/V + 3.9 µV 91µV/V + 3.9 µV 312 µV/V + 3.9 µV 723 µV/V + 6.1 µV 989 µV/V + 11.4 µV 1.4 mV/V + 23 µV 3.7 mV/V + 30 µV 457 µV/V + 4.6 µV 183 µV/V + 4.6 µV 91 µV/V + 4.6 µV 312 µV/V + 4.6 µV 723 µV/V + 6.1 µV 989 µV/V + 11.4 µV 1.4 mV/V + 23 µV 3.7 mV/V + 30 µV 457 µV/V + 12 µV 183 µV/V + 7.6 µV 84 µV/V + 7.6 µV 274 µV/V + 7.6 µV 685 µV/V + 23 µV 837 µV/V + 23 µV 1.4 mV/V + 30 µV 2.7 mV/V + 76 µV	Fluke 5700A/03 Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	220 mV 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 (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 (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	 457 µV/V + 8 µV 137 µV/V + 23 µV 65 µV/V + 5 µV 107 µV/V + 15 µV 213 µV/V + 61 µV 365 µV/V + 114 µV 913 µV /V + 304 µV 1.8 mV/V + 761 µV 457 µV/V + 761 µV 137 µV/V + 228 µV 65 µV/V + 54 µV 107 µV/V + 152 µV 213 µV/V + 304 µV 457 µV/V + 1294 µV 1.1 mV/V + 3805 µV 2.3 mV/V + 6848 µV 457 µV/V + 7.6 mV 137 µV/V + 2.4 mV 68 µV/V + 1.0 mV 190 µV/V + 3.1 mV 457 µV/V + 7.6 mV	Fluke 5700A/03 Multifunction Calibrator
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 9 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5700A/03 Multifunction Calibrator, 5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61% of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 13 µV	Fluke 5700A Option 003 Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(1.1 to 3.3) mV		Fluke 5700A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.58 % of output + 2.3 µV	
	30 Hz to 500 kHz	0.53 % of output + 2.3 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 4.6 µV	
	(1.2 to 2) MHz	0.54 % of output + 4.6 µV	
	(2 to 12) MHz	0.58 % of output + 4.6 µV	
	(12 to 20) MHz	0.65 % of output + 4.6 µV	
	(20 to 30) MHz	1.3 % of output + 4.6 µV	
	(3.3 to 11) mV		
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89 % of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(0.33 to 1.1) V		Fluke 5700A Multifunction Calibrator Option 003
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	
	(1.1 to 3.5) V		
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2 % of reading + 5 µV	
	(1 to 4) MHz	7 % of reading + 7 µV	
	(4 to 8) MHz	20 % of reading + 8 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	100 mV to 1 V		Agilent 3458A Multimeter
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.007 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.007 % of reading + 0.2 mV	
	(1 to 20) kHz	0.014 % of reading + 0.2 mV	
	(20 to 50) kHz	0.03 % of reading + 0.2 mV	
	(50 to 100) kHz	0.08 % of reading + 0.2 mV	
	(100 to 300) kHz	0.3 % of reading + 1 mV	
	300 kHz to 1 MHz	1 % of reading + 1 mV	
	(1 to 2) MHz	1.5 % of reading + 7 mV	
	(2 to 4) MHz	4 % of reading + 7 mV	
	(4 to 8) MHz	4 % of reading + 8 mV	
	(8 to 10) MHz	15 % of reading + 10 mV	
	(10 to 100) V		
	(1 to 40) Hz	0.02 % of reading + 4 mV	
	40 Hz to 1 kHz	0.02 % of reading + 2 mV	
	(1 to 20) kHz	0.02 % of reading + 2 mV	
	(20 to 50) kHz	0.035 % of reading + 2 mV	
	(50 to 100) kHz	0.12 % of reading + 2 mV	
	(100 to 300) kHz	0.4 % of reading + 10 mV	
	300 kHz to 1 MHz	1.5 % of reading + 10 mV	
	(100 to 700) V		
	(1 to 40) Hz	0.04 % of reading + 40 mV	
	40 Hz to 1 kHz	0.04 % of reading + 20 mV	
	(1 to 20) kHz	0.06 % of reading + 20 mV	
	(20 to 50) kHz	0.12 % of reading + 20 mV	
	(50 to 100) kHz	0.3 % of reading + 20 mV	
AC Voltage – Measure [1]	(60) Hz		Ross VD60 High Voltage Divider
	(1 to 10) kV	0.5 % of reading + 0.002 kV	
	(10 to 42) kV	0.5 % of reading + 0.02 kV	

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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 (22 to 220) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz	 228 µA/A + 15 nA 152 µA/A + 10 nA 107 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 107 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 107 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 µA 228 µA/A + 4 µA 152 µA/A + 3 µA 107 µA/A + 2 µA 183 µA/A + 3 µA	Fluke 5700A/03 Multifunction Calibrator
AC Current – Generate [1]	(22 to 220) mA (5 to 10) kHz (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 989 µA/A + 9 µA 243 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5700A/03 Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA /A + 141 µA 723 µA /A + 295 µA 2.8 mA /A + 573 µA	Fluke 5700A/03 Multifunction Calibrator / 5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of reading + 5 mA 0.11 % of reading + 5 mA 2.28 % of reading + 5 mA	Fluke 5522A Multiproduct Calibrator

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1] Clamp Meters	(3.3 to 30) A (10 to 100) Hz (100 to 440) Hz (30 to 200) A 10 to 100 Hz (100 to 440) Hz	 0.22 % of output + 0.028 A 0.30 % of output + 0.07 A 0.22 % of output + 0.032 A 0.79 % of output + 0.08 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
AC Current – Generate [1] Clamp Meters	(16.5 to 150) A (10 to 100) Hz (100 to 440) Hz (150 to 1 000) A (10 to 100) Hz (100 to 440) Hz	 0.22 % of output + 0.029 A 0.30 % of output + 0.08 A 0.22 % of output + 0.081 A 0.79 % of output + 0.20 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (0.1 to 1) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz (3 to 10) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz	 0.84 % of reading + 1.4 mA 0.27 % of reading + 1.4 mA 0.11 % of reading + 1.4 mA 0.27 % of reading + 16 mA 0.84 % of reading + 4.6 mA 0.27 % of reading + 4.6 mA 0.11 % of reading + 4.6 mA 0.27 % of reading + 53 mA	Fluke 8845A Multimeter
AC Current – Measure [1]	(10 to 1 000) A (10 to 100) Hz (100 to 500) Hz	 1.5 % of reading + 1A 1.9 % of reading+ 1A	Fluke 376 Clamp Meter
AC Current – Measure [1]	(100 to 2 500) A (10 to 500) Hz	 2.3 % of reading + 5A	Fluke 376 Clamp Meter W/i2500 flex probe
Resistance – Generate [1]	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω 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	30 μΩ/Ω + 0.001 Ω 23 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.2 Ω 21 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 2 Ω 24 μΩ/Ω + 2 Ω 46 μΩ/Ω + 23 Ω 99 μΩ/Ω + 38 Ω	Fluke 5522A Multiproduct Calibrator
Resistance – Generate [1]	(11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ 330 MΩ to 1.1 GΩ	190 μΩ/Ω + 1.9 KΩ 380 μΩ/Ω + 2.3 KΩ 0.23 % of setting + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multiproduct Calibrator

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 μΩ/Ω + 0.1 μΩ 25 μΩ/Ω + 1 μΩ 15 μΩ/Ω + 6 μΩ 11 μΩ/Ω + 60 μΩ 11 μΩ/Ω + 0.6 mΩ 12 μΩ/Ω + 6 mΩ 12 μΩ/Ω + 6 mΩ 18 μΩ/Ω + 60 mΩ 18 μΩ/Ω + 60 mΩ 35 μΩ/Ω + 0.6Ω 42 μΩ/Ω + 0.6Ω 99 μΩ/Ω + 6Ω	Fluke 5700A Multifunction Calibrator
Resistance – Generate [1] Fixed Points	100 V 100 kΩ (100 to 1 000) V 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ	1 % of output 1 % of output 1 % of output 1 % of output 1 % of output 1 % of output 1.2 % of output	TMI RB Resistance Standard
Resistance – Measure	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2) kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 0.6 mΩ 10 μΩ/Ω + 5.6 mΩ 10 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A Multimeter
Electrical Calibration of Thermocouple Indicating Devices [1]	Type B (600 to 800) °C (800 to 1 000) °C (1 000 to 1 550) °C (1 550 to 1 820) °C	 0.34 °C 0.26 °C 0.23 °C 0.25 °C	Fluke 5522A Multiproduct Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type C		Fluke 5522A Multiproduct Calibrator
	(0 to 150) °C	0.23 °C	
	(150 to 650) °C	0.2 °C	
	(650 to 1 000) °C	0.24 °C	
	(1 000 to 1 800) °C	0.39 °C	
	(1 800 to 2 316) °C	0.64 °C	
	Type E		
	(-250 to -100) °C	0.38 °C	
	(-100 to -25) °C	0.13 °C	
	(-25 to 350) °C	0.11°C	
	(350 to 650) °C	0.13 °C	
	(650 to 1 000) °C	0.16 °C	
	Type J		
	(-210 to -100) °C	0.21 °C	
	(-100 to -30) °C	0.13 °C	
	(-30 to 150) °C	0.11 °C	
	(150 to 760) °C	0.13 °C	
	(760 to 1 200) °C	0.18 °C	
	Type K		
	(-200 to -100) °C	0.25 °C	
	(-100 to -25) °C	0.14 °C	
	(-25 to 120) °C	0.13 °C	
	(120 to 1 000) °C	0.2 °C	
	(1 000 to 1 372) °C	0.31 °C	
	Type L		
	(-200 to -100) °C	0.28 °C	
	(-100 to 800) °C	0.2 °C	
	(800 to 900) °C	0.13 °C	
	Type N		
	(-200 to -100) °C	0.31 °C	
	(-100 to -25) °C	0.17 °C	
	(-25 to 120) °C	0.15 °C	
	(120 to 410) °C	0.14 °C	
	(410 to 1 300) °C	0.21 °C	
	Type R		
	(0 to 250) °C	0.43 °C	
	(250 to 1 000) °C	0.27 °C	
	(1 000 to 1 400) °C	0.25 °C	
	(1 400 to 1 767) °C	0.31 °C	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	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	 0.36 °C 0.28 °C 0.28 °C 0.35 °C 0.48 °C 0.18 °C 0.13 °C 0.11 °C 0.43 °C 0.21 °C	Fluke 5522A Multiproduct Calibrator
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) µF (1.1 to 3.299 99) µF (3.3 to 10.999 9) µF (11 to 32.999 9) µF (33 to 109.999) µF (110 to 329.999) µF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.38 % of output + 7.6pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF 0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 µF 0.34 % of output + 2.3 µF 0.34 % of output + 7.6 µF 0.57 % of output + 22.8 µF 0.84 % of output + 76 µF	Fluke 5522A Multiproduct Calibrator
Oscilloscopes Calibration – Generate [1] Voltage DC - 50Ω DC - 1MΩ	 (1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V (1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	 0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV 0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1]			Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Square Wave			
10Hz to 10kHz - 50Ω	(1 to 24.999) mVpp	0.19 % of Output + 31 µV	
	(25 to 109.99) mVpp	0.19 % of Output + 36 µV	
	(110mV to 2.1999) Vpp	0.19 % of Output + 87 µV	
	(2.2 to 6.6) Vpp	0.19 % of Output + 0.6 mV	
Square Wave			
10 Hz to 1KHz - 1MΩ	(1 to 24.999) mV	0.038 % of reading + 4 µV	
	(25 to 109.99) mV	0.038 % of reading + 9 µV	
	(110mV to 2.1999) V	0.038 % of reading + 60 µV	
	(2.2 to 10.999) V	0.038 % of reading + 0.6 mV	
	(11 to 130) V	0.038 % of reading + 6 mV	
Square Wave			
1 to 10KHz - 1MΩ	(1 to 24.999) mV	0.19 % of reading + 31 µV	
	(25 to 109.99) mV	0.19 % of reading + 36 µV	
	(110mV to 2.1999) V	0.19 % of reading + 87 µV	
	(2.2 to 10.999) V	0.19 % of reading + 0.6 mV	
	(11 to 130) V	0.19 % of reading + 6 mV	
Oscilloscopes Calibration – Generate [1]	3 dB Bandwidth		Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Leveled Sine Flatness	(5 to 50) mVpp		
50 kHz to 10 MHz Reference	50 kHz to 100) MHz	0.34 dB	
	(100 to 300) MHz	0.36 dB	
	(300 to 500) MHz	0.42 dB	
	(500 to 600) MHz	0.46 dB	
	(600 to 16 00) MHz	0.5 dB	
	(1 600 to 2 100) MHz	0.56 dB	
	50 mV to 3.5 Vpp		
	50 kHz to 100 MHz	0.24 dB	
	(100 to 300) MHz	0.24 dB	
	(300 to 500) MHz	0.32 dB	
	(500 to 600) MHz	0.34 dB	
	(600 to 16 00) MHz	0.4 dB	
	(1 600 to 2 100) MHz	0.44 dB	
	(3.5 to 5) Vpp		
	50 kHz to 100 MHz	0.24 dB	
	(100 to 300) MHz	0.24 dB	
	(300 to 500) MHz	0.32 dB	
	(500 to 600) MHz	0.34 dB	
Oscilloscopes Calibration – Generate [1]	3 dB Bandwidth		EPM Power Meter w/ E Series Power Sensors
Leveled Sine Flatness	50 mV to 3.5Vpp		
	(2 100 to 4 000) MHz	0.25 dB	
	(4 000 to 8 000) MHz	0.35 dB	
	(8 000 to 18 000) MHz	0.46 dB	

Electrical – DC/Low Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1] Time Marker	500 ps to 20 ms 50 ms to 5 s	0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Measure [1] Input Impedance Resistance Leakage	 (40 to 60) Ω 500 kΩ to 1.5MΩ (0 to 5.99) V	 0.08 % of reading 0.08 % of reading 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – RF/Microwave Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Flatness – Measure [1]	9 kHz to 2 000MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.34 dB 0.93 dB 0.12 dB 0.15 dB 0.34 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power – Measure [1]	100 kHz to 30 MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.12 dB 0.13 dB 0.15 dB 0.18 dB 0.21 dB 0.28 dB 0.43 dB	Agilent N5531S Measuring Receiver N1912A w/E9304A Power Sensor
RF Power – Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (2 000 to 3 050) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB 0.42 dB 0.3 dB 0.31 dB 0.32 dB 0.34 dB 0.35 dB 0.4 dB 0.51 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(3 050 to 6 600) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.48 dB	
	(-120 to -125) dB	0.64 dB	
	(6 600 to 13 200) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -100) dB	0.34 dB	
	(-100 to -105) dB	0.37 dB	
	(-105 to -110) dB	0.45 dB	
	(-110 to -115) dB	0.6 dB	
	(-115 to -120) dB	0.82 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -90) dB	0.33 dB	
	(-90 to -95) dB	0.35 dB	
	(-95 to -100) dB	0.41 dB	
	(-100 to -105) dB	0.53 dB	
	(-105 to -110) dB	0.72 dB	
	(18 000 to 19 200) MHz		
	(30 to 20) dB	0.48 dB	
	(20 to 0) dB	0.38 dB	
	(0 to -58) dB	0.39 dB	
	(-58 to -78) dB	0.4 dB	
	(-78 to -90) dB	0.41 dB	
	(-90 to -95) dB	0.42 dB	
	(-95 to -100) dB	0.47 dB	
	(-100 to -105) dB	0.58 dB	
	(-105 to -110) dB	0.75 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(19 200 to 26 500) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB	 0.48 dB 0.38 dB 0.39 dB 0.4 dB 0.43 dB 0.50 dB 0.63 dB 0.84 dB 1.1 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
Attenuation – Measure [1]	100 kHz to 3 050 MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (110 to 120) dB (3 050 to 6 600) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (110 to 120) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.13 dB 0.26 dB 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.15 dB 0.37 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Measure [1]	(6 600 to 13 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.14 dB	
	(100 to 110) dB	0.34 dB	
	(110 to 120) dB	0.77 dB	
	(13 200 to 19 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.27 dB	
	(100 to 110) dB	0.66 dB	
	(19 200 to 26 500) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.2 dB	
	(90 to 100) dB	0.5 dB	
	(100 to 110) dB	1.1 dB	

Electrical – RF/Microwave Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40KHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400KHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400KHz (13.2 to 26.5) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400KHz	β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.2 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad	3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad	Agilent N5531S Measuring Receiver
RF Power – Generate	(30 to 2 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB	0.26 dB 0.28 dB 0.29 dB 0.3 dB 0.37 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor, 83630B Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor, 83630B Signal Generator
	(20 to 0) dB	0.37 dB	
	(0 to -58) dB	0.38 dB	
	(-58 to -78) dB	0.38 dB	
	(-78 to -110) dB	0.4 dB	
	(-110 to -120) dB	0.52 dB	
	(3 050 to 6 600) MHz		
	(20 to 0) dB	0.37 dB	
	(0 to -58) dB	0.38 dB	
	(-58 to -78) dB	0.38 dB	
	(-78 to -110) dB	0.4 dB	
	(-110 to -120) dB	0.52 dB	
	(6 600 to 13 200) MHz		
	(20 to 0) dB	0.37 dB	
	(0 to -58) dB	0.38 dB	
	(-58 to -78) dB	0.38 dB	
	(-78 to -110) dB	0.49 dB	
	(-110 to -120) dB	0.84 dB	
	(13 200 to 18 000) MHz		
	(20 to 0) dB	0.37 dB	
	(0 to -58) dB	0.38 dB	
	(-58 to -78) dB	0.38 dB	
	(-78 to -110) dB	0.75 dB	
	(-110 to -120) dB	1.3 dB	
	(18 000 to 19 200) MHz		
	(20 to 0) dB	0.49 dB	
	(0 to -58) dB	0.5 dB	
	(-58 to -78) dB	0.5 dB	
	(-78 to -110) dB	0.81 dB	
	(-110 to -120) dB	1.4 dB	
	(19 200 to 26 500) MHz		
	(20 to 0) dB	0.49 dB	
	(0 to -58) dB	0.5 dB	
	(-58 to -78) dB	0.5 dB	
	(-78 to -110) dB	1.2 dB	
	(-110 to -120) dB	1.9 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Harmonic Distortion (THD)	(0 to 60) dB 20 Hz to 20 kHz (-40 to 0) dB (-50 to -40) dB (-60 to -50) dB (-65 to -60) dB 20 to 50 kHz (-40 to 0) dB (-50 to -40) dB (-60 to -50) dB 50 to 100 kHz (-40 to 0) dB (-50 to -40) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 26.5) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver
PM Distortion Measure [1]	(1 to 6 600) MHz Rate (20 to 500) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 0.4 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 1.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(6.6 to 13.2) GHz Rate (20 to 500) Hz Dev > 1.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 5.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 26.5) GHz Rate (20 to 500) Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(13.2 to 26.5) GHz Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 1.2 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1 kHz to 600 MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB	Agilent E4440A Measuring Receiver
Harmonics Measure [1]	(-80 to -10) dB 2nd through 4th Harmonic (5 300 to 6 625) MHz 2nd through 3rd Harmonic (6 625 to 8 833) MHz 2nd Harmonic (8 833 to 13 250) MHz	 2.1 dB 2.1 dB 2.1 dB	Agilent E4440A Measuring Receiver

Length – Dimensional metrology Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	Up to 12 in	(3.7 + 2.4*L*) µin	Master gage blocks, P&W Universal Measuring Machine
Micrometers [1,2]	Up to 18 in	(26 + 4.7*L*) µin	Gage blocks

Length – Dimensional metrology Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Laser Micrometer [1]	(0.5 to 1.5) in	88 µin	Pin Gages
Calipers [1,2]	Up to 40 in	(281 + 1.9*L*) µin	Gage blocks
Dial Indicators [1,2] Resolution: ≥ 50µin < 50µin	Up to 10 in Up to 0.1 in	(25 + 4*L*) µin 10 µin	Gage blocks
Height Gages [1,2]	Up to 40 in	(94 + 3.1*L*) µin	Gage blocks
Cylindrical Gages [2] – Rings Plain Pins, Plugs	(0.02 to 8) in (0 to 8) in	(10 + 2.7*D*) µin (10 + 3*D*) µin	Master gage blocks, P&W Universal Measuring Machine
Thread Plugs [1] – Major Diameter Pitch Diameter	Up to 10 in Up to 10 in	43 µin 94 µin	Fisher Machine Shop Model 1962 thread wire set, Gage blocks, Pratt & Whitney Model C
Surface Plates [1] Overall Flatness Local Area Flatness	(18 x 18) in to (10 x 10) ft (-0.001 to 0.001) in	66 µin 68 µin	Mahr Leveling System Repeat-O-Meter
Protractors [1]	(0 to 360)º	0.015º	Angle blocks
Linear Scales – Rulers [1]	Up to 36 in	0.009 1 in	Gage blocks
Pi Tapes [1]	Up to 3 in	450 µin	Plug Gages
Tape Measures [1]	Up to 150 ft	(0.000 28*F* + 0.024) in	Standard rule
Microscopes [1]	Up to 2 in	100 µin	Stage Micrometer

Mass and Mass Related Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,4]	1 mg to 220 g	(0.048 + 0.003 1*X*) mg	ASTM E617 Class 1 weights
	Up to 1 000 lb Up to 454 kg	(0.000 12*W*) lb (0.000 12*X*) g	NIST Class F weights

Mass and Mass Related Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure [1]	(-1 to 1) inH_2O -15 to 100 psig Up to 500 psig Up to 1 000 psig Up to 10 000 psig	0.004 inH_2O 0.027 psi 0.12 psi 0.26 psi 2.5 psi	Pressure Gauge/Module Additel ADT155-DPI-760, ADT681-02-GP100-PSI, ADT681-02-GP500-PSI ADT681-02-GP1K-PSI, ADT681-02-GP10K-PSI
Torque Tools [1]	(10 to 100) ozf·in 4 lbf·in to 250 lbf·ft	0.6 % of reading 0.32 % of reading	CDI 1001-O-DDT CDI 5000 ST Torque Tester
Force [1,2] Tension and Compression	(0.5 to 500) lbf 220 gf to 23 kgf	(0.000 06 + 0.000 12*W*) lbf^2 (0.03 + 0.000 12*M*) $grams^2$	Class F weights

Thermodynamic Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber
Relative Humidity Measure	(0 to 90) %RH	1.6 %RH	Vaisala M170/HMP75 Humidity Indicator and Probe
Temperature – Measure [1]	(-196 to 0.01) °C (0.01 to 660) °C	0.004 3 °C (0.004 3 +0.000 001*T*) °C	Fluke 5699 SPRT & Fluke 1594A Super-Thermometer
Temperature – Source	(-196 to 300) °C (>300 to 500) °C	0.014 °C 0.02 °C	Fluke 5699 SPRT, Fluke 1594A Super-Thermometer & Temperature Baths
Temperature – Source Fix Point	0.01 °C	0.002 6 °C	Triple Point of Water

Time and Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate	10 MHz	1 x 1^{e-9} Hz/Hz	HP Z3801A GPS Receiver

Time and Frequency Windsor, CT

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-9} Hz/Hz + 0.57 µHz 1 x 1^{e-9} Hz/Hz + 5.7 µHz 1 x 1^{e-9} Hz/Hz + 57 µHz 1 x 1^{e-9} Hz/Hz + 0.57 mHz 1 x 1^{e-9} Hz/Hz + 5.7 mHz 1 x 1^{e-9} Hz/Hz + 57 mHz 1 x 1^{e-9} Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP Z3801A GPS Receiver
Frequency – Generate	(10 to 26 500) MHz	1 x 1^{e-9} Hz/Hz + 0.57 kHz	HP 83630B Signal Generator / HP Z3801A GPS Receiver
Frequency – Measure [1]	1 to 10 Hz 10 to 100 Hz 100 to 1000 Hz 1 to 10 kHz 10 to 100 kHz 100 to 200 kHz 0.2 to 3 000 MHz	5.20 x 1^{e-9} Hz/Hz 2.46 x 1^{e-9} Hz/Hz 1.60 x 1^{e-9} Hz/Hz 1.33 x 1^{e-9} Hz/Hz 1.24 x 1^{e-9} Hz/Hz 1.21 x 1^{e-9} Hz/Hz 1.21 x 1^{e-9} Hz/Hz	Agilent 53131A Frequency Counter / HP Z3801A GPS Receiver
	10 to 26 500 MHz	1 x 1^{e-9} Hz/Hz + 0.1 Hz	Agilent E4440A Spectrum Analyzer / HP Z3801A GPS Receiver
Timer, Stopwatch [1]	10 s to 24 hr	34 ms	Totalize method with counter
Tachometers – RPM [1]	Up to 100 000 RPM	± (0.001% + 0.6*R*)	HP 33250A Signal Generator & LED

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Services performed at satellite laboratory

Technical Maintenance, Inc.
4613 Northwest Parkway
Hilliard, OH 43026
Matthew Ayres (Branch Manager) Phone: 614-850-9940
Scott Chamberlain (Quality Manager) Phone: 321-242-0890

CALIBRATION AND DIMENSIONAL MEASUREMENT CALIBRATION

Acoustics and Vibration Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration	(0.01 to 10) g (7 < 10) Hz (10 < 30) Hz (30 < 2 000) Hz (2 to 10) kHz	4 % of reading 3 % of reading 1.5 % of reading 4 % of reading	Accelerometer Calibrator

Chemical Quantities Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,5]	(4, 7, 10) pH	0.029 pH	Standard pH buffers
Conductivity Meters [1,5]	1 µS/cm 10 µS/cm 100 µS/cm 1 000 µS/cm 10 000 µS/cm	0.5 µS/cm 0.41 µS/cm 2.7 µS/cm 15 µS/cm 140 µS/cm	Standard conductivity solutions

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate [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	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5720A Multifunction Calibrator
DC Voltage – Generate [1]	(1 to 6) kV	2.4 % of output + 10 V	Associated Research 3565D Hypot
DC Voltage – Measure [1]	(0 to 100) mV 100 mV to 1V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6 µV/V + 100 µV + 12 µV/V x (Vin/1 000) ^2	HP 3458A Multimeter
DC Voltage – Measure [1]	(1 to 60) kV	0.1 % of reading	Ross VD60 High Voltage Divider, HP 34401A Multimeter
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 20 µA/A + 1 nA	Fluke 5720A Multifunction Calibrator & Fluke 5522A Multifunction Calibrator
DC Current – Generate [1]	(10 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5720A Multifunction Calibrator
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5720A Multifunction Calibrator, 5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A	761 µA/A + 578 µA	Fluke 5522A Multiproduct Calibrator
DC Current – Generate [1] Clamp Meters	(0 to 200) A	0.21% of output + 0.028A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
DC Current – Generate [1] Clamp Meters	(0 to 1000) A	0.21% of output + 0.040A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
High Voltage -Generate DC Voltage	(1 to 6) kV	2.4 % of reading + 10 V	Associated Research 3565D High Voltage Tester
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	34 µA/A + 0.12 pA 18 µA/A + 1.2 pA 11 µA/A + 0.01 nA 9.1 µA/A + 0.12 nA	Fluke 5720A Multifunction Calibrator, Agilent 3458A Multimeter Option 002
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10.1 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 1 000) A	0.26 % of reading	Current shunt
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2 kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 µΩ/Ω + 56 µΩ 12 µΩ/Ω + 0.5 mΩ 10 µΩ/Ω + 0.6 mΩ 10 µΩ/Ω + 5.6 mΩ 10 µΩ/Ω + 56 mΩ 15 µΩ/Ω + 2.2 Ω 50 µΩ/Ω + 120 Ω 500 µΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A Multimeter
Resistance [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ (100, 190) kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 µΩ/Ω + 0.1 µΩ 21 µΩ/Ω + 1 µΩ 9.1 µΩ/Ω + 6 µΩ 7.6 µΩ/Ω + 60 µΩ 7.6 µΩ/Ω + 0.6 mΩ 9.9 µΩ/Ω + 6 mΩ 18 µΩ/Ω + 60 mΩ 18 µΩ/Ω + 60 mΩ 35 µΩ/Ω + 0.6 Ω 42 µΩ/Ω + 0.6 Ω 91 µΩ/Ω + 6 Ω	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1]	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 kΩ 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 330 MΩ to 1.1 GΩ	30 μΩ/Ω + 0.001 Ω 23 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.2 Ω 21 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 2 Ω 24 μΩ/Ω + 2 Ω 46 μΩ/Ω + 23 Ω 99 μΩ/Ω + 38 Ω 190 μΩ/Ω + 1.9 k Ω 380 μΩ/Ω + 2.3 k Ω 0.23 % of setting + 76 k Ω 1.1 % of reading + 380 k Ω	Fluke 5522A Multiproduct Calibrator
Resistance – Generate [1] Fixed Points	100 V 100 kΩ (100 to 1 000) V 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ	1 % of output 1 % of output 1 % of output 1 % of output 1 % of output 1 % of output 1.2 % of output	TMI RB Resistance Standard
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2 kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10.0 μΩ/Ω + 0.6 mΩ 10.0 μΩ/Ω + 5.6 mΩ 10.0 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate [1]	(220 to 400) pF	0.38 % of output + 7.6 pF	Fluke 5522A Multiproduct Calibrator
	(0.4 to 3.299 9) nF	0.38 % of output + 0.01 nF	
	(3.3 to 10.999 9) nF	0.19 % of output + 0.01 nF	
	(11 to 32.999 9) nF	0.19 % of output + 0.08 nF	
	(33 to 109.999) nF	0.19 % of output + 0.08 nF	
	(110 to 329.999) nF	0.19 % of output + 0.23 nF	
	(0.33 to 1.099 99) µF	0.19 % of output + 0.76 nF	
	(1.1 to 3.299 99) µF	0.19 % of output + 2.3 nF	
	(3.3 to 10.999 9) µF	0.19 % of output + 7.6 nF	
	(11 to 32.999 9) µF	0.3 % of output + 23 nF	
	(33 to 109.999) µF	0.34 % of output + 76 nF	
	(110 to 329.999) µF	0.34 % of output + 228 nF	
	(0.33 to 1.099 99) mF	0.34 % of output + 0.76 µF	
	(1.1 to 3.299 99) mF	0.34 % of output + 2.3 µF	
	(3.3 to 10.999 9) mF	0.34 % of output + 7.6 µF	
	(11 to 32.999 9) mF	0.57 % of output + 23 µF	
	(33 to 110) mF	0.84 % of output + 76 µF	
AC Voltage – Generate [1]	(0.22 to 2.2) mV		Fluke 5720A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	
	(2.2 to 22) mV		
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(22 to 220) mV		Fluke 5720A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 11.4 µV	
	(20 to 40) Hz	88 µV/V + 6.1 µV	
	40 Hz to 20 kHz	76 µV/V + 6.1 µV	
	(20 to 50) kHz	190 µV/V + 6.1 µV	
	(50 to 100) kHz	457 µV/V + 15.2 µV	
	(100 to 300) kHz	837 µV/V + 19 µV	
	(300 to 500) kHz	1.3 mV/V + 23 µV	
	500 kHz to 1 MHz	2.5 mV/V + 46 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	228 µV/V + 38 µV	
	(20 to 40) Hz	84 µV/V + 15 µV	
	40 Hz to 20 kHz	40 µV/V + 8 µV	
	(20 to 50) kHz	68 µV/V + 9 µV	
	(50 to 100) kHz	99 µV/V + 30 µV	
	(100 to 300) kHz	380 µV/V + 76 µV	
	(300 to 500) kHz	913 µV/V + 190 µV	
	500 kHz to 1 MHz	1.5 mV/V + 304 µV	
	(2.2 to 22) V		
	(10 to 20) Hz	228 µV/V + 380 µV	
	(20 to 40) Hz	84 µV/V + 152 µV	
	40 Hz to 20 kHz	37 µV/V + 54 µV	
	(20 to 50) kHz	61 µV/V + 91 µV	
	(50 to 100) kHz	76 µV/V + 190 µV	
	(100 to 300) kHz	228 µV/V + 609 µV	
	(300 to 500) kHz	913 µV/V + 1.9 mV	
	500 kHz to 1 MHz	1.4 mV/V + 3 mV	
	(22 to 220) V		
	(10 to 20) Hz	228 µV/V + 3.8 mV	
	(20 to 40) Hz	84 µV/V + 1.5 mV	
	40 Hz to 20 kHz	49 µV/V + 0.6 mV	
	(20 to 50) kHz	76 µV/V + 0.9 mV	
	(50 to 100) kHz	137 µV/V + 2.3 mV	
AC Voltage – Generate [1]	(220 to 750) V		Fluke 5720A Multifunction Calibrator / Fluke 5725A Amplifier
	40 Hz to 1 kHz	68 µV/V + 3 mV	
	(1 to 20) kHz	126 µV/V + 5 mV	
	(20 to 50) kHz	457 µV/V + 8 mV	
	(50 to 100) kHz	1.8 mV/V + 34 mV	
	(750 to 1 000) V		
	40 Hz to 1 kHz	68 µV/V + 3 mV	
	(1 to 20) kHz	126 µV/V + 5 mV	
	(20 to 30) kHz	457 µV/V + 8 mV	

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV		Fluke 5720A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.65 % of output + 1.5 µV	
	30 Hz to 500 kHz	0.61 % of output + 1.5 µV	
	(0.5 to 1.2) MHz	0.63 % of output + 3.8 µV	
	(1.2 to 2) MHz	0.63 % of output + 3.8 µV	
	(2 to 12) MHz	0.68 % of output + 3.8 µV	
	(12 to 20) MHz	0.76 % of output + 3.8 µV	
	(20 to 30) MHz	1.3 % of output + 12.9 µV	
	(1.1 to 3.3) mV		
	(10 to 30 Hz)	0.58 % of output + 2.3 µV	
	30 Hz to 500 kHz	0.53 % of output + 2.3 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 4.6 µV	
	(1.2 to 2) MHz	0.54 % of output + 4.6 µV	
	(2 to 12) MHz	0.58 % of output + 4.6 µV	
	(12 to 20) MHz	0.65 % of output + 4.6 µV	
	(20 to 30) MHz	1.3 % of output + 4.6 µV	
	(3.3 to 11) mV		
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89% of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(110 to 330) mV		Fluke 5720A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	0.33 to 1.1 V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	
	(1.1 to 3.5) V		
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(0 to 10) mV		HP 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2 % of reading + 5 µV	
	(1 to 4) MHz	7 % of reading + 7 µV	
	(4 to 8) MHz	20 % of reading + 8 µV	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) mV		HP 3458A Multimeter
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	100 mV to 1 V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.007 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.007 % of reading + 0.2 mV	
	(1 to 20) kHz	0.014 % of reading + 0.2 mV	
	(20 to 50) kHz	0.03 % of reading + 0.2 mV	
	(50 to 100) kHz	0.08 % of reading + 0.2 mV	
	(100 to 300) kHz	0.3 % of reading + 1 mV	
	300 kHz to 1 MHz	1 % of reading + 1 mV	
	(1 to 2) MHz	1.5 % of reading + 7 mV	
	(2 to 4) MHz	4 % of reading + 7 mV	
	(4 to 8) MHz	4 % of reading + 8 mV	
	(8 to 10) MHz	15 % of reading + 10 mV	

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.02 % of reading + 4 mV 0.02 % of reading + 2 mV 0.02 % of reading + 2 mV 0.035 % of reading + 2 mV 0.12 % of reading + 2 mV 0.4 % of reading + 10 mV 1.5 % of reading + 10 mV 0.04 % of reading + 40 mV 0.04 % of reading + 20 mV 0.06 % of reading + 20 mV 0.12 % of reading + 20 mV 0.3 % of reading + 20 mV	HP 3458A Multimeter
AC Voltage – Measure [1]	(1 to 10) kV (60) Hz (10 to 42) kV (60) Hz	 0.5 % of reading + 0.002 kV 0.5 % of reading + 0.02 kV	Ross VD60 High Voltage Divider, HP 34401A Multimeter
AC Current – Generate [1]	(9 to 200) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 107 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 107 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 µA	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(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 (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 4 µA 152 µA/A + 3 µA 107 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 243 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5720A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA/A + 141 µA 723 µA/A + 295 µA 2.7 mA/A + 573 µA	Fluke 5720A Multifunction Calibrator / Fluke 5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 Hz to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.3 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current – Generate [1] Clamp Meters	(3.3 to 30) A (10 to 100) Hz (100 to 440) Hz (30 to 200) A 10 to 100 Hz (100 to 440) Hz	 0.22 % of output + 0.028 A 0.3 % of output + 0.07 A 0.22 % of output + 0.032 A 0.79 % of output + 0.08 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
AC Current – Generate [1] Clamp Meters	(16.5 to 150) A (10 to 100) Hz (100 to 440) Hz (150 to 1 000) A (10 to 100) Hz (100 to 440) Hz	 0.22 % of output + 0.029 A 0.3 % of output + 0.08 A 0.22 % of output + 0.081 A 0.79 % of output + 0.20 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (0.1 to 1 A) (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A Multimeter
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz (3 to 10) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz	 0.84 % of reading + 1.4 mA 0.27 % of reading + 1.4 mA 0.11 % of reading + 1.4 mA 0.27 % of reading + 16 mA 0.84 % of reading + 4.6 mA 0.27 % of reading + 4.6 mA 0.11 % of reading + 4.6 mA 0.27 % of reading + 53 mA	Fluke 8845A Multimeter
AC Current – Measure [1]	(10 to 30) A 40 Hz to 1 kHz (1 to 5) kHz	 0.3 % of reading + 0.07 A 5 % of reading + 0.14 A	Agilent 3458A Multimeter, Keysight, 34330A Current Shunt
Low Frequency Power – Generate [1]	Up to 20 kW (45 to 65) Hz, 0 PF DC	 0.44 % of reading 0.13 % of reading	Fluke 5522A Multiproduct Calibrator
Electrical Calibration of Thermocouple Indicators [1]	Type B (600 to 800) °C (800 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 000) °C (2 000 to 2 316) °C	 0.27 °C 0.22 °C 0.17 °C 0.13 °C 0.18 °C 0.2 °C 0.27 °C	Fluke 7526A Process Calibrator

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type E		Fluke 7526A Process Calibrator
	(-250 to -200) °C	0.19 °C	
	(-200 to -100) °C	0.1 °C	
	(-100 to 0) °C	0.07 °C	
	(0 to 600) °C	0.07 °C	
	(600 to 1 000) °C	0.08 °C	
	Type J		
	(-210 to -100) °C	0.11 °C	
	(-100 to 800) °C	0.07 °C	
	(800 to 1 200) °C	0.08 °C	
	Type K		
	(-250 to -200) °C	0.35 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 800) °C	0.08 °C	
	(800 to 1 372) °C	0.1 °C	
	Type L		
	(-200 to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	
	Type R		
	(-50 to -25) °C	0.42 °C	
	(-25 to 0) °C	0.34 °C	
	(0 to 100) °C	0.3 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.17 °C	
	(600 to 1 000) °C	0.16 °C	
	(1 000 to 1 600) °C	0.15 °C	
	(1 600 to 1 767) °C	0.18 °C	
	Type S		
	(50 to -25) °C	0.39 °C	
	(-25 to 0) °C	0.33 °C	
	(0 to 100) °C	0.29 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.18 °C	
	(600 to 1 600) °C	0.17 °C	
	(1 600 to 1 767) °C	0.2 °C	

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type T (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.26 °C 0.13 °C 0.09 °C 0.07 °C 0.13 °C 0.08 °C	Fluke 7526A Process Calibrator
Electrical Calibration of RTD Indicating Devices [1]	Pt 385, 100 Ω (-200 to 800) °C Pt 3926, 100 Ω (-200 to 630) °C Pt 3916, 100 Ω (-200 to 630) °C Pt 385, 200 Ω (-200 to 400) °C (400 to 630) °C Pt 385, 500 Ω (-200 to 630) °C Pt 385, 1 000 Ω (-200 to 630) °C	 0.05 °C 0.05 °C 0.05 °C 0.4 °C 0.5 °C 0.17 °C 0.09 °C	Fluke 7526A Process Calibrator
Oscilloscopes Calibration[1] – Generate Voltage DC - 50Ω DC - 1MΩ Square Wave 10 Hz to 10 kHz - 50Ω	 (1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V (1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V (1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.1999) Vpp (2.2 to 6.6) Vpp	 0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV 0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6 mV 0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration[1] – Generate Square Wave 10 Hz to 1 kHz – 1 MΩ Square Wave (1 to 10) kHz – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV 110 mV to 2.199 9 V (2.2 to 10.999) V (11 to 130) V (1 to 24.999) mV (25 to 109.99) mV 110mV to 2.199 9 V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6 mV 0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth (5 to 50) mVpp 50 kHz to 100) MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 16 00) MHz (1 600 to 2 100) MHz	 0.34 dB 0.36 dB 0.42 dB 0.46 dB 0.5 dB 0.56 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth 50 mV to 3.5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 16 00) MHz (1 600 to 2 100) MHz (3.5 to 5) Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz	 0.24 dB 0.24 dB 0.32 dB 0.34 dB 0.4 dB 0.44 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness	3 dB Bandwidth 50 mV to 3.5Vpp (2 100 to 4 000) MHz (4 000 to 8 000) MHz (8 000 to 18 000) MHz	 0.25 dB 0.35 dB 0.46 dB	EPM Power Meter w/ E Series Power Sensors
Oscilloscopes Calibration – Generate [1] Time Marker	500 ps to 20 ms 50 ms to 5 s	0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Measure [1] Input Impedance Resistance Capacitance Leakage	 (40 to 60) Ω 500 kΩ to 1.5MΩ (5 to 50) pF (0 to 5.99) V	 0.08 % of reading 0.08 % of reading 3.8 % of reading + 0.4pF 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Fundamental AC Voltage – Generate [1]	(15 to 17) V (45 to 65) Hz (0 to 23) V (45 to 65) Hz (16 to 850) Hz (28 to 32) V (45 to 65) Hz (23 to 45) V (45 to 65) Hz (16 to 850) Hz (56 to 64) V (45 to 65) Hz (45 to 90) V (45 to 65) Hz (16 to 850) Hz (110 to 128) V (45 to 65) Hz (90 to 180) V (45 to 65) Hz (16 to 850) Hz (215 to 246) V (45 to 65) Hz (180 to 360) V (45 to 65) Hz (16 to 850) Hz (425 to 490) V (45 to 65) Hz (360 to 650) V (45 to 65) Hz (16 to 850) Hz	 42 µV/V 42 µV/V + 0.2 mV 60 µV/V + 0.2 mV 42 µV/V 42 µV/V + 0.4 mV 60 µV/V + 0.4 mV 42 µV/V 42 µV/V + 0.8 mV 60 µV/V + 0.8 mV 44 µV/V 44 µV/V + 1.6 mV 60 µV/V + 1.6 mV 44 µV/V 60 µV/V + 3.2 mV 61 µV/V + 3.2 mV 44 µV/V 60 µV/V + 5.8 mV 61 µV/V + 5.8 mV	Fluke 6105A Power Quality Calibrator
Fundamental AC Voltage – Generate [1]	(740 to 850) V (45 to 65) Hz (650 to 1 008) V (45 to 65) Hz (16 to 850) Hz	 44 µV/V 60 µV/V + 10 mV 61 µV/V + 10 mV	Fluke 6105A Power Quality Calibrator

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Additive DC Offset Voltage – Generate [1] Additive signal to the Fundamental AC Voltage, up to 50% of range	(0 to 11.5) V (0 to 22.5) V (0 to 45) V (0 to 90) V (0 to 180) V (0 to 325) V (0 to 504) V	91 µV/V + 2 mV 91 µV/V + 4 mV 91 µV/V + 8 mV 91 µV/V + 16 mV 91 µV/V + 32 mV 92 µV/V + 60 mV 92 µV/V + 100 mV	Fluke 6105A Power Quality Calibrator
Additive AC Voltage Harmonics – Generate [1] Additive signal to the Fundamental AC Voltage, up to 30% of range	(0 to 6.9) V (16 to 850) Hz (850 to 6000) Hz (0 to 13.5) V (16 to 850) Hz (850 to 6 000) Hz	 58 µV/V + 1 mV 451 µV/V + 1 mV 58 µV/V + 2 mV 451 µV/V + 2 mV	Fluke 6105A Power Quality Calibrator
Additive AC Voltage Harmonics – Generate [1] Additive signal to the Fundamental AC Voltage, up to 30% of range	(0 to 27) V (16 to 850) Hz (850 to 6 000) Hz (0 to 54) V (16 to 850) Hz (850 to 6 000) Hz (0 to 108) V (16 to 850) Hz (850 to 6 000) Hz (0 to 195) V (16 to 850) Hz (850 to 6 000) Hz (0 to 302) V (16 to 850) Hz (850 to 6 000) Hz	 60 µV/V + 2.2 mV 451 µV/V + 2.2 mV 60 µV/V + 4.4 mV 451 µV/V + 4.4 mV 60 µV/V + 12 mV 451 µV/V + 12 mV 61 µV/V + 22 mV 451 µV/V + 22 mV 61 µV/V + 33 mV 451 µV/V + 33 mV	Fluke 6105A Power Quality Calibrator
Fundamental AC Current – Generate [1]	Up to 0.25 A (45 to 65) Hz (16 to 850) Hz (0.25 to 0.5) A (45 to 65) Hz (16 to 850) Hz	 46 µA/A + 2.5 µA 60 µA/A + 5 µA 46 µA/A + 5 µA 61 µA/A + 10 µA	Fluke 6105A Power Quality Calibrator

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Fundamental AC Current – Generate [1]	(0. 5 to 1) A (45 to 65) Hz (16 to 850) Hz (1 to 2) A (45 to 65) Hz (16 to 850) Hz (2 to 5) A (45 to 65) Hz (16 to 850) Hz (5 to 10) A (45 to 65) Hz (16 to 850) Hz (10 to 21) A (45 to 65) Hz (16 to 850) Hz (21 to 50) A (45 to 65) Hz (40 to 850) Hz (50 to 80) A (40 to 450) Hz (450 to 850) Hz	 47 µA/A + 10 µA 61 µA/A + 20 µA 46 µA/A + 20 µA 61 µA/A + 40 µA 49 µA/A + 50 µA 64 µA/A + 100 µA 49 µA/A + 100 µA 65 µA/A + 200 µA 49 µA/A + 200 µA 69 µA/A + 400 µA 49 µA/A + 500 µA 74 µA/A + 1 mA 106 µA/A + 2.8 mA 118 µA/A + 2.8 mA	Fluke 6105A Power Quality Calibrator
Additive DC Offset Current – Generate [1] Additive signal to the Fundamental AC Current, up to 50% of range	(0 to 0.125) A (0 to 0.25) A (0 to 0.5) A (0 to 1) A (0 to 2.5) A (0 to 5) A (0 to 10) A	89 µA/A + 25 µA 89 µA/A + 50 µA 89 µA/A + 100 µA 89 µA/A + 200 µA 89 µA/A + 500 µA 89 µA/A + 1 mA 90 µA/A + 2 mA	Fluke 6105A Power Quality Calibrator
Additive AC Current Harmonics – Generate [1] Additive signal to the Fundamental AC Current, up to 30% of range	Up to 0.075 A (16 to 850) Hz (850 to 6 000) Hz Up to 0.15 A (16 to 850) Hz (850 to 6 000) Hz Up to 0.3 A (16 to 850) Hz (850 to 6 000) Hz Up to 0.6 A (16 to 850) Hz (850 to 6 000) Hz	 61 µA/A + 5 µA 400 µA/A + 5 µA 61 µA/A + 10 µA 400 µA/A + 10 µA 61 µA/A + 20 µA 400 µA/A + 20 µA 61 µA/A + 40 µA 400 µA/A + 40 µA	Fluke 6105A Power Quality Calibrator

Electrical – DC/Low Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Additive AC Current Harmonics – Generate [1] Additive signal to the Fundamental AC Current, up to 30% of range	Up to 1.5 A (16 to 850) Hz (850 to 6 000) Hz Up to 3 A (16 to 850) Hz (850 to 6 000) Hz Up to 6 A (16 to 850) Hz (850 to 6 000) Hz Up to 15 A (16 to 850) Hz (850 to 3000) Hz Up to 24 A (16 to 850) Hz (850 to 3 000) Hz	 61 µA/A + 100 µA 400 µA/A + 100 µA 64 µA/A + 200 µA 400 µA/A + 200 µA 65 µA/A + 400 µA 400 µA/A + 400 µA 69 µA/A + 1 mA 400 µA/A + 1 mA 112 µA/A + 2 mA 400 µA/A + 2 mA	Fluke 6105A Power Quality Calibrator
Current to Voltage Phase Offsets (regardless of voltage range)	(-180 to +180)° or (0 to 360)° Up to 50 A (45 to 65) Hz (16 to 69) Hz (69 to 180) Hz (180 to 450) Hz (450 to 850) Hz (850 to 3 000) Hz (3 000 to 6 000) kHz Up to 80 A (45 to 65) Hz (16 to 69) Hz (69 to 180) Hz (180 to 450) Hz (450 to 850) Hz (850 to 3 000) Hz	 0.002 3° 0.003° 0.007° 0.018° 0.033° 0.12° 0.23° 0.003° 0.003° 0.008° 0.025° 0.05° 0.25°	Fluke 6105A Power Quality Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(30 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.13 dB	
	(110 to 120) dB	0.26 dB	
	(3 050 to 6 600) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.15 dB	
	(110 to 120) dB	0.37 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.14 dB	
	(100 to 110) dB	0.34 dB	
	(110 to 120) dB	0.77 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(13 200 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.27 dB	
	(100 to 110) dB	0.66 dB	
	(19 200 to 26 500) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(19 200 to 26 500) MHz		
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.2 dB	
	(90 to 100) dB	0.5 dB	
	(100 to 110) dB	1.1 dB	
RF Flatness – Measure [1]	9 kHz to 2 000 MHz		Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
	(20 to -10) dBm	0.1 dB	
	(-10 to -30) dBm	0.1 dB	
	(-30 to -40) dBm	0.11 dB	
	(-40 to -42) dBm	0.12 dB	
	(2 to 14) GHz		
	(20 to -10) dBm	0.1 dB	
	(-10 to -30) dBm	0.09 dB	
	(-30 to -40) dBm	0.1 dB	
	(-40 to -42) dBm	0.11 dB	
	(14 to 18) GHz		
	(20 to -10) dBm	0.11 dB	
	(-10 to -30) dBm	0.12 dB	
	(-30 to -40) dBm	0.12 dB	
	(-40 to -42) dBm	0.13 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	100 kHz to 30 MHz		Agilent N5531S Measuring Receiver N1912A w/E9304A Power Sensor
	(20 to 0) dB	0.12 dB	
	(0 to -58) dB	0.13 dB	
	(-58 to -78) dB	0.15 dB	
	(-78 to -110) dB	0.18 dB	
	(-110 to -115) dB	0.21 dB	
	(-115 to -120) dB	0.28 dB	
	(-120 to -125) dB	0.43 dB	
	(30 to 2 000) MHz		
	(30 to 20) dB	0.36 dB	
	(20 to 0) dB	0.2 dB	
	(0 to -58) dB	0.22 dB	
	(-58 to -78) dB	0.23 dB	
	(-78 to -110) dB	0.25 dB	
	(-110 to -115) dB	0.27 dB	
	(-115 to -120) dB	0.33 dB	
	(-120 to -125) dB	0.46 dB	
	(2 000 to 3 050) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.35 dB	
	(-115 to -120) dB	0.4 dB	
	(-120 to -125) dB	0.51 dB	
	(3 050 to 6 600) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.48 dB	
	(-120 to -125) dB	0.64 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(6 600 to 13 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -100) dB	0.34 dB	
	(-100 to -105) dB	0.37 dB	
	(-105 to -110) dB	0.45 dB	
	(-110 to -115) dB	0.60 dB	
	(-115 to -120) dB	0.82 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -90) dB	0.33 dB	
	(-90 to -95) dB	0.35 dB	
	(-95 to -100) dB	0.41 dB	
	(-100 to -105) dB	0.53 dB	
	(-105 to -110) dB	0.72 dB	
	(18 000 to 19 200) MHz		
	(30 to 20) dB	0.48 dB	
	(20 to 0) dB	0.38 dB	
	(0 to -58) dB	0.39 dB	
	(-58 to -78) dB	0.4 dB	
	(-78 to -90) dB	0.41 dB	
	(-90 to -95) dB	0.42 dB	
	(-95 to -100) dB	0.47 dB	
	(-100 to -105) dB	0.58 dB	
	(-105 to -110) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.48 dB	
	(20 to 0) dB	0.38 dB	
	(0 to -58) dB	0.39 dB	
	(-58 to -78) dB	0.4 dB	
	(-78 to -90) dB	0.43 dB	
	(-90 to -95) dB	0.50 dB	
	(-95 to -100) dB	0.63 dB	
	(-100 to -105) dB	0.84 dB	
	(-105 to -110) dB	1.1 dB	

Electrical – RF/Microwave Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 0.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 26.5) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.20 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad	3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad	Agilent N5531S Measuring Receiver
RF Power – Generate [1]	(30 to 2 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB	0.26 dB 0.28 dB 0.29 dB 0.3 dB 0.37 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor, 83630B Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(2 000 to 3 050) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB (3 050 to 6 600) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB (6 600 to 13 200) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (13 200 to 18 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (18 000 to 19 200) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (19 200 to 26 500) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB	 0.37 dB 0.38 dB 0.38 dB 0.4 dB 0.52 dB 0.37 dB 0.38 dB 0.38 dB 0.4 dB 0.52 dB 0.37 dB 0.38 dB 0.38 dB 0.49 dB 0.37 dB 0.38 dB 0.38 dB 0.75 dB 0.49 dB 0.5 dB 0.5 dB 0.81 dB 0.49 dB 0.5 dB 0.5 dB 1.2 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor, 83630B Signal Generator
AM Distortion Measure[1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2KHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 26.5) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(1 to 6 600) MHz		Agilent N5531S Measuring Receiver
	Rate (20 to 500) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.4 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 1.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(6.6 to 13.2) GHz		
	Rate (20 to 500) Hz		
	Dev > 1.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 5.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(13.2 to 26.5) GHz Rate (20 to 500) Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer

Electrical – RF/Microwave Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1 kHz to 600 MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (-80 to -10) dB 2nd through 4th Harmonic (5 300 to 6 625) MHz 2nd through 3rd Harmonic (6 625 to 8 833) MHz 2nd Harmonic (8 833 to 13 250) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB	Agilent E4440A Measuring Receiver

Length – Dimensional Metrology Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers [1,2]	Up to 24 in (24 to 80) in	(283 + 1.7*L*) µin (231 + 3.6*L*) µin	Grade 2 gage blocks
Micrometers [1,2]	Up to 46 in	(19 + 9*L*) µin	
Dial Indicators [1,2] Resolution: ≥ 50µin < 50µin	Up to 10 in Up to 0.1 in	(27 + 3.3*L*) µin 7 µin	
Feeler Gages [1]	Up to 1 in	52 µin	Pratt & Whitney Supermicrometer Model C
Height Gages [1,2]	Up to 46 in	(137 + 2.2*L*) µin	Grade 2 gage blocks
Protractors [1]	(0 to 360)º	0.011º	Angle blocks
Surface Plates [1] Overall Flatness Local Area Flatness	Up to 6 ft × 6 ft (-0.001 to 0.001) in	125 µin 68 µin	Leveling system Repeat-o-Meter
Cylindrical Gages [1,2] – Plain Pin, Plug Gages Ring Gages	(0 to 13) in (0 to 14) in	(4.8 + 2.3*D*) µin (9.3 + 1.5*D*) µin	Universal measuring machine, gage blocks (Grade 1)

Length – Dimensional Metrology Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Coating Thickness Gages [1] Eddy Current & Magnetic Induction, Fixed Point	(0.737 to 100) mils (100 to 243) mils	53 µin 280 µin	Coating thickness standards
Coating Thickness Shims [1,3]	Up to 243 mils	98 µin	Micrometer
Metal Tapes and Rules [1]	Up to 100 ft	(0.023 + 0.000 27*F*) in	Standard rule
Gage Blocks [2]	(0 to 13) in	(2.6 + 2.4*L*) µin	Universal measuring machine, master gage block set
Thread Plugs – Major Diameter Pitch Diameter, (6 to 72) TPI	 Up to 12 in Up to 12 in	 46 µin 92 µin	Gage Blocks, P&W Model C Bench Micrometer, Van Keuren thread wire set
Adjustable Thread Rings [2,3] Pitch Diameter (Tactile Fit)	Up to 12 in	(350 + 47*D*) µin	Thread Setting Plug Gages
Radius Gages	(0.01 to 1) in	340 µin	Optical comparator
Micrometer Standards Length Rods [2]	(1 to 10) in	(21 + 2.2*L*) µin	Gage blocks (grade 2), P&W Model C Bench Micrometer

Mass and Mass Related Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,4]	(1 to 500) mg 500 mg to 200 g (200 to 300) g 300 g to 3 kg	0.01 mg 10 mg 19 mg 47 mg	Class 1 weights
	(3 to 18) kg (18 to 30) kg	0.65 g 2.5 g	Class F weights & Class 2 weights
	(1 to 1 550) lb	0.01 % of reading	Class F weights
Torque Wrenches [1]	5 lbf·in to 1 000 lbf·ft	0.31 % of reading	CDI torque system
Torque Analyzers	5 lbf·in to 1 000 lbf·ft	0.06 % of reading	Class F weights, torque arm

Mass and Mass Related Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure Gauges	(-14.75 to 1 015) psig (0.75 to 1 015) psia (60 to 13 000) psig (72 to 13 000) psia (145 to 29 000) psig (160 to 29 000) psia	0.001 7 % of reading 0.003 5 % of reading 0.004 % of reading	Fluke PG7601 Piston Gauge w/ PC-7100/7600-1, PC-7200-2 and PC-7300-5 Piston-Cylinder
Pressure Gauges	(0 to 12) inH_2O	0.002 5 inH_2O	Dwyer 1425-25 Hook Gage
Pressure Gauges [1]	(-15 to 100) psi (0 to 10 000) psi	0.08 psi 3 psi	Digital gage Additel 681
Force Gages, Load Cells & Dynamometers Tension/Compression	10 mg to 10 kg (20 to 500) lb	0.028 % of reading 0.024 % of reading	Class F weights
Rockwell Hardness Testers [1]	(20 to 65) HRA (70 to 78) HRA (80 to 84) HRA (40 to 59) HRBW (60 to 79) HRBW (80 to 100) HRBW (20 to 30) HRC (35 to 55) HRC (56 to 65) HRC	0.62 HRA 0.58 HRA 0.41 HRA 0.84 HRBW 0.79 HRBW 0.68 HRBW 0.57 HRC 0.5 HRC 0.44 HRC	Indirect Verification per ASTM E18-17e1
Mass - Fixed Points Metric	(1, 2, 3, 5, 10, 20, 30) mg (50, 100, 200) mg 300 mg 500 mg (1, 2, 5) g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 5 kg 10 kg 20 kg 25 kg	1.8 µg 1.8 µg 2 µg 1.8 µg 5.2 µg 8.2 µg 10 µg 21 µg 41 µg 61 µg 0.16 mg 0.31 mg 0.61 mg 2.1 mg 3.1 mg 8.1 mg 8.1 mg	ASTM E617 Class 0 Weights OIML Class E2 Weights Precision Mass Comparators Balances

Mass and Mass Related Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass - Fixed Points Avoirdupois	(0.001, 0.002) lb 0.005 lb 0.01 lb 0.02 lb 0.05 lb 0.1 lb 0.2 lb (0.5, 1) lb 2 lb 5 lb 10 lb 20 lb 25 lb 50 lb	2.5 µg 6.1 µg 6.2 µg 7.3 µg 15 µg 20 µg 38 µg 0.25 mg 0.33 mg 1.2 mg 2.1 mg 4.1 mg 4.2 mg 14 mg	Comparison to ASTM E617 Class 1 weights Precision Mass Comparators Balances
Durometers Scale (Force) Accuracy Types A, B, C, D, E, DO Type M, Types O, OO Indenter Geometry Length Diameter Angle	 (0 to 100) duros 0.1 in 0.05 in (30 to 35)°	 0.06 duros 0.09 duros 0.07 duros 180 µin 180 µin 0.004°	Direct Verification Master balance Optical comparator

Photometry and Radiometry Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gloss Meters [1]	(20, 60, 85) ° (0 to 100) GU	0.71 GU	Gloss standards

Thermodynamic Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure	(-196 to 420) ºC	0.044 ºC	Hart 1502 Indicator, Burns Engineering 12005 PRT

Thermodynamic Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Infrared (IR) Thermometry [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 Infrared Calibrator λ = (8 to 14) µm, Ɛ = 0.95
Humidity – Measure [1]	(10 to 90) %RH	1.4 %RH	Vaisala MI70 Indicator and HMP77B Probe
Relative Humidity Measuring Equipment [1]	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber

Time and Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-9} Hz/Hz	HP Z3801A GPS Receiver
Frequency – Generate [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-9} Hz/Hz + 0.57 µHz 1 x 1^{e-9} Hz/Hz + 5.7 µHz 1 x 1^{e-9} Hz/Hz + 57 µHz 1 x 1^{e-9} Hz/Hz + 0.57 mHz 1 x 1^{e-9} Hz/Hz + 5.7 mHz 1 x 1^{e-9} Hz/Hz + 57 mHz 1 x 1^{e-9} Hz/Hz + 0.57 Hz	Agilent 3325B Function Generator / HP Z3801A GPS Receiver
Frequency – Generate [1]	(10 to 26 500) MHz	1 x 1^{e-9} Hz/Hz + 0.57 kHz	HP 83630B Signal Generator / HP Z3801A GPS Receiver
Frequency – Measure [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 200) kHz (0.2 to 3 000) MHz	5.2 x 1^{e-9} Hz/Hz 2.5 x 1^{e-9} Hz/Hz 1.6 x 1^{e-9} Hz/Hz 1.3 x 1^{e-9} Hz/Hz 1.2 x 1^{e-9} Hz/Hz 1. x 1^{e-9} Hz/Hz 1.21 x 1^{e-9} Hz/Hz	Agilent 53131A Frequency Counter / HP Z3801A GPS Receiver
	(10 to 26 500) MHz	1 x 1^{e-9} Hz/Hz + 0.1 Hz	Agilent E4440A Spectrum Analyzer / HP Z3801A GPS Receiver
Timer, Stopwatch [1]	10 s to 24 hr	34 ms	Totalize method with counter

Time and Frequency Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tachometers – RPM [1,2]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 3325B Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length	X Axis (0.01 to 8) in Y Axis (0.01 to 4) in	180 µin 180 µin	Optical comparator

2 Dimensional Hilliard, OH

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle	Up to 360°	0.004°	Optical comparator

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Services performed at satellite laboratory

Technical Maintenance, Inc.
12240 SW 53rd Street, Suite 506
Fort Lauderdale, FL 33330
Jon Parmenter (Branch Manager) Phone: (954)-252-2223
Scott Chamberlain (Quality Manager) Phone: (321) 242-0890

CALIBRATION

Acoustics and Vibration Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration	(0.01 to 10) g (7 to < 10) Hz (10 to < 30) Hz (30 to < 2 000) Hz (2 to 10) kHz	 4 % of reading 3 % of reading 1.5 % of reading 4 % of reading	Accelerometer Calibrator

Chemical Quantities Ft Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH meters [1,5]	(4, 7, 10) pH	0.034 pH	pH buffer solutions
Conductivity Meters [1,5]	2 µS/cm 5 µS/cm 10 µS/cm 100 µS/cm 500 µS/cm 1 000 µS/cm 10 000 µS/cm 100 000 µS/cm	0.2 µS/cm 0.2 µS/cm 0.17 µS/cm 0.74 µS/cm 2.3 µS/cm 3.6 µS/cm 36 µS/cm 350 µS/cm	Conductivity solutions

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate [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	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5720A Multifunction Calibrator
DC Voltage – Measure [1]	Up to 100 mV 100 mV to 1V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6.0 µV/V + 100 µV + 12 µV/V x (Vin/1 000) ^2	Agilent 3458A Multimeter
DC Voltage – Measure [1]	(1 to 40) kV	2.3 % of reading	Agilent 34401A Multimeter, Fluke 80k-40 High Voltage Probe
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 20 µA/A + 1 nA	Fluke 5720A Multifunction Calibrator & Fluke 5522A Multifunction Calibrator
DC Current – Generate [1]	(10 to 220) µA 0.22 to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5720A Multifunction Calibrator
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5720A Multifunction Calibrator, 5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A	761 µA/A + 578 µA	Fluke 5522A Multiproduct Calibrator
DC Current – Generate [1] Clamps Only	(0 to 200) A	0.21 % of output + 0.028 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
DC Current – Generate [1] Clamps Only	(0 to 1 000) A	0.21 % of output + 0.04 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.12 pA 18 µA/A + 1.2 pA 11 µA/A + 0.01 nA 9.1 µA/A + 0.12 nA	Fluke 5720A Multifunction Calibrator, Agilent 3458A Multimeter Option 002
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 500) A	0.26 % of reading	Empro current shunts, Multimeter
Resistance – Generate [1] Fixed Points	100 V 100 kΩ (100 to 1 000) V 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ	 1 % of output 1 % of output 1 % of output 1 % of output 1 % of output 1.2 % of output	TMI RB Resistance Standard
Resistance – Generate [1]	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	30 µΩ/Ω + 0.001 Ω 23 µΩ/Ω + 0.001 Ω 21 µΩ/Ω + 0.001 Ω 21 µΩ/Ω + 0.002 Ω 21 µΩ/Ω + 0.002 Ω 21 µΩ/Ω + 0.02 Ω 21 µΩ/Ω + 0.02 Ω 21 µΩ/Ω + 0.2 Ω 21 µΩ/Ω + 0.2 Ω 24 µΩ/Ω + 2 Ω 24 µΩ/Ω + 2 Ω 46 µΩ/Ω + 23 Ω 99 µΩ/Ω + 38 Ω 190 µΩ/Ω + 1.9 kΩ 380 µΩ/Ω + 2.3 kΩ 0.23 % of setting + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multiproduct Calibrator

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ (100, 190) kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 μΩ/Ω + 0.1 μΩ 21 μΩ/Ω + 1 μΩ 9.1 μΩ/Ω + 6 μΩ 7.6 μΩ/Ω + 60 μΩ 7.6 μΩ/Ω + 0.6 mΩ 9.9 μΩ/Ω + 6 mΩ 18 μΩ/Ω + 60 mΩ 18 μΩ/Ω + 60 mΩ 35 μΩ/Ω + 0.6 Ω 42 μΩ/Ω + 0.6 Ω 91 μΩ/Ω + 6 Ω	Fluke 5720A Multifunction Calibrator
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2 kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 0.6 mΩ 10 μΩ/Ω + 5.6 mΩ 10 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A Multimeter
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) μF (1.1 to 3.299 99) μF (3.3 to 10.999 9) μF (11 to 32.999 9) μF (33 to 109.999) μF (110 to 329.999) μF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.38% of output + 7.6 pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF 0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 μF 0.34 % of output + 2.3 μF 0.34 % of output + 7.6 μF 0.57 % of output + 23 μF 0.84 % of output + 76 μF	Fluke 5522A Multiproduct Calibrator

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure [1]	100 Hz /120 Hz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF (0.1 to 1) mF 1 000 Hz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF (0.1 to 1) mF 10 kHz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF (0.1 to 1) mF 20 kHz (16 to 400) pF (0.4 to 1) nF (1 to 100) nF (0.1 to 1) µF (1 to 100) µF	 2 % of reading + 0.3 pF 0.17 % of reading 0.23 % of reading 0.23 % of reading 0.23 % of reading 0.23 % of reading 0.43 % of reading + 0.3 pF 0.1 % of reading 0.13 % of reading 0.12 % of reading 0.13 % of reading 0.45 % of reading 0.56 % of reading + 0.3 pF 0.15 % of reading 0.2 % of reading 0.17 % of reading 0.69 % of reading 3.5 % of reading 1.2 % of reading + 0.3 pF 0.66 % of reading 0.65 % of reading 0.53 % of reading 1.7 % of reading	Agilent 4263B LCR Meter
Inductance – Measure [1]	100 Hz /120 Hz (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H	 5.2 % of reading + 0.03 µH 2.3 % of reading + 0.03 µH 0.57 % of reading + 0.03 µH 0.4 % of reading 0.32 % of reading 0.28 % of reading 0.23 % of reading 0.18 % of reading 0.22 % of reading	Agilent 4263B LCR Meter

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure [1]	1 000 Hz		Agilent 4263B LCR Meter
	(1 to 4) µH	1 % of reading + 0.03 µH	
	(4 to 10) µH	0.46 % of reading + 0.03 µH	
	(10 to 40) µH	0.74 % of reading + 0.03 µH	
	(40 to 100) µH	0.35 % of reading + 0.03 µH	
	(0.01to 0.4) mH	0.3 % of reading	
	(0.4 to 1) mH	0.11 % of reading	
	(1 to 10) mH	0.12 % of reading	
	(10 to 100) mH	0.1 % of reading	
	(0.1 to 1) H	0.1 % of reading	
	(1 to 10) H	0.12 % of reading	
	10 kHz		
	(1 to 4) µH	0.62 % of reading + 0.03 µH	
	(4 to 10) µH	0.4 % of reading + 0.03 µH	
	(10 to 40) µH	0.32 % of reading + 0.03 µH	
	(40 to 100) µH	0.18 % of reading + 0.03 µH	
	(0.1 to 0.4) mH	0.2 % of reading	
	(0.4 to 1) mH	0.14 % of reading	
	(1 to 10) mH	0.17 % of reading	
	(10 to 100) mH	0.2 % of reading	
	(0.1 to 1) H	0.2 % of reading	
	(1 to 10) H	0.44 % of reading	
	20 kHz		
	(1 to 4) µH	1.3 % of reading + 0.03 µH	
	(4 to 10) µH	0.68 % of reading + 0.03 µH	
	(10 to 40) µH	0.63 % of reading + 0.03 µH	
	(40 to 100) µH	0.53 % of reading + 0.03 µH	
	(0.1 to 0.4) mH	0.49 % of reading	
	(0.4 to 1) mH	0.48 % of reading	
	(1 to 10) mH	0.65 % of reading	
	(10 to 100) mH	0.66 % of reading	
	(0.1 to 1) H	1.2 % of reading	
	(1 to 10) H	3.3 % of reading	

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure [1]	100 kHz (1 to 4) µH (4 to 10) µH (10 to 40) µH (40 to 100) µH (0.1 to 0.4) mH (0.4 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H	 2.7 % of reading + 0.03 µH 0.86 % of reading + 0.03 µH 1.2 % of reading + 0.03 µH 0.68 % of reading + 0.03 µH 0.9 % of reading 1.1 % of reading 1.4 % of reading 1.4 % of reading 6.3 % of reading	Agilent 4263B LCR Meter
AC Voltage – Generate [1]	(0.22 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 (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 (0.22 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	 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV 228 µV/V + 11 µV 88 µV/V + 6.1 µV 76 µV/V + 6.1 µV 190 µV/V + 6.1 µV 457 µV/V + 15 µV 837 µV/V + 19 µV 1.3 mV/V + 23 µV 2.5 mV/V + 46 µV 228 µV/V + 38 µV 84 µV/V + 15 µV 40 µV/V + 8 µV 68 µV/V + 9 µV 99 µV/V + 30 µV 380 µV/V + 76 µV 913 µV/V + 190 µV 1.5 mV/V + 304 µV	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(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 (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	 228 µV/V + 380 µV 84 µV/V + 152 µV 37 µV/V + 54 µV 61 µV/V + 91 µV 76 µV/V + 190 µV 228 µV/V + 609 µV 913 µV/V + 1.9 mV 1.4 mV/V + 3 mV 228 µV/V + 3.8 mV 84 µV/V + 1.5 mV 49 µV/V + 0.6 mV 76 µV/V + 0.9 mV 137 µV/V + 2.3 mV	Fluke 5720A Multifunction Calibrator
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5720A Multifunction Calibrator, 5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 13 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV	Fluke 5720A Option 003 Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(3.3 to 11) mV		Fluke 5720A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89 % of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	0.33 to 1.1 V		
	(10 to 30 Hz)	0.45% of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(1.1 to 3.5) V		Fluke 5720A Multifunction Calibrator Option 003
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(0 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2 % of reading + 5 µV	
	(1 to 4) MHz	7 % of reading + 7 µV	
	(4 to 8) MHz	20 % of reading + 8 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(1 to 10) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz (10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.007 % of reading + 0.4 mV 0.007 % of reading + 0.2 mV 0.014 % of reading + 0.2 mV 0.03 % of reading + 0.2 mV 0.08 % of reading + 0.2 mV 0.3 % of reading + 1 mV 1 % of reading + 1 mV 1.5 % of reading + 7 mV 4 % of reading + 7 mV 4 % of reading + 8 mV 15 % of reading + 10 mV 0.02 % of reading + 4 mV 0.02 % of reading + 2 mV 0.02 % of reading + 2 mV 0.035 % of reading + 2 mV 0.1 % of reading + 2 mV 0.4 % of reading + 10 mV 1.5 % of reading + 10 mV 0.04 % of reading + 40 mV 0.04 % of reading + 20 mV 0.06 % of reading + 20 mV 0.12 % of reading + 20 mV 0.3 % of reading + 20 mV	Agilent 3458A Multimeter
AC Voltage – Measure [1]	(1 to 28) kV 60 Hz	 5.8 % of reading	Agilent 34401A Multimeter / Fluke 80k-40 High Voltage Probe
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 107 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA	Fluke 5720A Multifunction Calibrator

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(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 (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 (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 385 nA 152 µA/A + 310 nA 107 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4.6 µA 228 µA/A + 4 µA 152 µA/A + 3 µA 107 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 243 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5720A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA/A + 141 µA 723 µA/A + 295 µA 2.7 mA/A + 573 µA	Fluke 5720A Multifunction Calibrator, 5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.28 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current – Generate [1] Clamp Meters Only	(3.3 to 30) A (10 to 100) Hz (100 to 440) Hz (30 to 200) A 10 to 100 Hz (100 to 440) Hz	 0.22 % of output + 0.028 A 0.3 % of output + 0.07 A 0.22 % of output + 0.032 A 0.79 % of output + 0.08 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
AC Current – Generate [1] Clamp Meters Only	(16.5 to 150) A (10 to 100) Hz (100 to 440) Hz (150 to 1 000) A (10 to 100) Hz (100 to 440) Hz	 0.22 % of output + 0.029 A 0.3 % of output + 0.08 A 0.22 % of output + 0.081 A 0.79 % of output + 0.2 A	Fluke 5522A Multiproduct Calibrator /9100-200 x50 Coil

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (0.1 to 1) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (0.1 to 1) A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 Hz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A Multimeter
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	 0.72 % of reading + 1.2 mA 0.23 % of reading + 1.2 mA 0.1 % of reading + 1.2 mA	Agilent 34401A Multimeter
AC Current – Measure [1]	(3 to 30) A 40 Hz to 1 kHz (1 to 5) kHz	 0.3 % of reading + 0.07 A 5 % of reading + 0.14 A	Agilent 3458A Multimeter, Keysight 34330A Current Shunt
AC Current – Measure [1]	(30 to 600) A (10 to 100) Hz (100 to 400) Hz	 1.5 % of reading + 1.1 A 4.6 % of reading + 1.1 A	Fluke 336 Clamp Meter

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration[1] – Generate			
Voltage DC - 50Ω	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.199 9) V (2.2 to 6.6) V	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	
DC - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.199 9) V (2.2 to 10.999) V (11 to 130) V	0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6 mV	
Square Wave 10Hz to 10kHz - 50Ω	(1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.199 9) Vpp (2.2 to 6.6) Vpp	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Square Wave 10 Hz to 1KHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6 mV	
Square Wave 1 to 10KHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.199 9) V (2.2 to 10.999) V (11 to 130) V	0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1]	3 dB Bandwidth		Fluke 5820A Oscilloscope Calibrator w/ GHz Option
	(5 to 50) mVpp		
	50 kHz to 100) MHz	0.34 dB	
Leveled Sine Flatness	(100 to 300) MHz	0.36 dB	
50 kHz to 10 MHz Reference	(300 to 500) MHz	0.42 dB	
	(500 to 600) MHz	0.46 dB	
	(600 to 16 00) MHz	0.5 dB	
	(1 600 to 2 100) MHz	0.56 dB	
	50 mV to 3.5 Vpp		
	50 kHz to 100 MHz	0.24 dB	
	(100 to 300) MHz	0.24 dB	
	(300 to 500) MHz	0.32 dB	
	(500 to 600) MHz	0.34 dB	
	(600 to 16 00) MHz	0.4 dB	
	(1 600 to 2 100) MHz	0.44 dB	
	(3.5 to 5) Vpp		
	50 kHz to 100 MHz	0.24 dB	
	(100 to 300) MHz	0.24 dB	
	(300 to 500) MHz	0.32 dB	
	(500 to 600) MHz	0.34 dB	
Oscilloscopes Calibration – Generate [1]	3 dB Bandwidth		EPM Power Meter w/ E Series Power Sensors
	50 mVpp to 3.5Vpp		
Leveled Sine Flatness	(2 100 to 4 000) MHz	0.25 dB	
50 kHz to 10 MHz Reference	(4 000 to 8 000) MHz	0.35 dB	
	(8 000 to 18 000) MHz	0.46 dB	
Oscilloscopes Calibration – Generate [1]	500 ps to 20 ms	0.25 µs/s	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Time Marker	50 ms to 5 s	1.9 µs/s + 3.8 µHz	
Input Impedance	(40 to 60) Ω	0.08 % of reading	
Resistance	500 kΩ to 1.5MΩ	0.08 % of reading	
Leakage	(0 to 5.99) V	0.038 % of reading + 0.8 mV	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type B		Fluke 7526A Process Calibrator
	(600 to 800) °C	0.27 °C	
	(800 to 1 550) °C	0.22 °C	
	(1 550 to 1 820) °C	0.17 °C	
	Type C		
	(0 to 1 000) °C	0.13 °C	
	(1 000 to 1 800) °C	0.18 °C	
	(1 800 to 2 000) °C	0.2 °C	
	(2 000 to 2 316) °C	0.27 °C	
	Type E		
	(-250 to -200) °C	0.19 °C	
	(-200 to -100) °C	0.1 °C	
	(-100 to 0) °C	0.07 °C	
	(0 to 600) °C	0.07 °C	
	(600 to 1 000) °C	0.08 °C	
	Type J		
	(-210 to -100) °C	0.11 °C	
	(-100 to 800) °C	0.07 °C	
	(800 to 1 200) °C	0.08 °C	
	Type K		
	(-250 to -200) °C	0.35 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 800) °C	0.08 °C	
	(800 to 1 372) °C	0.1 °C	
	Type L		
	(-200 to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type R (-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1 000) °C (1 000 to 1 600) °C (1 600 to 1 767) °C Type S (50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1 600) °C (1 600 to 1 767) °C Type T (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.42 °C 0.34 °C 0.3 °C 0.22 °C 0.17 °C 0.16 °C 0.15 °C 0.18 °C 0.39 °C 0.33 °C 0.29 °C 0.22 °C 0.18 °C 0.17 °C 0.2 °C 0.26 °C 0.13 °C 0.09 °C 0.07 °C 0.13 °C 0.08 °C	Fluke 7526A Process Calibrator
Electrical Calibration of RTD Indicators [1]	Pt 385, 100 Ω (-200 to 800) °C Pt 3926, 100 Ω (-200 to 630) °C Pt 3916, 100 Ω (-200 to 630) °C Pt 385, 200 Ω (-200 to 400) °C (400 to 630) °C Pt 385, 500 Ω (-200 to 630) °C Pt 385, 1 000 Ω (-200 to 630) °C	 0.05 °C 0.05 °C 0.05 °C 0.4 °C 0.5 °C 0.17 °C 0.09 °C	Fluke 7526A Process Calibrator

Electrical – DC/Low Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of RTD Indicators [1]	Cu 427, 10 Ω (100 °C to 260) °C PtNi 385, 120 Ω (Ni120) (-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.35 °C 0.093 °C 0.093 °C 0.16 °C	Fluke 5522A Multiproduct Calibrator
Phase Angle	(-180 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	0.14 % of reading 0.3 % of reading 0.61 % of reading 2.9 % of reading 5.8% of reading 12% of reading	Fluke 5522A Multiproduct Calibrator
Power Meters [1]	3 µW to 100 mW	0.32 % of reading	HP 11683A Range Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation –Measure [1]	(30 to 3 050) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (110 to 120) dB	0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.13 dB 0.26 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(3 050 to 6 600) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.15 dB	
	(110 to 120) dB	0.37 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.14 dB	
	(100 to 110) dB	0.34 dB	
	(110 to 120) dB	0.77 dB	
	(13 200 to 19 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.27 dB	
	(100 to 110) dB	0.66 dB	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(19 200 to 26 500) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.2 dB 0.52 dB 1.1 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
RF Power – Measure [1] 50 MHz	1.0 mW	0.0032 mW	HP 478A, 432A Power Meter
RF Flatness – Measure [1]	9 kHz to 2 000 MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power – Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	100 kHz to 30 MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.12 dB 0.13 dB 0.15 dB 0.19 dB 0.26 dB 0.39 dB 0.59 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (2 000 to 3 050) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (3 050 to 6 600) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB 0.42 dB 0.3 dB 0.31 dB 0.32 dB 0.34 dB 0.35 dB 0.4 dB 0.51 dB 0.42 dB 0.3 dB 0.31 dB 0.32 dB 0.34 dB 0.38 dB 0.48 dB 0.64 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(6 600 to 13 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -100) dB	0.34 dB	
	(-100 to -105) dB	0.37 dB	
	(-105 to -110) dB	0.45 dB	
	(-110 to -115) dB	0.6 dB	
	(-115 to -120) dB	0.82 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -90) dB	0.33 dB	
	(-90 to -95) dB	0.35 dB	
	(-95 to -100) dB	0.41 dB	
	(-100 to -105) dB	0.53 dB	
	(-105 to -110) dB	0.72 dB	
	(18 000 to 19 200) MHz		
	(30 to 20) dB	0.48 dB	
	(20 to 0) dB	0.38 dB	
	(0 to -58) dB	0.39 dB	
	(-58 to -78) dB	0.4 dB	
	(-78 to -90) dB	0.41 dB	
	(-90 to -95) dB	0.42 dB	
	(-95 to -100) dB	0.47 dB	
	(-100 to -105) dB	0.58 dB	
	(-105 to -110) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.48 dB	
	(20 to 0) dB	0.38 dB	
	(0 to -58) dB	0.39 dB	
	(-58 to -78) dB	0.4 dB	
	(-78 to -90) dB	0.43 dB	
	(-90 to -95) dB	0.5 dB	
	(-95 to -100) dB	0.63 dB	
	(-100 to -105) dB	0.84 dB	
	(-105 to -110) dB	1.1 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 0.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver
Frequency Modulation Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 26.5) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400KHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.2 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad	Agilent N5531S Measuring Receiver
AM Distortion Measure[1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 26.5) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) kHz Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1 kHz to 600 MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz 2nd through 4th Harmonic (5 300 to 6 625) MHz 2nd through 3rd Harmonic (6 625 to 8 833) MHz 2nd Harmonic (8 833 to 13 250) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB	Agilent E4440A Measuring Receiver

Length – Dimensional Metrology Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers [1,2]	Up to 46 in	(281 + 1.8*L*) µin	Gage blocks (Grade 2)
Micrometers [1,2]	Up to 46 in	(31 + 4.2*L*) µin	
Dial Indicators [1,2] Resolution: ≥ 50µin < 50µin	 Up to 10 in Up to 0.1 in	 (26 + 3.3*L*) µin 12 µin	
Height Gages [1,2]	Up to 46 in	(236 + 1.5*L*) µin	

Length – Dimensional Metrology Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales – Rulers [1]	Up to 46 in	0.009 1 in	Gage blocks (Grade 2)
Tape Measures	Up to 100 ft	(0.025 + 0.000 26*F*) in	Standard rule
Protractors [1]	(0 to 360)º	0.014º	Angle blocks
Feeler Gages [1]	Up to 1 in	30 µin	P&W Model C Bench Micrometer
Cylindrical Gages [2] – Inside Outside	Up to 11 in Up to 10 in	(14 + 2*D*) µin (4.3 + 2.3*D*) µin	Gage blocks, P&W universal measuring machine
Gage Blocks [2] – Length Only	Up to 10 in	(3.6 + 2.9*L*) µin	Master gage blocks, P&W universal measuring machine
Thread Plugs – Major Diameter Pitch Diameter	Up to 10 in Up to 10 in	47 µin 80 µin	P & W Model C Bench Micrometer, Van Keuren thread wire set, gage blocks

Mass and Mass Related Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,2,4]	0.001 g to 10 kg	(0.02 + 0.003*X*) mg	Class 1 weights
	Up to 400 lb Up to 181 kg	(0.000 5 + 0.000 13*M*) lb (0.22 + 0.000 13*X*) g	Class F weights
Torque – Measure [1]	(10 to 100) ozf·in 5 lbf·in to 250 lbf·ft (250 to 1 000) lbf·ft	0.59 % of reading 0.32 % of reading 0.32 % of reading	Torque Testers CDI 1001-0-DDT CDI 5000-ST CDI 2000-13-02
Pressure [1]	(0.2 to 1 000) psi	0.002 2 % of reading	Ruska 2468A Deadweight Tester
Pressure [1]	(-15 to 100) psi	0.082 psi	Fluke 74x Series Process Calibrator w/700PD6 Pressure Module
Pressure [1]	(100 to 500) psi	0.31 psi	Fluke 700G07 Pressure Gauge

Mass and Mass Related Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure [1]	(-150 to 150) inH_2O (0 to 15) psi (500 to 1 000) psi (1 000 to 10 000) psi	0.09 inH_2O 0.004 psi 0.6 psi 6.1 psi	Additel 681 Pressure Gage
Force [1] Tension and Compression	Up to 10 kgf (0.1 to 300) lbf	(5.7 + 0.002 9*X*) mg 0.086 % of reading	Class 1 weights Class F weights

Thermodynamic Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	(-200 to 300) ˚C	0.031 ºC	Hart 1502 Indicator with 5622 PRT
Temperature Measuring Equipment [1]	(-25 to 140) ˚C (140 to 300) ˚C	0.13 ºC 0.42 ºC	Hart 1502 Indicator with 5622 PRT and dry block
Infrared (IR) Temperature [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 Portable Infrared Calibrator ε= 0.95, λ = (8 to 14) µm
Relative Humidity Measuring Equipment [1]	11 %RH 33 %RH 75 %RH 97 %RH	1.2 %RH 1.1 %RH 1.3 %RH 2.8 %RH	Standard salts
Relative Humidity Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber
Relative Humidity – Measure [1]	Up to 90 %RH (90 to 97) %RH	1.4 %RH 2.4 %RH	Vaisala HM141/HMP46 Indicator and Probe

Time and Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-12} Hz/Hz	HP 58503A GPS Receiver

Time and Frequency Fort Lauderdale, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 µHz $1 \times 1^{e-12}$ Hz/Hz + 5.7 µHz $1 \times 1^{e-12}$ Hz/Hz + 57 µHz $1 \times 1^{e-12}$ Hz/Hz + 0.57 mHz $1 \times 1^{e-12}$ Hz/Hz + 5.7 mHz $1 \times 1^{e-12}$ Hz/Hz + 57 mHz $1 \times 1^{e-12}$ Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	(10 to 20 000) MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 mHz	Agilent E8257D Opt 520 Signal Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	(10 to 26 500) MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.57 kHz	HP 83630B Signal Generator / HP 58503A GPS Receiver
Time – Generate	1 pps	$1 \times 1^{e-12}$ s/s + 750 ps	HP 58503A GPS Receiver
Frequency – Measure [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 200) kHz (0.2 to 3 000) MHz	$4.2 \times 1^{e-9}$ Hz/Hz $1.5 \times 1^{e-9}$ Hz/Hz $0.6 \times 1^{e-9}$ Hz/Hz $0.33 \times 1^{e-9}$ Hz/Hz $0.24 \times 1^{e-9}$ Hz/Hz $0.21 \times 1^{e-9}$ Hz/Hz $0.21 \times 1^{e-9}$ Hz/Hz	Agilent 53131A Opt 030 Frequency Counter / HP 58503A GPS Receiver
Frequency – Measure [1]	(10 to 26 500) MHz	$1 \times 1^{e-12}$ Hz/Hz + 0.1 Hz	Agilent E4440A Spectrum Analyzer / HP 58503A GPS Receiver
Timers and Stopwatches [1]	Up to 24 hr	346 ms	GPS Reference Frequency Counter
Tachometers – RPM	Up to 100 000 RPM	± (0.001% + 0.6*R*)	HP 33250A Signal Generator & LED

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Services performed at satellite laboratory

Technical Maintenance, Inc.
3060 Venture Lane, Suite 106
Melbourne, FL 32934
Schuyler Cournoyer (Branch Manager) Phone: 321-242-0890
Scott Chamberlain (Quality Manager) Phone: 321-242-0890

CALIBRATION

Chemical Quantities Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,5]	(4, 7) pH (10) pH	0.02 pH 0.03 pH	pH buffer solutions
Conductivity Meters [1,5]	84 µS/cm 1 413 µS/cm 10 000 µS/cm	0.83 µS/cm 5.7 µS/cm 37 µS/cm	Conductivity solutions

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 15 µA/A + 1 nA	Fluke 5730A/03 Multifunction Calibrator, Agilent 3458 Option 002 Precision Multimeter
DC Current – Generate [1]	(10 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5730A/03 Multifunction Calibrator
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 365 µA	Fluke 5730A/03 Multifunction Calibrator and 5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A	761 µA/A + 578 µA	Fluke 5522A Multifunction Calibrator

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current Clamp Meters Toroidal-Wound	(0 to 1025) A	0.21 % of output + 0.05 A	Fluke 5522A Multiproduct Calibrator / 5500A/Coil x50
DC Current Clamp Meters Other	(0 to 1 025) A	0.39 % of output + 0.38A	Fluke 5522A Multiproduct Calibrator / 5500A/Coil x50
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.12 pA 13 µA/A + 1.2 pA 9.1 µA/A + 0.01 nA 7.9 µA/A + 0.12 nA	Fluke 5730A Multifunction Calibrator Agilent 3458A Option 002 Precision Multimeter
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 10) A (10 to 100) A	100 µA/A + 72 µA 100 µA/A + 1 mA	Agilent 3458A Option 002 Multimeter Standard Resistor L&N 4361 Current Shunt
DC Current – Measure [1]	(100 to 1 000) A	0.25% of reading	Agilent 3458A Multimeter Empro Current Shunt
DC Voltage – Generate [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	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3.0 µV/V + 2.5 µV 3.0 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5730A Multifunction Calibrator
DC Voltage – Measure [1]	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	5 µV/V + 1.2 µV 4 µV/V + 1.2 µV 4 µV/V + 2.1 µV 6 µV/V + 30 µV 6 µV/V + 100 µV + 12 µV/V x (Vin/1 000) ^2	Agilent 3458A Option 002 Precision Multimeter
DC Voltage – Measure [1]	(1 to 60) kV	0.1 % of reading	Ross VD60 High Voltage Divider, HP 34401A Precision Multimeter

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(0.22 to 2.2) mV		Fluke 5730A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	
	(2.2 to 22) mV		
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	
	(22 to 220) mV		
	(10 to 20) Hz	228 µV/V + 11.4 µV	
	(20 to 40) Hz	88 µV/V + 6.1 µV	
	40 Hz to 20 kHz	53 µV/V + 6.1 µV	
	(20 to 50) kHz	114 µV/V + 6.1 µV	
	(50 to 100) kHz	304 µV/V + 15 µV	
	(100 to 300) kHz	609 µV/V + 19 µV	
	(300 to 500) kHz	1.3 mV /V + 22.8 µV	
	500 kHz to 1 MHz	2.5 mV /V + 45.7 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	228 µV/V + 38 µV	
	(20 to 40) Hz	84 µV/V + 15 µV	
	40 Hz to 20 kHz	37 µV/V + 8 µV	
	(20 to 50) kHz	61 µV/V + 9 µV	
	(50 to 100) kHz	76 µV/V + 30 µV	
	(100 to 300) kHz	304 µV/V + 76 µV	
	(300 to 500) kHz	913 µV /V + 190 µV	
	500 kHz to 1 MHz	1.5 mV/V + 304 µV	

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(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 (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	 228 µV/V + 380 µV 84 µV/V + 152 µV 37 µV/V + 54 µV 61 µV/V + 91 µV 76 µV/V + 190 µV 228 µV/V + 609 µV 913 µV/V + 1.9 mV 1.4 mV/V + 3 mV 228 µV/V + 3.8 mV 84 µV/V + 1.5 mV 49 µV/V + 0.6 mV 76 µV/V + 0.9 mV 137 µV/V + 2.3 mV	Fluke 5730A Multifunction Calibrator
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5730A Multifunction Calibrator, 5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 13 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV	Fluke 5730A Option 003 Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(3.3 to 11) mV		Fluke 5730A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89 % of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	0.33 to 1.1 V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(1.1 to 3.5) V		Fluke 5730A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A/002 Precision Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2 % of reading + 5 µV	
	(1 to 4) MHz	7 % of reading + 7 µV	
	(4 to 8) MHz	20 % of reading + 8 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	(0.1 to 1) V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(1 to 10) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz (10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.007 % of reading + 0.4 mV 0.007 % of reading + 0.2 mV 0.014 % of reading + 0.2 mV 0.03 % of reading + 0.2 mV 0.08 % of reading + 0.2 mV 0.3 % of reading + 1 mV 1 % of reading + 1 mV 1.5 % of reading + 7 mV 4 % of reading + 7 mV 4 % of reading + 8 mV 15 % of reading + 10 mV 0.02 % of reading + 4 mV 0.02 % of reading + 2 mV 0.02 % of reading + 2 mV 0.035 % of reading + 2 mV 0.12 % of reading + 2 mV 0.4 % of reading + 10 mV 1.5 % of reading + 10 mV 0.04 % of reading + 40 mV 0.04 % of reading + 20 mV 0.06 % of reading + 20 mV 0.12 % of reading + 20 mV 0.3 % of reading + 20 mV	Agilent 3458A Precision Multimeter
AC Voltage – Measure [1]	(1 to 10) kV 60 Hz (10 to 42) kV 60 Hz	 0.5 % of reading + 0.002 kV 0.5 % of reading + 0.02 kV	Ross VD60 High Voltage Divider, HP 34401A Multimeter
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	0.22 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 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 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 (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 39 nA 152 µA/A + 31 nA 91 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 91 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4566 nA 228 µA/A + 4 µA 152 µA/A + 3 µA 91 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 228 µA/A + 31 µA 380 µA/A + 76 µA 6.1 mA/A + 152 µA	Fluke 5730A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA/A + 141 µA 723 µA/A + 295 µA 2.7 mA/A + 573 µA	Fluke 5730A Multifunction Calibrator 5725A Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.3 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current Clamps – Toroidal-Wound	(16.5 to 1 025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	 0.23 % of reading + 0.1 A 0.6 % of reading + 0.085 A	Fluke 5522A Multiproduct Calibrator /5500A/Coil x50
AC Current Clamps – Other	(16.5 to 1025) A (45 to 65) Hz (16.5 to 150) A (65 to 440) Hz	0.44 % of reading +0.53 A 0.79 % of reading +0.68 A	Fluke 5522A Multiproduct Calibrator /5500A/Coil x50

Electrical – DC/Low Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	Up to 100 µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz 100 µA to 1 mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 Hz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A Precision Multimeter
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	 0.72 % of reading + 1.2 mA 0.23 % of reading + 1.2 mA 0.1 % of reading + 1.2 mA	Agilent 34401A Multimeter
AC Current – Measure [1]	(3 to 30) A 40 Hz to 1 kHz (1 to 5) kHz	 0.3 % of reading + 0.07 A 5 % of reading + 0.14 A	Agilent 3458A Multimeter Keysight 34330A Current Shunt
AC Current – Measure [1]	(100 to 1 000) A (10 to 100) Hz (100 to 500) Hz	 1.5 % of reading + 1A 1.9 % of reading + 1A	Fluke 376 Clamp Meter
AC Current – Measure [1]	(100 to 2 500) A (10 to 500) Hz	 2.3 % of reading + 5A	Fluke 376 Clamp Meter W/i2500 flex probe
Resistance – Generate [1] Fixed Points	(0.001, 0.01, 0.1) Ω	100 µΩ/Ω	Standard Resistors

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 μΩ/Ω + 0.1 μΩ 21 μΩ/Ω + 1 μΩ 9.1 μΩ/Ω + 6 μΩ 6.1 μΩ/Ω + 60 μΩ 6.1 μΩ/Ω + 0.6 mΩ 7.6 μΩ/Ω + 6 mΩ 9.1 μΩ/Ω + 6 mΩ 11 μΩ/Ω + 60 mΩ 16 μΩ/Ω + 60 mΩ 35 μΩ/Ω + 0.6 Ω 42 μΩ/Ω + 0.6 Ω 91 μΩ/Ω + 6 Ω	Fluke 5730A/03 Multifunction Calibrator
Resistance – Generate [1]	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	30 μΩ/Ω + 0.001 Ω 23 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.2 Ω 21 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 2 Ω 24 μΩ/Ω + 2 Ω 46 μΩ/Ω + 23 Ω 99 μΩ/Ω + 38 Ω 190 μΩ/Ω + 1.9 kΩ 380 μΩ/Ω + 2.3 kΩ 0.23 % of setting + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multifunction Calibrator
Resistance – Generate [1] Fixed Points	100V 100 kΩ	1 % of reading	Standard Resistors
Resistance – Generate [1] Fixed Points	(100 to 1 000) V 1 MΩ 10 MΩ 100 MΩ 1 GΩ 10 GΩ 100 GΩ	1 % of reading 1 % of reading 1 % of reading 1 % of reading 1.2 % of reading 3.2 % of reading	Standard Resistors

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2) kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 0.6 mΩ 10 μΩ/Ω + 5.6 mΩ 10 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A Multimeter
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) μF (1.1 to 3.299 99) μF (3.3 to 10.999 9) μF (11 to 32.999 9) μF (33 to 109.999) μF (110 to 329.999) μF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.38% of output + 7.6 pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF 0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 μF 0.34 % of output + 2.3 μF 0.34 % of output + 7.6 μF 0.57 % of output + 23 μF 0.84 % of output + 76 μF	Fluke 5522A Multiproduct Calibrator
Capacitance – Measure [1] 1V @ 1 kHz	(400 to 6 400) pF (6.4 to 100) nF (100 to 1 000) nF (1 000 to 1 600) nF (1.6 to 10) μF (10 to 25) μF	0.1 % of reading + 0.4 pF 0.1 % of reading + 0.003 nF 0.1 % of reading + 0.012 nF 0.1 % of reading + 0.11 nF 0.1 % of reading + 0.001 μF 0.1 % of reading + 0.01 μF	GW Instek LCR-816 LCR Meter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration[1] – Generate			
Voltage DC - 50Ω	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	
DC - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6.0 mV	
Square Wave 10 Hz to 10 kHz - 50Ω	(1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.1999) Vpp (2.2 to 6.6) Vpp	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Square Wave 10 Hz to 1 kHz – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6.0 mV	
Square Wave (1 to 10) kHz – 1 MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6.0 mV	
Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth (5 to 50) mVpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz	 0.34 dB 0.36 dB 0.42 dB 0.46 dB 0.5 dB 0.56 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth 50 mV to 3.5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz (3.5 to 5) Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz	 0.24 dB 0.24 dB 0.32 dB 0.34 dB 0.4 dB 0.44 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscope Calibration Generate [1] Leveled Sine Flatness	3 dB Bandwidth 50 mV to 3.5 Vpp (2 100 to 4 000) MHz (4 000 to 8 000) MHz (8 000 to 18 000) MHz	 0.25 dB 0.35 dB 0.46 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
Oscilloscope Calibration Generate [1] Time Marker	 500 ps to 20 ms 50 ms to 5 s	 0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscope Calibration Measure [1] Resistance Leakage	 (40 to 60) Ω 500 kΩ to 1.5 MΩ (0 to 5.99) V	 0.08 % of reading 0.08 % of reading 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Power Meter Range Calibration[1]	3 µW to 100 mW	0.25 % of reading	HP 11683A Power Meter Calibrator
Electrical Calibration of Thermocouple Indicating Devices [1]	Type B (600 to 800) °C (800 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 000) °C (2 000 to 2 316) °C	 0.27 °C 0.22 °C 0.17 °C 0.13 °C 0.18 °C 0.2 °C 0.27 °C	Fluke 7526A Process Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type E		Fluke 7526A Process Calibrator
	(-250 to -200) °	0.19 °C	
	(-200 to -11) °C	0.1 °C	
	(-100 to 0) °C	0.07 °C	
	(0 to 600) °C	0.07 °C	
	(600 to 1 000) °C	0.08 °C	
	Type J		
	(-210 to -100) °C	0.11 °C	
	(-100 to 800) °C	0.07 °C	
	(800 to 1 200) °C	0.08 °C	
	Type K		
	(-250 to -200) °C	0.35 °C	
	-200 to -100) °C	0.13 °C	
	(-100 to 800) °C	0.08 °C	
	(800 to 1 372) °C	0.1 °C	
	Type L		
	(-200 to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	
	Type R		
	(-50 to -25) °C	0.42 °C	
	(-25 to 0) °C	0.34 °C	
	(0 to 100) °C	0.3 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.17 °C	
	(600 to 1 000) °C	0.16 °C	
	(1 000 to 1 600) °C	0.15 °C	
	(1 600 to 1 767) °C	0.18 °C	
	Type S		
	(-50 to -25) °C	0.39 °C	
	(-25 to 0) °C	0.33 °C	
	(0 to 100) °C	0.29 °C	
	(100 to 400) °C	0.22 °C	
	(400 to 600) °C	0.18 °C	
	(600 to 1 600) °C	0.17 °C	
	(1 600 to 1 767) °C	0.2 °C	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices [1]	Type T (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.26 °C 0.13 °C 0.09 °C 0.07 °C 0.13 °C 0.08 °C	Fluke 7526A Process Calibrator
Electrical Calibration of RTD Indicating Devices [1]	Pt 385, 100 Ω (-200 to 800) °C Pt 3926, 100 Ω (-200 to 630) °C Pt 3916, 100 Ω (-200 to 630) °C Pt 385, 200 Ω (-200 to 400) °C (400 to 630) °C Pt 385, 500 Ω (-200 to 630) °C Pt 385, 1 000 Ω (-200 to 630) °C	 0.05 °C 0.05 °C 0.05 °C 0.4 °C 0.5 °C 0.17 °C 0.09 °C	Fluke 7526A Process Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(50 to 26 500) MHz (20 to 10) dB (10 to -50) dB (-50 to -60) dB (-60 to -65) dB	 0.25 dB 0.22 dB 0.37 dB 0.94 dB	Agilent EPM Series Power Meter w/E4413A Power Sensor
RF Flatness – Measure [1]	9 kHz to 2 000 MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Flatness – Measure [1]	(2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power – Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power – Measure [1]	(10 to 100) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.07 dB 0.06 dB 0.06 dB 0.06 dB 0.11 dB	Agilent EPM Series Power Meter w/N8485A Power Sensor
RF Power – Measure [1]	(100 to 2 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (2 000 to 12 400) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.07 dB 0.07 dB 0.06 dB 0.07 dB 0.11 dB 0.08 dB 0.08 dB 0.08 dB 0.08 dB 0.12 dB	Agilent EPM Series Power Meter w/N8485A Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(12 400 to 18 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (18 000 to 26 500) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.09 dB 0.08 dB 0.08 dB 0.09 dB 0.12 dB 0.12 dB 0.12 dB 0.12 dB 0.12 dB 0.15 dB	Agilent EPM Series Power Meter w/N8485A Power Sensor
RF Power – Measure [1]	(50 to 100) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (100 to 6 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (6 000 to 12 400) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (12 400 to 18 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.07 dB 0.07 dB 0.06 dB 0.07 dB 0.11 dB 0.07 dB 0.07 dB 0.07 dB 0.07 dB 0.11 dB 0.08 dB 0.08 dB 0.07 dB 0.08 dB 0.12 dB 0.09 dB 0.08 dB 0.08 dB 0.08 dB 0.12 dB	Agilent EPM Series Power Meter w/N8487A Power Sensor

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(18 000 to 26 500) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (26 5000 to 33 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (33 000 to 40 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (40 000 to 50 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.11 dB 0.10 dB 0.10 dB 0.10 dB 0.13 dB 0.12 dB 0.12 dB 0.11 dB 0.12 dB 0.14 dB 0.13 dB 0.12 dB 0.12 dB 0.13 dB 0.15 dB 0.18 dB 0.18 dB 0.18 dB 0.18 dB 0.2 dB	Agilent EPM Series Power Meter w/N8487A Power Sensor
RF Power – Measure [1]	100 kHz to 30 MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.12 dB 0.13 dB 0.14 dB 0.18 dB 0.2 dB 0.28 dB 0.43 dB	Agilent N5531S Measuring Receiver N1912A w/E9304A Power Sensor
RF Power – Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.35 dB	
	(-115 to -120) dB	0.4 dB	
	(-120 to -125) dB	0.51 dB	
	(3 050 to 6 600) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.48 dB	
	(-120 to -125) dB	0.64 dB	
	(6 600 to 13 200) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -100) dB	0.34 dB	
	(-100 to -105) dB	0.37 dB	
	(-105 to -110) dB	0.45 dB	
	(-110 to -115) dB	0.6 dB	
	(-115 to -120) dB	0.82 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.31 dB	
	(-58 to -78) dB	0.32 dB	
	(-78 to -90) dB	0.33 dB	
	(-90 to -95) dB	0.35 dB	
	(-95 to -100) dB	0.41 dB	
	(-100 to -105) dB	0.53 dB	
	(-105 to -110) dB	0.72 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1]	(18 000 to 19 200) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB (19 200 to 26 500) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB	 0.48 dB 0.38 dB 0.39 dB 0.4 dB 0.41 dB 0.42 dB 0.47 dB 0.58 dB 0.75 dB 0.48 dB 0.38 dB 0.39 dB 0.4 dB 0.43 dB 0.5 dB 0.63 dB 0.84 dB 1.1 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
(30 to 3 050) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (110 to 120) dB	(30 to 3 050) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (110 to 120) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.13 dB 0.26 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Measure [1]	(3 050 to 6 600) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.15 dB	
	(110 to 120) dB	0.37 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.14 dB	
	(100 to 110) dB	0.34 dB	
	(110 to 120) dB	0.77 dB	
	(13 200 to 19 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.27 dB	
	(100 to 110) dB	0.66 dB	

Electrical – RF/Microwave Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Measure [1]	(19 200 to 26 500) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.2 dB 0.52 dB 1.1 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor
Amplitude Modulation – Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 0.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver
Frequency Modulation – Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 26.5) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.20 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8.0 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad	 3 % of reading 1 % of reading 3 % of reading 1 % of reading 3 % of reading 1 % of reading	Agilent N5531S Measuring Receiver
Phase Noise for Signal Sources [1] Offset Frequency, ≤ 100 kHz	5 MHz < f ≤ 18 GHz	2.3 dB	HP 3048A Phase Noise System with 866XA Source
RF Power – Generate [1]	(30 to 2 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB (2 000 to 3 050) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB (3 050 to 6 600) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB (6 600 to 13 200) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (13 200 to 18 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB	 0.26 dB 0.28 dB 0.29 dB 0.3 dB 0.37 dB 0.37 dB 0.38 dB 0.38 dB 0.4 dB 0.52 dB 0.37 dB 0.38 dB 0.38 dB 0.4 dB 0.52 dB 0.37 dB 0.38 dB 0.38 dB 0.49 dB 0.37 dB 0.38 dB 0.38 dB 0.75 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor, E8257D Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Generate [1]	(18 000 to 19 200) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (19 200 to 26 500) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB	 0.49 dB 0.50 dB 0.5 dB 0.81 dB 0.49 dB 0.5 dB 0.5 dB 1.2 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 526 Power Sensor, E8257D Signal Generator
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB	Agilent N5531S Measuring Receiver
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 26.5) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver
PM Distortion Measure [1]	(1 to 6 600) MHz Rate (20 to 500) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 0.4 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 1.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(6.6 to 13.2) GHz Rate (20 to 500) Hz Dev > 1.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 5.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Rate (500 to 1 000) Hz Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 26.5) GHz Rate 20 to 500 Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(13.2 to 26.5) GHz Rate 500 Hz to 1000 Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1kHz to 600MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz 2nd through 4th Harmonic (5 300 to 6 625) MHz 2nd through 3rd Harmonic (6 625 to 8 833) MHz 2nd Harmonic (8 833 to 13 250) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB	Agilent E4440A Measuring Receiver

Length – Dimensional Metrology Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	Up to 13 in	(3.8 + 2.4*L*) µin	Master gage blocks, P&W Labmaster Universal
Micrometer Standards Length Rods	Up to 13 in	(0.75 + 6.9*L*) µin	Gage blocks (grade 2), P&W Labmaster Universal
Micrometers [1,2]	Up to 40 in	(31 + 4.1*L*) µin	Gage blocks (grade 2)
Calipers [1,2]	Up to 40 in	(280 + 1.8*L*) µin	
Dial Indicators [1,2] Resolution ≥ 50µin Resolution < 50µin	Up to 10 in Up to 0.1 in	(27 + 3.3*L*) µin 7 µin	Gage blocks (grade 2)
Height Gages [1,2]	Up to 40 in	(98 + 2.6*L*) µin	
Rulers [1]	Up to 46 in	0.009 1 in	
Feeler Gage [1]	Up to 1 in	45 µin	Pratt & Whitney Supermicrometer C
Radius Gages	(0.01 to 1) in	590 µin	Optical comparator
Bore Micrometers/Gages [2] 2 point 3 point	Up to 8 in	(7 + 2L) µin (42 + 1.4L) µin	Master gage blocks, P&W universal measuring machine, Master Ring
Protractors [1]	(0 to 360) °	0.019 °	Angle blocks, Sine Bar, Gage Blocks Grade 0
Parallelism & Straightness	(0 to 4) in	110 µin	Gage Amplifier, Surface Plate
Cylindrical Gages [2] Plain Pins, Plugs Rings	(0 to 13) in (0.04 to 14) in	(2 + 3*D*) µin (6.5 + 3.2*D*) µin	Master gage blocks, P&W universal measuring machine
Thread Plugs [1] Major Diameter Pitch Diameter	Up to 12 in Up to 12 in	52 µin 110 µin	B & S 599-246-00, Van Keuren thread wire set, Gage blocks, P & W Model C
Thread Rings [3] Pitch Diameter (tactile fit)	Up to 12 in	(350 + 47*D*) µin	Thread setting plug gages
Surface Plates [1] – Overall Flatness Local Area Flatness	Up to 6 ft × 6 ft (-0.001 to 0.001) in	125 µin 68 µin	Planekator Repeat-o-meter

Length – Dimensional Metrology Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Comparators [1] Linearity Magnification Angle	Up to 20 in (20 to 40) in (10 to 100) X (0 to 360)°	190 µin 350 µin 250 µin 0.02°	Gage blocks, SI Industries glass scales, angle blocks
Tape Measures [2]	Up to 100 ft	(0.000 26F + 0.026) in	Standard rule
Coating Thickness Gages [1,2] Eddy Current & Magnetic Induction	(0.9 to 20) mils	75 µin	Coating thickness Standards
Coating Thickness Shims [2]	(0 to 243) mils	61 µin	Pratt & Whitney Supermicrometer C
Ultrasonic Thickness Gauges [1]	Up to 10 in	590 µin	Gage blocks

Mass and Mass Related Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [1,2,4]	(1 to 400) g	(0.001 5X + 0.019) mg	Class 0 Weights
Scales & Balances [1,2,4]	(1 to 1 000) g (1 000 to 40 000) g	(0.0031X + 0.04) mg (0.003 3X) mg	Class 1 Weights
Scales & Balances [1,2,4]	(1 to 9 100) g	(0.12X + 9.3) mg	Class F Weights
Scales & Balances [1,2,4]	(0.002 to 1 000) lb	(0.000 12W + 0.000 04) lb	Class F Weights
Force [1] Tension and Compression	(0.5 to 500) lbf	0.09 % of reading	Class F weights
Pressure - Generate	(10 to 500) psi (200 to 10 000) psi	0.008% of reading 0.01% of reading	Fluke P3224-PSI Pressure Calibrator

Mass and Mass Related Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure [1]	(-1 to 1) inH_2O (-50 to 50) inH_2O (-30 to 0) inHg (-15 to 30) psi (30 to 100) psi (100 to 500) psi (500 to 1 000) psi (1 000 to 5 000) psi (5 000 to 15 000) psi	0.001 2 inH_2O 0.058 inH_2O 0.015 inHg 0.007 2 psi 0.033 psi 0.14 psi 0.3 psi 1.5 psi 8.9 psi	Digital Pressure Gages Additel ADT681-05-DP1 Additel ADT681-05-DP50 Additel ADT681-02-CP30 Additel ADT681-02-CP30 Additel ADT681-02-GP100 Additel ADT681-02-GP500 Additel ADT681-02-GP1K Additel ADT681-02-GP5K Additel ADT681-05-GP15K
Torque Tools [1]	(1 to 10) ozf·in (10 to 100) ozf·in 4 lbf·in to 1 000 lbf·ft	0.63 % of reading 0.6 % of reading 0.32 % of reading	AWS QCMIO-10 CDI 1001-O-DDT CDI 5000 ST torque tester
Torque Analyzers	(1 to 20) ozf·in (20 to 100) ozf·in (4 to 150) lbf·in (12.5 to 250) lbf·ft	0.25 % of reading 0.12 % of reading 0.04 % of reading 0.16 % of reading	Torque wheels & weights
Rockwell Hardness Testers [1]	(0 to 59) HRBW (60 to 79) HRBW (80 to 100) HRBW (20 to 39) HRC (40 to 59) HRC (60 to 70) HRC (20 to 65) HRA (70 to 78) HRA (80 to 84) HRA	1.9 HRBW 1.4 HRBW 1.3 HRBW 1.3 HRC 1.3 HRC 0.68 HRC 1.3 HRA 1.3 HRA 0.68 HRA	Indirect verification per ASTM E18

Thermodynamic Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber
Relative Humidity – Measure	(0 to 90) %RH	1.3 %RH	Vaisala MI70 / HMP75 Thermohygrometer
Temperature – Measuring Equipment [1]	(-25 to 375) °C	0.19 °C	Hart 1502A with 5615 PRT and dry block

Thermodynamic Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	(-196 to 232) °C (-321to 450) °F (232 to 420) °C (450 to 788) °F	0.026 °C 0.047 °F 0.033 °C 0.059 °F	Hart 1502A Indicator with 5615 PRT
Infrared (IR) Thermometry [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 Blackbody ε = 0.95, λ= (8 to 14) µm

Time and Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-12} Hz/Hz	HP 58503A GPS Receiver
Frequency – Generate [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-12} Hz/Hz + 0.57 µHz 1 x 1^{e-12} Hz/Hz + 5.7 µHz 1 x 1^{e-12} Hz/Hz + 57 µHz 1 x 1^{e-12} Hz/Hz + 0.57 mHz 1 x 1^{e-12} Hz/Hz + 5.7 mHz 1 x 1^{e-12} Hz/Hz + 57 mHz 1 x 1^{e-12} Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	(10 to 40 000) MHz	1 x 1^{e-12} Hz/Hz + 0.57mHz	Agilent E8257D Opt 540 Signal Generator / HP 58503A GPS Receiver
Time – Generate	1 pps	1 x 1^{e-12} s/s + 750 ps	HP 58503A GPS Receiver
Frequency – Measure [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 200) kHz (0.2 to 3 000) MHz	1.82 x 1^{e-9} Hz/Hz 0.59 x 1^{e-9} Hz/Hz 0.20 x 1^{e-9} Hz/Hz 74 x 1^{e-10} Hz/Hz 35 x 1^{e-10} Hz/Hz 23 x 1^{e-10} Hz/Hz 20 x 1^{e-10} Hz/Hz	Agilent 53132A Opt 030 Frequency Counter / HP 58503A GPS Receiver
Frequency – Measure [1]	(10 to 26 500) MHz	1 x 1^{e-12} Hz/Hz + 0.1 Hz	Agilent E4440A Spectrum Analyzer / HP 58503A GPS Receiver
Type I (digital) Timers	(0 to19.99) sec/day (0 to 599) sec/month	0.031 sec/day 1.1 sec/month	Helmut Klein Timometer 4500

Time and Frequency Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Type II (mechanical) Timers	(0 to 320) sec/day	0.6 sec/day	Helmut Klein Timometer 4500
Tachometers – RPM [1]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 33250A Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length	X Axis (0.01 to 10) in Y Axis (0.01 to 6) in	162 µin 123 µin	Optical comparator

2 Dimensional Melbourne, FL

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle	Up to 360°	0.006°	Optical comparator

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Services performed at satellite laboratory

Technical Maintenance, Inc.
Toyo Tires
3660 Highway 411 N.E.
White, GA 30184
Chris Hale (On-site Technical Services Operations Manager) Phone: (318) 805-8600
Scott Chamberlain (Quality Manager) Phone: (321) 242-0890

CALIBRATION

Electrical – DC/Low Frequency White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate	(0 to 329.999) mV 330 mV to 3.299 99 V (3.3 to 32.999 9) V (33 to 329.999) V (330 to 1 020) V	0.028 % of reading + 10 µV 0.013 % of reading + 15 µV 0.016 % of reading + 150 µV 0.015 % of reading + 1.5 mV 0.015 % of reading + 5.5 mV	Fluke 5080A Multiproduct Calibrator
DC Voltage – Measure	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	0.007 6 % of reading + 3.5 µV 0.005 8 % of reading + 7 µV 0.005 1 % of reading + 50 µV 0.006 4 % of reading + 600 µV 0.005 6 % of reading + 10 mV	Fluke 8845A Multimeter
DC Current – Generate	(0 to 329.99) µA (.330 to 3.299 9) mA (3.3 to 32.999) mA (33 to 329.999) mA 330 mA to 1.099 9 A (1.1 to 2.999 9) A (3 to 10.999) A (11 to 20.5) A	0.1 % of reading + 0.1 µA 0.095 % of reading + 0.25 µA 0.083 % of reading + 1.25 µA 0.1 % of reading + 16.5 µA 0.18 % of reading + 220 µA 0.19 % of reading + 220 µA 0.29 % of reading + 2.5 mA 0.58 % of reading + 3.8 mA	Fluke 5080A Multiproduct Calibrator
	(20.5 to 150) A (150 to 1 050) A	0.44 % of reading + 0.14 A 0.55 % of reading + 0.14 A	Fluke 5080A Multiproduct Calibrator, 5500A/Coil x50
Resistance – Generate	0 Ω 100 Ω 1 000 Ω	0.014 Ω 0.049 % of reading 0.029 % of reading	Fluke 5080A Multiproduct Calibrator
Resistance – Generate	10 kΩ 100 kΩ 1 MΩ 10 MΩ	0.029 % of reading 0.044 % of reading 0.11 % of reading 0.12 % of reading	Fluke 5080A Multiproduct Calibrator

Electrical – DC/Low Frequency White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate	100 MΩ 1 000 MΩ	1 % of reading 1 % of reading	Tsuruga 5804 Resistor
AC Voltage – Generate 45 Hz to 1 kHz	(1 to 32.99) mV (33 to 329.99) mV 330 mV to 3.299 9 V (3.3 to 32.999) V (33 to 101.99) V (102 to 329.99) V (330 to 1 020) V	0.42 % of reading + 60 µV 0.2 % of reading + 60 µV 0.15 % of reading + 180 µV 0.16 % of reading + 1.8 mV 0.19 % of reading + 18 mV 0.19 % of reading + 18 mV 0.2 % of reading + 180 mV	Fluke 5080A Multiproduct Calibrator
AC Voltage – Measure	(0 to 100) mV 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.1to 1) V 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (1 to 10) V 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (10 to 100) V 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (100 to 750) V 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	 0.12 % of reading + 0.04 mV 0.19 % of reading + 0.05 mV 0.79 % of reading + 0.08 mV 4.8 % of reading + 0.5 mV 0.13 % of reading + 0.3 mV 0.18 % of reading + 0.5 mV 0.74 % of reading + 0.8 mV 4.7 % of reading + 5 mV 0.12 % of reading + 3 mV 0.18 % of reading + 5 mV 0.74 % of reading + 8 mV 4.7 % of reading + 50 mV 0.12 % of reading + 30 mV 0.18 % of reading + 50 mV 0.74 % of reading + 80 mV 4.7 % of reading + 500 mV 0.12 % of reading + 0.3 V 0.18 % of reading + 0.5 V 0.74 % of reading + 0.8 V 4.7 % of reading + 5 V	Fluke 8845A Multimeter

Electrical – DC/Low Frequency White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate 45 Hz to 1 kHz	(29 to 329.9) µA 330 µA to 3.299 9 mA (3.3 to 32.999) mA (33 to 329.99) mA 330 mA to 1.099 9 A (1.1 to 2.999 9) A (3 to 10.999) A (11 to 20.5) A	0.31 % of reading + 0.75 µA 0.27 % of reading + 0.9 µA 0.23 % of reading + 12 µA 0.32 % of reading + 120 µA 0.28 % of reading + 1.2 mA 0.33 % of reading + 1.5 mA 0.47 % of reading + 6 mA 0.8 % of reading + 15 mA	Fluke 5080A Multiproduct Calibrator
AC Current – Generate 45 Hz to 1 kHz	(20.5 to 1 000) A (45 to 65) Hz (65 to 440) Hz	0.57 % of reading + 1 A 0.86 % of reading + 0.98 A	Fluke 5080A Multiproduct Calibrator, 5500A/Coil x50
Electrical Simulation of Thermocouple Indicators	Type J (-200 to -0) °C (0 to 1 200) °C	1.2 °C 0.83 °C	Fluke 725 Process Calibrator
Electrical Simulation of RTD Indicators	Pt100-385 (0 to 200) °C Pt100-392 (0 to 200) °C	0.39 °C 0.36 °C	

Length – Dimensional Metrology White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers	Up to 300 mm	1.6 µm	Gage Blocks
Micrometers	Up to 25 mm	0.63 µm	Gage Blocks
Dial Indicators	Up to 50 mm	1 µm	Gage Blocks
Linear Scales – Rulers	Up to 300 mm	0.29 mm	Gage Blocks
Tape Measures	Up to 300 cm	0.69 mm	Steel Rule

Mass and Mass Related White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances [2,4]	(0.1 to 250) kg	9 g + 0.6*R*	F Class Weights

Mass and Mass Related White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure	Up to 100 psi Up to 689 kPa	0.09 psi 0.62 kPa	Fluke 700P06 Pressure Module
	Up to 300 psi Up to 2 068 kPa	0.22 psi 1.5 kPa	Fluke 700P27 Pressure Module
	Up to 1 000 psi Up to 6 895 kPa	0.72 psi 5 kPa	Fluke 700P08 Pressure Module
	Up to 10 000 psi Up to 68 948 kPa	10 psi 69 kPa	Fluke 700P31 Pressure Module

Thermodynamic White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RTD – Measure Pt100-385 Pt100-3926	 (0 to 200) °C (0 to 200) °C	 0.39 °C 0.36 °C	Fluke 725 Process Calibrator
Type J Thermocouples Measure	(50 to 105) °C	1.2 °C	Fluke 725 Process Calibrator, Fluke 9140 Dry Block

Time and Frequency White, GA

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency	(45 to 119.99) Hz (120 to 1 000) Hz	0.017 % of reading + 2 mHz 0.16 % of reading + 2 mHz	Fluke 5080A Multiproduct Calibrator

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Services performed at satellite laboratory

Technical Maintenance, Inc.
1355 Garden of the Gods Road, Suite 100
Colorado Springs, CO 80907
Glenn Curtis (Branch Manager) Phone: (719) 424-7068
Scott Chamberlain (Quality Manager) Phone: (321) 242-0890

CALIBRATION AND DIMENSIONAL MEASUREMENT

CALIBRATION

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometers – Acceleration	(0.01 to 10) g (5 to < 10) Hz (10 to < 30) Hz (30 to < 2 000) Hz (2 to 10) kHz	4 % of reading 3 % of reading 1.5 % of reading 4 % of reading	Accelerometer Calibrator

Chemical Quantities Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH meters [1,5]	4 pH 7 pH 10 pH	0.016 pH 0.025 pH 0.061 pH	pH buffer solutions
Conductivity Meters [1,5]	0.65 µS/cm 10 µS/cm 100 µS/cm 1 000 µS/cm 10 000 µS/cm 100 000 µS/cm	0.33 µS/cm 0.64 µS/cm 2.1 µS/cm 5 µS/cm 44 µS/cm 400 µS/cm	Conductivity solutions

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Generate [1]	(1 to 2.2) nA (2.2 to 22) nA (22 to 220) nA (0.22 to 2.2) µA (2.2 to 10) µA	93 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 15 µA/A + 1 nA	Fluke 5730A Multifunction Calibrator, Fluke 5522A Multiproduct Calibrator
DC Current – Generate [1]	(10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 6 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5730A Multifunction Calibrator
DC Current – Generate [1]	(2.2 to 11) A	274 µA/A + 371 µA	Fluke 5730A Multifunction Calibrator 5725A Amplifier
DC Current – Generate [1]	(11 to 20.5) A	761 µA/A + 631 µA	Fluke 5522A Multiproduct Calibrator
DC Current – Generate 1 Clamp Meters	(0 to 200) A	0.21 % of output + 0.028 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
DC Current – Generate 1 Clamp Meters	(0 to 1 000) A	0.21 % of output + 0.04 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.12 pA 13 µA/A + 1.2 pA 9.1 µA/A + 0.01 nA 7.9 µA/A + 0.12 nA	Fluke 5730A Multifunction Calibrator Agilent 3458A Option 002 Multimeter
DC Current – Measure [1]	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 0.8 nA 20 µA/A + 5 nA 20 µA/A + 0.05 µA 35 µA/A + 0.5 µA 110 µA/A + 10 µA	Agilent 3458A Multimeter
DC Current – Measure [1]	(1 to 3) A (3 to 10) A	761 µA/A + 462 µA 1.1 mA/A + 614 µA	Fluke 8846A Multimeter
DC Current – Measure [1]	(1 to 1 000) A	0.25 % of reading	Agilent 3458A Option 002 Multimeter, Empro Current Shunt

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Generate [1]	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5730A Multifunction Calibrator
DC Voltage – Measure [1]	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	5.0 µV/V + 1.2 µV 4.0 µV/V + 1.2 µV 4.0 µV/V + 2.1 µV 6.0 µV/V + 30 µV 6 µV/V + 100 µV + 12 µV/V x (Vin/1 000) ^2	Agilent 3458A Option 002 Multimeter
DC Voltage – Measure [1]	(1 to 30) kV	0.1 % of reading	Ross VD30 High Voltage Divider, Fluke 287 Multimeter
AC Voltage – Generate [1]	(0.22 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 (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	 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV 228 µV/V + 3.9 µV 88 µV/V + 3.9 µV 76 µV/V + 3.9 µV 190 µV/V + 3.9 µV 457 µV/V + 4.6 µV 989 µV/V + 9.2 µV 1.3 mV/V + 19 µV 2.6 mV/V + 19 µV	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(22 to 220) mV		Fluke 5730A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 11.4 µV	
	(20 to 40) Hz	88 µV/V + 6.1 µV	
	40 Hz to 20 kHz	53 µV/V + 6.1 µV	
	(20 to 50) kHz	114 µV/V + 6.1 µV	
	(50 to 100) kHz	304 µV/V + 15.2 µV	
	(100 to 300) kHz	609 µV/V + 19 µV	
	(300 to 500) kHz	1.3 mV /V + 23 µV	
	500 kHz to 1 MHz	2.5 mV /V + 46 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	228 µV/V + 38 µV	
	(20 to 40) Hz	84 µV/V + 15 µV	
	40 Hz to 20 kHz	37 µV/V + 8 µV	
	(20 to 50) kHz	61 µV/V + 9 µV	
	(50 to 100) kHz	76 µV/V + 30 µV	
	(100 to 300) kHz	304 µV/V + 76 µV	
	(300 to 500) kHz	913 µV /V + 190 µV	
	500 kHz to 1 MHz	1.5 mV/V + 304 µV	
	(2.2 to 22) V		
	(10 to 20) Hz	228 µV/V + 380 µV	
	(20 to 40) Hz	84 µV/V + 152 µV	
	40 Hz to 20 kHz	37 µV/V + 54 µV	
	(20 to 50) kHz	61 µV/V + 91 µV	
	(50 to 100) kHz	76 µV/V + 190 µV	
	(100 to 300) kHz	228 µV/V + 609 µV	
	(300 to 500) kHz	913 µV/V + 1.9 mV	
	500 kHz to 1 MHz	1.4 mV/V + 3 mV	
	(22 to 220) V		
	(10 to 20) Hz	228 µV/V + 3.8 mV	
	(20 to 40) Hz	84 µV/V + 1.5 mV	
	40 Hz to 20 kHz	49 µV/V + 0.6 mV	
	(20 to 50) kHz	76 µV/V + 0.9 mV	
	(50 to 100) kHz	137 µV/V + 2.3 mV	

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5730A Multifunction Calibrator, 5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 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 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (11 to 33) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 13 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV 0.58 % of output + 6.1 µV 0.53 % of output + 6.1 µV 0.54 % of output + 8.4 µV 0.54 % of output + 8.4 µV 0.55 % of output + 8.4 µV 0.61 % of output + 8.4 µV 0.93 % of output + 8.4 µV 0.52 % of output + 12 µV 0.46 % of output + 12 µV 0.47 % of output + 14 µV 0.47 % of output + 14 µV 0.49 % of output + 14 µV 0.55 % of output + 14 µV 0.89 % of output + 14 µV	Fluke 5730A Option 003 Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(33 to 110) mV		Fluke 5730A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	(0.33 to 1.1) V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	
	(1.1 to 3.5) V		
	(10 to 30 Hz)	0.39 % of output + 0.4 mV	
	30 Hz to 500 kHz	0.3 % of output + 0.4 mV	
	(0.5 to 1.2) MHz	0.32 % of output + 0.4 mV	
	(1.2 to 2) MHz	0.32 % of output + 0.4 mV	
	(2 to 12) MHz	0.35 % of output + 0.4 mV	
	(12 to 20) MHz	0.44 % of output + 0.4 mV	
	(20 to 30) MHz	0.82 % of output + 0.4 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.03 % of reading + 3 µV	
	40 Hz to 1 kHz	0.02 % of reading + 1.1 µV	
	(1 to 20) kHz	0.03 % of reading + 1.1 µV	
	(20 to 50) kHz	0.1 % of reading + 1.1 µV	
	(50 to 100) kHz	0.5 % of reading + 1.1 µV	
	100 kHz to 1 MHz	1.2 % of reading + 5 µV	
	(1 to 4) MHz	7 % of reading + 7 µV	
	(4 to 8) MHz	20 % of reading + 8 µV	

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.007 % of reading + 4 µV	
	40 Hz to 1 kHz	0.007 % of reading + 2 µV	
	(1 to 20) kHz	0.014 % of reading + 2 µV	
	(20 to 50) kHz	0.03 % of reading + 2 µV	
	(50 to 100) kHz	0.08 % of reading + 2 µV	
	(100 to 300) kHz	0.3 % of reading + 10 µV	
	300 kHz to 1 MHz	1 % of reading + 10 µV	
	(1 to 2) MHz	1.5 % of reading + 70 µV	
	(2 to 4) MHz	4 % of reading + 70 µV	
	(4 to 8) MHz	4 % of reading + 80 µV	
	(8 to 10) MHz	15 % of reading + 100 µV	
	(0.10 to 1) V		
	(1 to 40) Hz	0.007 % of reading + 40 µV	
	40 Hz to 1 kHz	0.07 % of reading + 20 µV	
	(1 to 20) kHz	0.014 % of reading + 20 µV	
	(20 to 50) kHz	0.03 % of reading + 20 µV	
	(50 to 100) kHz	0.08 % of reading + 20 µV	
	(100 to 300) kHz	0.3 % of reading + 100 µV	
	300 kHz to 1 MHz	1 % of reading + 100 µV	
	(1 to 2) MHz	1.5 % of reading + 0.7 mV	
	(2 to 4) MHz	4 % of reading + 0.7 mV	
	(4 to 8) MHz	4 % of reading + 0.8 mV	
	(8 to 10) MHz	15 % of reading + 1 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.007 % of reading + 0.4 mV	
	40 Hz to 1 kHz	0.007 % of reading + 0.2 mV	
	(1 to 20) kHz	0.014 % of reading + 0.2 mV	
	(20 to 50) kHz	0.03 % of reading + 0.2 mV	
	(50 to 100) kHz	0.08 % of reading + 0.2 mV	
	(100 to 300) kHz	0.3 % of reading + 1 mV	
	300 kHz to 1 MHz	1 % of reading + 1 mV	
	(1 to 2) MHz	1.5 % of reading + 7 mV	
	(2 to 4) MHz	4 % of reading + 7 mV	
	(4 to 8) MHz	4 % of reading + 8 mV	
	(8 to 10) MHz	15 % of reading + 10 mV	

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.02 % of reading + 4 mV 0.02 % of reading + 2 mV 0.02 % of reading + 2 mV 0.035 % of reading + 2 mV 0.12 % of reading + 2 mV 0.4 % of reading + 10 mV 1.5 % of reading + 10 mV 0.04 % of reading + 40 mV 0.04 % of reading + 20 mV 0.06 % of reading + 20 mV 0.12 % of reading + 20 mV 0.3 % of reading + 20 mV	Agilent 3458A/002 Precision Multimeter
AC Voltage – Measure [1]	(1 to 5) kV 60 Hz (5 to 21) kV 60 Hz	 0.5 % of reading 0.5 % of reading	Ross VD30 Voltage Divider, Fluke 287 Multimeter
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 91 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 91 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4566 nA	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(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 (0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 228 µA/A + 4 µA 152 µA/A + 3 µA 91 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA 228 µA/A + 31 µA 380 µA/A + 76 µA 0.61 % of reading + 152 µA	Fluke 5730A Multifunction Calibrator
AC Current – Generate [1]	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 350 µA /A + 141 µA 723 µA /A + 295 µA 0.27 % of reading + 573 µA	Fluke 5730A Multifunction Calibrator, 5725 Amplifier
AC Current – Generate [1]	(11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	 0.09 % of output + 5 mA 0.11 % of output + 5 mA 2.3 % of output + 5 mA	Fluke 5522A Multiproduct Calibrator
AC Current – Generate [1] Clamp Meters	(3.3 to 30) A (10 to 100) Hz (100 to 440) Hz (30 to 200) A 10 to 100 Hz (100 to 440) Hz	 0.22 % of output + 0.028 A 0.3 % of output + 0.07 A 0.22 % of output + 0.032 A 0.79 % of output + 0.08 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x10 Coil
AC Current – Generate [1] Clamp Meters	(16.5 to 150) A (10 to 100) Hz (100 to 440) Hz (150 to 1 000) A (10 to 100) Hz (100 to 440) Hz	 0.22 % of output + 0.029 A 0.3 % of output + 0.08 A 0.22 % of output + 0.081 A 0.79 % of output + 0.20 A	Fluke 5522A Multiproduct Calibrator / 9100-200 x50 Coil
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz 100 µA to 1 mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 0.03 µA 0.15 % of reading + 0.03 µA 0.06 % of reading + 0.03 µA 0.4 % of reading + 0.2 µA 0.15 % of reading + 0.2 µA 0.06 % of reading + 0.2 µA 0.03 % of reading + 0.2 µA	Agilent 3458A Multimeter

Electrical – DC/Low Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % of reading + 2 µA 0.15 % of reading + 2 µA 0.06 % of reading + 2 µA 0.03 % of reading + 2 µA 0.4 % of reading + 20 µA 0.15 % of reading + 20 µA 0.06 % of reading + 20 µA 0.03 % of reading + 20 µA 0.4 % of reading + 0.2 mA 0.15 % of reading + 0.2 mA 0.06 % of reading + 0.2 mA 0.03 % of reading + 0.2 mA	Agilent 3458A Multimeter
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz (3 to 10) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz	 0.84 % of reading + 1.4 mA 0.27 % of reading + 1.4 mA 0.11 % of reading + 1.4 mA 0.27 % of reading + 16 mA 0.84 % of reading + 4.6 mA 0.27 % of reading + 4.6 mA 0.11 % of reading + 4.6 mA 0.27 % of reading + 53 mA	Fluke 8846A Multimeter
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 µΩ/Ω + 0.1 µΩ 21 µΩ/Ω + 1 µΩ 9.1 µΩ/Ω + 6 µΩ 6.1 µΩ/Ω + 60 µΩ 6.1 µΩ/Ω + 0.6 mΩ 7.6 µΩ/Ω + 6 mΩ 9.1 µΩ/Ω + 6 mΩ 11.4 µΩ/Ω + 60 mΩ 16 µΩ/Ω + 60 mΩ 35 µΩ/Ω + 0.6 Ω 42 mΩ/Ω + 0.6 Ω 91 mΩ/Ω + 6 Ω	Fluke 5730A Multifunction Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate [1] Fixed Points	100 V 100 kΩ (100 to 1 000) V (1, 10, 100) MΩ (1, 10) GΩ 100 GΩ	 1 % of reading 1 % of reading 1 % of reading 2 % of reading	TMI RB Resistance Standard
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2) kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	15 μΩ/Ω + 56 μΩ 12 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 0.6 mΩ 10 μΩ/Ω + 5.6 mΩ 10 μΩ/Ω + 56 mΩ 15 μΩ/Ω + 2.2 Ω 50 μΩ/Ω + 120 Ω 500 μΩ/Ω + 1.2 kΩ 0.5 % of reading + 70 kΩ	Agilent 3458A Multimeter
Resistance – Generate [1]	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	30 μΩ/Ω + 0.001 Ω 23 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.001 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.002 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.02 Ω 21 μΩ/Ω + 0.2 Ω 21 μΩ/Ω + 0.2 Ω 24 μΩ/Ω + 2 Ω 24 μΩ/Ω + 2 Ω 46 μΩ/Ω + 23 Ω 99 μΩ/Ω + 38 Ω 190 μΩ/Ω + 1.9 kΩ 380 μΩ/Ω + 2.3 kΩ 0.23 % of setting + 76 kΩ 1.1 % of reading + 380 kΩ	Fluke 5522A Multiproduct Calibrator
Capacitance – Generate [1]	(220 to 400) pF (0.4 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 329.999) nF (0.33 to 1.099 99) μF (1.1 to 3.299 99) μF (3.3 to 10.999 9) μF	0.38% of output + 7.6 pF 0.38 % of output + 0.01 nF 0.19 % of output + 0.01 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.08 nF 0.19 % of output + 0.23 nF 0.19 % of output + 0.76 nF 0.19 % of output + 2.3 nF 0.19 % of output + 7.6 nF	Fluke 5522A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate [1]	(11 to 32.999 9) µF (33 to 109.999) µF (110 to 329.999) µF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	0.3 % of output + 23 nF 0.34 % of output + 76 nF 0.34 % of output + 228 nF 0.34 % of output + 0.76 µF 0.34 % of output + 2.3 µF 0.34 % of output + 7.6 µF 0.57 % of output + 23 µF 0.84 % of output + 76 µF	Fluke 5522A Multiproduct Calibrator
Oscilloscopes Calibration[1] – Generate Voltage DC - 50Ω	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 6.6) V	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
DC - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.019 % of reading + 20 µV 0.019 % of reading + 25 µV 0.019 % of reading + 76 µV 0.019 % of reading + 0.6 mV 0.019 % of reading + 6 mV	
Square Wave 10 Hz to 10 kHz - 50Ω	(1 to 24.999) mVpp (25 to 109.99) mVpp (110mV to 2.1999) Vpp (2.2 to 6.6) Vpp	0.19 % of Output + 31 µV 0.19 % of Output + 36 µV 0.19 % of Output + 87 µV 0.19 % of Output + 0.6 mV	
Square Wave 10 Hz to 1 kHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.038 % of reading + 4 µV 0.038 % of reading + 9 µV 0.038 % of reading + 60 µV 0.038 % of reading + 0.6 mV 0.038 % of reading + 6 mV	
Square Wave (1 to 10) kHz - 1MΩ	(1 to 24.999) mV (25 to 109.99) mV (110mV to 2.1999) V (2.2 to 10.999) V (11 to 130) V	0.19 % of reading + 31 µV 0.19 % of reading + 36 µV 0.19 % of reading + 87 µV 0.19 % of reading + 0.6 mV 0.19 % of reading + 6 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness 50 kHz to 10 MHz Reference	3 dB Bandwidth (5 to 50) mVpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz 50 mV to 3.5 Vpp 50 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz (600 to 1 600) MHz (1 600 to 2 100) MHz (3.5 to 5) Vpp 50 kHz to 100) MHz (100 to 300) MHz (300 to 500) MHz (500 to 600) MHz	 0.34 dB 0.36 dB 0.42 dB 0.46 dB 0.5 dB 0.56 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB 0.4 dB 0.44 dB 0.24 dB 0.24 dB 0.32 dB 0.34 dB	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Generate [1] Leveled Sine Flatness	3 dB Bandwidth 50 mV to 3.5Vpp (2 100 to 4 000) MHz (4 000 to 8 000) MHz (8 000 to 18 000) MHz	 0.25 dB 0.35 dB 0.46 dB	EPM Power Meter w/ E Series Power Sensors
Oscilloscopes Calibration – Generate [1] Time Marker	500 ps to 20 ms 50 ms to 5 s	0.25 µs/s 1.9 µs/s + 3.8 µHz	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
Oscilloscopes Calibration – Measure [1] Input Impedance Resistance Leakage	(40 to 60) Ω 500 kΩ to 1.5 MΩ (0 to 5.99) V	0.08 % of reading 0.08 % of reading 0.038 % of reading + 0.8 mV	Fluke 5820A Oscilloscope Calibrator w/ GHz Option
DC/Low Frequency Power – Generate [1]	11 µW to 20 kW DC (45 to 65) Hz, PF = 1	 0.21 % of reading 0.25 % of reading	Fluke 5522A Multiproduct Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type B		Fluke 7526A Process Calibrator
	(600 to 800) °C	0.27 °C	
	(800 to 1 550) °C	0.22 °C	
	(1 550 to 1 820) °C	0.17 °C	
	Type C		
	(0 to 1 000) °C	0.13 °C	
	(1 000 to 1 800) °C	0.18 °C	
	(1 800 to 2 000) °C	0.2 °C	
	(2 000 to 2 316) °C	0.27 °C	
	Type E		
	(-250 to -200) °C	0.19 °C	
	(-200 to -100) °C	0.1 °C	
	(-100 to 0) °C	0.07 °C	
	(0 to 600) °C	0.07 °C	
	(600 to 1 000) °C	0.08 °C	
	Type J		
	(-210 to -100) °C	0.11 °C	
	(-100 to 800) °C	0.07 °C	
	(800 to 1 200) °C	0.08 °C	
	Type K		
	(-250 to -200) °C	0.35 °C	
	(-200 to -100) °C	0.13 °C	
	(-100 to 800) °C	0.08 °C	
	(800 to 1 372) °C	0.1 °C	
	Type L		
	(-200 to -100) °C	0.08 °C	
	(-100 to 900) °C	0.07 °C	
	Type N		
	(-250 to -200) °C	0.56 °C	
	(-200 to -100) °C	0.18 °C	
	(-100 to 0) °C	0.1 °C	
	(0 to 100) °C	0.09 °C	
	(100 to 800) °C	0.08 °C	
	(800 to 1 300) °C	0.1 °C	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	Type R (-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1 000) °C (1 000 to 1 600) °C (600 to 1 767) °C Type S (50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1 600) °C (1 600 to 1 767) °C Type T (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	 0.42 °C 0.34 °C 0.3 °C 0.22 °C 0.17 °C 0.16 °C 0.15 °C 0.18 °C 0.39 °C 0.33 °C 0.29 °C 0.22 °C 0.18 °C 0.17 °C 0.2 °C 0.26 °C 0.13 °C 0.09 °C 0.07 °C 0.13 °C 0.08 °C	Fluke 7526A Process Calibrator
Electrical Calibration of RTD Indicators [1]	Pt 385, 100 Ω (-200 to 800) °C Pt 3926, 100 Ω (-200 to 630) °C Pt 3916, 100 Ω (-200 to 630) °C Pt 385, 200 Ω (-200 to 400) °C (400 to 630) °C Pt 385, 500 Ω (-200 to 630) °C Pt 385, 1 000 Ω (-200 to 630) °C	 0.05 °C 0.05 °C 0.05 °C 0.4 °C 0.5 °C 0.17 °C 0.09 °C	Fluke 7526A Process Calibrator
Power Meter Range Calibration [1]	3 µW to 100 mW	0.25 % of reading	HP 11683A Power Meter Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Flatness – Measure [1]	9 kHz to 2 000 MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power Measure [1]	(100 to 2 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (2 000 to 12 400) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.14 dB 0.06 dB 0.07 dB 0.08 dB 0.15 dB 0.15 dB 0.07 dB 0.07 dB 0.08 dB 0.15 dB	Agilent EPM Series Power Meter 8487A Power Sensor

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(12 400 to 18 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (18 000 to 26 500) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (26 5000 to 40 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (40 000 to 50 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.15 dB 0.08 dB 0.08 dB 0.09 dB 0.15 dB 0.16 dB 0.1 dB 0.1 dB 0.11 dB 0.16 dB 0.17 dB 0.12 dB 0.12 dB 0.13 dB 0.18 dB 0.22 dB 0.19 dB 0.19 dB 0.19 dB 0.23 dB	Agilent EPM Series Power Meter 8487A Power Sensor
RF Power Measure [1]	100 kHz to 30 MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.12 dB 0.13 dB 0.15 dB 0.19 dB 0.26 dB 0.39 dB 0.59 dB	Agilent N5531S Measuring Receiver N1912A w/E9304A H18 Power Sensor
RF Power Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.46 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.26 dB	
	(-110 to -115) dB	0.28 dB	
	(-115 to -120) dB	0.34 dB	
	(-120 to -125) dB	0.7 dB	
	(3 050 to 6 600) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.29 dB	
	(-110 to -115) dB	0.38 dB	
	(-115 to -120) dB	0.53 dB	
	(6 600 to 13 200) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.46 dB	
	(-115 to -120) dB	0.65 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -90) dB	0.26 dB	
	(-90 to -95) dB	0.26 dB	
	(-95 to -100) dB	0.26 dB	
	(-100 to -105) dB	0.29 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(18 000 to 19 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.27 dB	
	(-90 to -95) dB	0.27 dB	
	(-95 to -100) dB	0.27 dB	
	(-100 to -105) dB	0.3 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(19 200 to 26 500) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.28 dB	
	(-90 to -95) dB	0.33 dB	
	(-95 to -100) dB	0.43 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.85 dB	
	(-110 to -115) dB	1.2 dB	
	(-115 to -120) dB	1.5 dB	
	(26 500 to 31 150) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.34 dB	
	(-78 to - 90) dB	0.36 dB	
	(-90 to -95) dB	0.39 dB	
	(-95 to -100) dB	0.46 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.82 dB	
	(-110 to -115) dB	1.1 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(31 150 to 41 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (-105 to -110) dB (41 000 to 45 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (45 000 to 50 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.42 dB 0.3 dB 0.34 dB 0.35 dB 0.48 dB 0.64 dB 0.87 dB 1.2 dB 1.5 dB 0.42 dB 0.3 dB 0.34 dB 0.38 dB 0.68 dB 0.93 dB 1.2 dB 1.6 dB 0.42 dB 0.3 dB 0.34 dB 0.67 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
RF Attenuation – Measure [1]	(30 to 3 050) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.13 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(3 050 to 6 600) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.19 dB	
	(6 600 to 13 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.25 dB	
	(13 200 to 19 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.31 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(19 200 to 26 500) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.14 dB	
	(90 to 100) dB	0.36 dB	
	(100 to 110) dB	0.82 dB	
	(26 500 to 31 150) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.13 dB	
	(90 to 100) dB	0.33 dB	
	(100 to 110) dB	0.77 dB	
	(31 150 to 41 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.14 dB	
	(80 to 90) dB	0.36 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(41 000 to 45 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (45 000 to 50 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.11 dB 0.24 dB 0.6 dB 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.11 dB 0.29 dB 0.7 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
Amplitude Modulation Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (26.5 to 31.15) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (31.15 to 50) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 6.8 % of reading + 0.4 digits 1.9 % of reading + 0.4 digits 26 % of reading + 0.4 digits 6 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 31.15) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (31.15 to 50) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.2 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 – 8.5 % of reading + 17 Hz β > 16 - 1 % of reading + 17 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad (26.5 to 31.15) GHz Deviations: > 1.3 rad Deviations > 4.0 rad (31.15 to 50) GHz Deviations: > 2.4 rad Deviations > 8.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.018 rad 1 % of reading + 0.018 rad	Agilent N5531S Measuring Receiver
RF Power Generate [1]	0.25 to 30 MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB (30 to 2 000) MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB	 0.23 dB 0.23 dB 0.25 dB 0.27 dB 0.43 dB 0.29 dB 0.3 dB 0.31 dB 0.32 dB	Agilent N5531S Measuring Receiver N1912A w/E9304A Power Sensor, E8257D Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Generate [1]	(2 000 to 3 050) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(3 050 to 6 600) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(6 600 to 13 200) MHz		
	(20 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.42 dB	
	(13 200 to 18 000) MHz		
	(15 to 0) dB	0.34 dB	
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.46 dB	
	(18 000 to 19 200) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.5 dB	
	(19 200 to 26 500) MHz		
	(15 to 0) dB	0.41 dB	
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.9 dB	
	(26 500 to 31 150) MHz		
	(15 to 0) dB	0.62 dB	
	(0 to -58) dB	0.63 dB	
	(-58 to -78) dB	0.64 dB	
	(-78 to -110) dB	0.96 dB	
	(31 150 to 41 000) MHz		
	(10 to 0) dB	0.82 dB	
	(0 to -58) dB	0.83 dB	
	(-58 to -78) dB	0.84 dB	
	(-78 to -100) dB	1.1 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Generate [1]	(41 000 to 45 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -100) dB (45 000 to 50 000) MHz (10 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.82 dB 0.83 dB 0.85 dB 1.4 dB 0.82 dB 0.83 dB 1 dB 1.5 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, E8257D Signal Generator
AM Distortion Measure [1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1% (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (26.5 MHz to 50.0 GHz) AM Depth > 3% (0 to -20) dB AM Depth > 5% (0 to -20) dB (-20 to -30) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB 1.8 dB 1.5 dB 3.5 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure [1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz Dev 500 Hz to 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (6.6 to 13.2) GHz Dev > 2.3 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 4.5 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Dev > 2.7 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 6.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (31.15 to 50.0) GHz Dev > 4 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 12.0 kHz (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.4 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(1 to 6 600) MHz		Agilent N5531S Measuring Receiver
	Rate (20 to 500) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.4 rad	0.26 dB	
	(0 to -20) dB	0.79 dB	
	(-20 to -30) dB	2.3 dB	
	(-30 to -40) dB		
	Dev > 1.0 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	(6.6 to 13.2) GHz		
	Rate (20 to 500) Hz		
	Dev > 1.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 5.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure [1]	(13.2 to 31.15) GHz Rate (20 to 500) Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer

Electrical – RF/Microwave Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Harmonics Measure [1]	(-80 to -10) dB 2nd through 5th Harmonic 1kHz to 600MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (5 300 to 10 000) MHz 2nd through 4th Harmonic (10 000 to 12 500) MHz 2nd through 3rd Harmonic (12 500 to 16 667) MHz 2nd Harmonic (16 667 to 25 000) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB 2.3 dB	Agilent E4440A Measuring Receiver
EFT/Burst Generator – Voltage (+/-) Risetime Impulse Duration Burst Duration Burst Period	 10 V to 8 kV 5 ns +/- 30 % 50 ns +/- 30 % 15 ms +/- 20 % 300 ms +/- 20 %	 2.6 % of reading 0.003 % of reading 0.003 % of reading 0.003 % of reading 0.003 % of reading	IEC/EN 61000-4-4 Tektronix TDS784C Oscilloscope, EFT Attenuator Set
Surge Generator – Front Time (+/-) Risetime Open/Short Circuit (+/-) Time to Half Value (+/-) Open Circuit Voltage (+/-) Short Circuit Voltage (+/-) Ring Wave Voltage Ring Wave Risetime	 (0.1 to 50) µs (0.1 to 50) µs (20 to 1 500) µs 10 V to 18 kV (0.125 to 3) kA 1 kV +/- 10 % 1.5 µs +/- 0.5 µs	 0.008 % of reading 0.008 % of reading 0.008 % of reading 2.9 % of reading 2.9 % of reading 2.9 % of reading 0.008 % of reading	IEC/EN 61000-4-5 IEC/EN 61000-4-8 IEC/EN 61000-4-9 IEC/EN 61000-4-10 IEC/EN 61000-4-11 IEC/EN 61000-4-12 Tektronix TDS784C Oscilloscope, Tektronix P5210 High Voltage Probe Pearson 411 Current Probe
ISN – Relative Amplitude (dB) Insertion Loss Impedance Magnitude (Ω) Impedance Phase (°)	 (0 to 120) dB 150 kHz to 80 MHz (0 to 1) kΩ 150 kHz to 80 MHz (-180 to 180)° 150 kHz to 80 MHz	 0.59 dB 2 % of reading 1.8°	CISPR 22, CISPR 32, CISPR 16-1-2 HP 8751A Network Analyzer & HP 87512A Transmission/Reflection Test Set, 85032B Calibration Kit

Electrical – RF/Microwave Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
CDN's & Adapters – (50 to 150) Ω Relative Amplitude (dB) Adapter Insertion Loss Relative Amplitude (dB) Coupling Factor Impedance Magnitude (Ω) Relative Amplitude (dB) Voltage Division Factor	(0 to 120) dB 10 kHz to 230 MHz (0 to 120) dB 10 kHz to 230 MHz (0 to 1) kΩ 10 kHz to 230 MHz (0 to 120) dB 10 kHz to 230 MHz	1.3 dB 1.3 dB 2 % reading 0.59 dB	IEC/EN 61000-4-6 CISPR 16-1-2 HP 8751A Network Analyzer & HP 87512A Transmission/Reflection Test Set, 85032B Calibration Kit
LISN – Relative Amplitude (dB) Insertion Loss Impedance Magnitude (Ω) Impedance – Phase (°) Relative Amplitude (dB) Isolation	(0 to 120) dB 9 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz (0 to 1) kΩ Ω 9 kHz to 500 MHz (-180 to 180)° 9 kHz to 500 MHz (0 to 120) dB 9 kHz to 100 MHz (100 to 300) MHz (300 to 500) MHz	0.59 dB 1.3 dB 1.8 dB 2 % of reading 1.8° 0.59 dB 1.3 dB 1.8 dB	ANSI C63.4, CISPR 25, CISPR 16-1-2 HP 8751A Network Analyzer & HP 87512A Transmission/Reflection Test Set, 85032B Calibration Kit
Current Probes and Bulk Current Injection Probes Insertion Loss and Transfer Impedance Relative Amplitude (dB)	(0 to 120) dB 20 Hz to 100 MHz (100 to 300) MHz (300 to 500) MHz	0.59 dB 1.3 dB 1.8 dB	CISPR 16-1-2 IEC/EN 61000-4-6 HP 8751A Network Analyzer & HP 87512A Transmission/Reflection Test Set, 85032B Calibration Kit
Source Errors for CISPR Bands A, B, C and D for Impulse Spectral Amplitude Absolute Amplitude Pulse Response & Relative Ratio	Band A (0 to 120) dB (10 to 150) kHz Band B (0 to 120) dB (0.15 to 30) MHz	0.82 dB 0.82 dB	IGUU 2918 Pulse Generator CISPR 16-1-1 Signal Generator, Agilent 33250A Waveform Generator
Source Errors for CISPR Bands A, B, C and D for Impulse Spectral Amplitude Absolute Amplitude Pulse Response & Relative Ratio	Band C and D (0 to 120) dB (30 to 1 000) MHz (0 to 120) dB Band E (1 to 18) GHz	1.5 dB 0.77 dB	IGUU 2918 Pulse Generator CISPR 16-1-1 Signal Generator, Agilent 33250A Waveform Generator

Electrical – RF/Microwave Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Source Errors for Sinewave output for CISPR Checks (at 60 dBµV) Absolute Amplitude	60 dBµV Band A through D Band E	 0.58 dB 0.58 dB	CISPR 16-1-1 Agilent E8257D Signal Generator, Agilent 33250A Waveform Generator
QuasiPeak to Peak & Average Detector Response Relative Amplitude Ratio	(-60 to 60) dB Band A through D	1.3 dB	IGUU 2918 Pulse Generator
Return Loss (VSWR) 30 kHz to 6 GHz 6 GHz to 18 GHz	 (0 to 80) dB (0 to 50) dB	 2.4 dB 0.32 dB	Agilent 8753ES Network Analyzers Wiltron 87A50 VSWR Bridge
ESD Simulators Contact Voltage (Positive and Negative) Risetime Peak Current 30 ns Current 60 ns Current Air Discharge Voltage (Positive and Negative) Risetime RC Time Constant (at +/- 15 kV)	 (0 to 20) kV (20 to 30) kV (0 to 5) ns (0 to 60) A (0 to 60) A (0 to 60) A (1 to 20) kV (20 to 30) kV (0 to 5) ns 600 ns +/- 130 ns (for 330 pF probe) 300 ns +/- 60 ns (for 150 pF probe)	 1.2 % of reading + 2V 1.2 % of reading + 20V 31.5 ps 4.2 % of reading 4.2 % of reading 4.2 % of reading 1.2 % of reading + 2V 1.2 % of reading + 20V 31.5 ps 7.2 ns 6 ns	 ESVM Agilent 54855A Oscilloscope, IEC ESD Target IEC 61000-4-2 ISO 10605 MIL STD 331

Length – Dimensional Metrology Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	Up to 13 in	(4.2 + 2.1*L*) µin	Master gage blocks P&W Universal Measuring Machine

Length – Dimensional Metrology Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers [1,2]	Up to 40 in	(28 + 4.6*L*) µin	Gage Blocks
Bore Micrometers [2] 2 point 3 point	 Up to 12 in Up to 3 in	 (56 + 3.3*L*) µin (57 + 2.8*L*) µin	Master gage blocks, P&W Labmaster Universal, Master Ring
Calipers [1,2]	Up to 40 in	(280 + 1.8*L*) µin	Gage Blocks
Dial Indicators [1,2] Resolution ≥ 50µin Resolution < 50µin	 Up to 10 in Up to 0.1 in	 (26 + 3.8*L*) µin 8.1 µin	Gage Blocks
Height Gages [1,2]	Up to 40 in	(95 + 3*L*) µin	Gage Blocks
Rulers [1]	Up to 46 in	0.009 1 in	Gage Blocks
Tape Measures[2]	Up to 100 ft	(0.000 26*F* + 0.025) in	Standard rule
Protractors[1]	(0 to 360)°	0.013°	Angle Blocks
Rotary Encoders - Angle [1]	(0 to 360)°	24 arc sec	Rotary Encoder
Feeler Gage	Up to 1 in	31 µin	Pratt & Whitney Supermicrometer C
Cylindrical Gages [2] Plain Pins, Plugs Plain Rings	 (0 to 13) in (0.04 to 14) in	 (10 + 3.1*D*) µin (11 + 3.2*D*) µin	Master gage blocks P&W Universal Measuring Machine
Solid Thread Rings Pitch Diameter	Up to 12 in	98 µin	Pratt & Whitney Labmaster Measuring Machine
Thread Plugs Major Diameter Pitch Diameter	 Up to 10 in Up to 10 in	 44 µin 79 µin	Thread Wires Gage Blocks Pratt & Whitney Supermicrometer C
Thread Rings [2] Pitch Diameter	 Up to 1 in	 (350 + 47*D*) µin	Thread Setting Plugs Tactile Fit
Thread Wires	Up to 0.5 in	11 µin	Master gage blocks, P&W universal measuring machine

Length – Dimensional Metrology Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Plates [1] Overall Flatness Local Area Flatness	 (18 x 18) in to (6 x 6) ft (-0.001 to 0.001) in	 86 µin 68 µin	 Planekator Repeat-o-meter
Optical Comparators[1] – Angle Linearity Magnification	 (0 to 360) ° Up to 20 in (20 to 40) in 10x to 100x	 0.016 ° 320 µin 630 µin 430 µin	 Gage blocks, Angle blocks, SI Industries glass scales

Mass and Mass Related Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure [1]	(-150 to 150) inH_20 Up to 30 psia Up to 100 psig (-15 to 300) psig Up to 1 000 psig Up to 5 000 psig Up to 10 000 psig Up to 15 000 psig	0.07 inH_20 0.035 psi 0.025 psi 0.077 psi 0.25 psi 1.5 psi 3.1 psi 3.6 psi	Pressure Gages ADT681-02-DP150 ADT681-10AP30 ADT681-02-GP100 ADT681-02-CP300 ADT681-02-GP1K ADT681-02-GP5K ADT681-02-GP10K ADT681-05-GP15K
Pressure [1]	(5 to 15 000) psi	0.04 % of reading	Ametek type T Deadweight Tester
Pipettes [1,2]	(10 to 100) µL (100 to 1000) µL (1 to 10) mL	(0.58 + 0.004V) µL (0.6 + 0.001V) µL (2.6 + 0.0012V) µL	Mass Balance
Torque Tools [1]	(10 to 100) ozf-in 4 lbf-in to 1 000 lbf-ft	0.59 % of reading 0.3 % of reading	Torque Testers CDI 1001-O-DDT CDI 5000 ST
Torque Analyzers [1]	Up to 100 ozf-in (4 to 150) lbf-in (12.5 to 1 000) lbf-ft	0.1 % of reading 0.064 % of reading 0.036 % of reading	Torque Arms and Class F Weights
Force [1] Tension and Compression	(0.5 to 500) lbf	0.02 % of reading	Class F Weights
Force Tension and Compression	(200 to 25 000) lbf	0.017 % of reading	Morehouse Load Cells
Scales and Balances [1,2,4]	1 mg to 420 g	(0.021 + 0.003 4X) mg	Class 1 Weights

Mass and Mass Related Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales and Balances [1,2,4]	500 g to 41 kg	(0.015 + 0.024*X*) mg	Class 4 Weights
Scales and Balances [1,2,4]	Up to 100 kg Up to 1 000 lb	(0.001 7 + 0.000 12*X*) g (0.002 1 + 0.000 12*W*) lb	Class F Weights
Mass - Fixed Points Metric	(1, 2, 3, 5, 10) mg (20, 30, 50, 100) mg (200, 300, 500) mg (1, 2, 3, 5) g (10, 20, 30) g 50 g 100 g 200 g	0.013 mg 0.013 mg 0.013 mg 0.049 mg 0.068 mg 0.072 mg 0.23 mg 0.38 mg	Comparison to ASTM E617 Class 1 weights
Mass - Fixed Points Metric	500 g (1, 2, 3) kg (5, 10, 20) kg	58 mg	Comparison to ASTM E617 Class 4 weights
Rockwell Hardness Testers [1]	(< 60) HRBW (≥ 60 to < 80) HRBW ≥ 80 HRBW < 35 HRC (≥ 35 to < 60) HRC ≥ 60 HRC < 70 HRA (≥ 70 and < 80) HRA ≥ 80 HRA	3 HRBW 3 HRBW 1.3 HRBW 1.3 HRC 1.2 HRC 0.7 HRC 1.3 HRA 1.2 HRA 0.7 HRA	Indirect verification per ASTM E18

Thermodynamic Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber
Relative Humidity Measure [1]	(0 to 90) %RH (90 to 100) %RH	1.2 %RH 2 %RH	Vaisala MI70/HMP76 Humidity Indicator and Probe
Temperature Measuring Equipment [1]	(-40 to 660) °C	0.18 °C	Dry Well Calibrators

Thermodynamic Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Measure [1]	(-200 to 400) °C (400 to 660) °C	0.043 °C 0.13 °C	Secondary PRT
Infrared (IR) Thermometers [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 IR Calibrator Ɛ = 0.95, λ = (8 to 14) µm

Time and Frequency Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-12} Hz/Hz	HP 58503A GPS Receiver
Frequency – Generate [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-12} Hz/Hz + 0.57 µHz 1 x 1^{e-12} Hz/Hz + 5.7 µHz 1 x 1^{e-12} Hz/Hz + 57 µHz 1 x 1^{e-12} Hz/Hz + 0.57 mHz 1 x 1^{e-12} Hz/Hz + 5.7 mHz 1 x 1^{e-12} Hz/Hz + 57 mHz 1 x 1^{e-12} Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP 58503A GPS Receiver
Frequency – Generate [1]	(10 to 40 000) MHz	1 x 1^{e-12} Hz/Hz + 0.57 mHz	Agilent E8257D Opt 540 Signal Generator / HP 58503A GPS Receiver
Time – Generate	1 pps	1 x 1^{e-12} s/s + 750 ps	HP 58503A GPS Receiver
Frequency – Measure [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 200) kHz (0.2 to 3 000) MHz	4.2 x 1^{e-9} Hz/Hz 1.5 x 1^{e-9} Hz/Hz 0.6 x 1^{e-9} Hz/Hz 0.33 x 1^{e-9} Hz/Hz 0.24 x 1^{e-9} Hz/Hz 0.21 x 1^{e-9} Hz/Hz 0.21 x 1^{e-9} Hz/Hz	Agilent 53131A Opt 030 Frequency Counter / HP 58503A GPS Receiver
Frequency – Measure [1]	(10 to 50 000) MHz	1 x 1^{e-12} Hz/Hz + 0.1 Hz	Agilent E4448A Spectrum Analyzer / HP 58503A GPS Receiver
Timer, Stopwatch [1]	10 s to 24 hr	34 ms	Totalize method with counter
Tachometers – RPM [1]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 33250A Signal Generator & LED

DIMENSIONAL MEASUREMENT

1 Dimensional Colorado Springs, CO

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length [1,2]	(0 to 480) in	(0.8 + 2.6*L*) µin	Laser measurement system

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Services performed at satellite laboratory

Technical Maintenance, Inc.
2200 Gateway Centre Blvd. #208
Morrisville, NC 27560
Taylor Floyd (Branch Manager) Phone: (919) 234-1291
Scott Chamberlain (Quality Manager) Phone: (321) 242-0890

CALIBRATION

Chemical Quantities Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH meters [1,5]	4 pH 7 pH 10 pH	0.025 pH 0.027 pH 0.064 pH	pH buffer solutions
Conductivity Meters [1,5]	10 µS/cm 500 µS/cm 1 000 µS/cm	0.17 µS/cm 2.2 µS/cm 3.6 µS/cm	Conductivity solutions

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Generate [1]	(1 to 1.2) nA (1.2 to 12) nA (12 to 120) nA (0.12 to 1.2) µA (1.2 to 10) µA	92 µA/A + 0.007 nA 92 µA/A + 0.007 nA 92 µA/A + 0.01 nA 36 µA/A + 0.1 nA 13 µA/A + 1 nA	Fluke 5730A Multifunction Calibrator, Fluke 5560A Multiproduct Calibrator
DC Current – Generate [1]	(10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA (0.22 to 1) A (1 to 2.2) A	38 µA/A + 5 nA 30 µA/A + 7 nA 30 µA/A + 44 nA 38 µA/A + 0.7 µA 45 µA/A + 0.7 µA 68 µA/A + 12 µA 105 µA/A + 12 µA	Fluke 5730A Multifunction Calibrator
	(2.2 to 3.1) A (3.1 to 12) A (12 to 30) A	228 µA/A + 115 µA 228 µA/A + 191 µA 761 µA/A + 392 µA	Fluke 5560A Multiproduct Calibrator

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Generate [1] Clamp Meters	(3.1 to 300.2) A	0.65 % of output + 0.014 A	Fluke 5560A Multiproduct Calibrator 55xxA x1/2/10 Coil
DC Current – Measure [1]	(1 to 10) nA (10 to 100) nA (0.1 to 1) µA (1 to 10) µA	35 µA/A + 0.1 pA 12 µA/A + 1 pA 8.3 µA/A + 0.01 nA 6.9 µA/A + 0.1 nA	Fluke 5730A Multifunction Calibrator Agilent 3458A Option 002 Multimeter
	(0.1 to 20.2) µA (20.2 to 202) µA (0.202 to 2.02) mA (2.02 to 20.2) mA (20.2 to 202) mA (0.202 to 2.02) A	30.4 µA/A + 0.4 nA 11.4 µA/A + 0.5 nA 11.4 µA/A + 5 nA 15.2 µA/A + 0.05 µA 58 µA/A + 1.5 µA 150 µA/A + 0.2mA	Fluke 8588A Multimeter
	(1 to 3) A (3 to 10) A	0.08 % of Reading + 0.46 mA 0.11 % of Reading + 0.61 mA	Fluke 8845A Multimeter
	(10 to 250) A	0.25 % of Reading + 0.02A	Fluke 8845A Multimeter, Empro Current Shunt
DC Voltage – Generate [1]	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	6.8 µV/V + 0.8 µV 4.6 µV/V + 0.9 µV 3 µV/V + 2.5 µV 3 µV/V + 3.9 µV 4.6 µV/V + 38 µV 6.1 µV/V + 385 µV	Fluke 5730A Multifunction Calibrator
DC Voltage – Measure [1]	(0 to 220) mV (0.202 to 2.02) V (2.02 to 20.2) V (20.2 to 202) V (202 to 1 000) V	8.1 µV/V + 0.7 µV 5.2 µV/V + 0.8 µV 5.2 µV/V + 0.9 µV 8.3 µV/V + 34 µV 8.4 µV/V + 1.3 mV	Fluke 8558A Multimeter
DC Voltage – Measure [1]	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	3.3 µV/V + 1 µV 2.6 µV/V + 1 µV 2.6 µV/V + 1.5 µV 3.9 µV/V + 20 µV 3.9 µV/V + 66 µV + 12µV/V x (Vin/1000) ^2	Agilent 3458A Multimeter
DC Voltage – Measure [1]	(1 to 30) kV	0.1 % of reading	Ross VD30 High Voltage Divider, HP 34401A Multimeter

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(0.22 to 2.2) mV		Fluke 5730A Multifunction Calibrator
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	
	(2.2 to 22) mV		
	(10 to 20) Hz	228 µV/V + 3.9 µV	
	(20 to 40) Hz	88 µV/V + 3.9 µV	
	40 Hz to 20 kHz	76 µV/V + 3.9 µV	
	(20 to 50) kHz	190 µV/V + 3.9 µV	
	(50 to 100) kHz	457 µV/V + 4.6 µV	
	(100 to 300) kHz	989 µV/V + 9.2 µV	
	(300 to 500) kHz	1.3 mV/V + 19 µV	
	500 kHz to 1 MHz	2.6 mV/V + 19 µV	
	(22 to 220) mV		
	(10 to 20) Hz	228 µV/V + 11.4 µV	
	(20 to 40) Hz	88 µV/V + 6.1 µV	
	40 Hz to 20 kHz	53 µV/V + 6.1 µV	
	(20 to 50) kHz	114 µV/V + 6.1 µV	
	(50 to 100) kHz	304 µV/V + 15.2 µV	
	(100 to 300) kHz	609 µV/V + 19 µV	
	(300 to 500) kHz	1.3 mV /V + 23 µV	
	500 kHz to 1 MHz	2.5 mV /V + 46 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	228 µV/V + 38 µV	
	(20 to 40) Hz	84 µV/V + 15 µV	
	40 Hz to 20 kHz	37 µV/V + 8 µV	
	(20 to 50) kHz	61 µV/V + 9 µV	
	(50 to 100) kHz	76 µV/V + 30 µV	
	(100 to 300) kHz	304 µV/V + 76 µV	
	(300 to 500) kHz	913 µV /V + 190 µV	
	500 kHz to 1 MHz	1.5 mV/V + 304 µV	

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1]	(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 (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	 228 µV/V + 380 µV 84 µV/V + 152 µV 37 µV/V + 54 µV 61 µV/V + 91 µV 76 µV/V + 190 µV 228 µV/V + 609 µV 913 µV/V + 1.9 mV 1.4 mV/V + 3 mV 228 µV/V + 3.8 mV 84 µV/V + 1.5 mV 49 µV/V + 0.6 mV 76 µV/V + 0.9 mV 137 µV/V + 2.3 mV	Fluke 5730A Multifunction Calibrator
AC Voltage – Generate [1]	(220 to 750) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (750 to 1 000) V 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV 1.8 mV/V + 34 mV 68 µV/V + 3 mV 126 µV/V + 5 mV 457 µV/V + 8 mV	Fluke 5730A Multifunction Calibrator, 5725A Amplifier
AC Voltage – Generate [1] Wideband Absolute	(0.3 to 1.1) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz (1.1 to 3.3) mV (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.65 % of output + 1.5 µV 0.61 % of output + 1.5 µV 0.63 % of output + 3.8 µV 0.63 % of output + 3.8 µV 0.68 % of output + 3.8 µV 0.76 % of output + 3.8 µV 1.3 % of output + 12.9 µV 0.58 % of output + 2.3 µV 0.53 % of output + 2.3 µV 0.54 % of output + 4.6 µV 0.54 % of output + 4.6 µV 0.58 % of output + 4.6 µV 0.65 % of output + 4.6 µV 1.3 % of output + 4.6 µV	Fluke 5730A Option 003 Multifunction Calibrator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(3.3 to 11) mV		Fluke 5730A Option 003 Multifunction Calibrator
	(10 to 30 Hz)	0.58 % of output + 6.1 µV	
	30 Hz to 500 kHz	0.53 % of output + 6.1 µV	
	(0.5 to 1.2) MHz	0.54 % of output + 8.4 µV	
	(1.2 to 2) MHz	0.54 % of output + 8.4 µV	
	(2 to 12) MHz	0.55 % of output + 8.4 µV	
	(12 to 20) MHz	0.61 % of output + 8.4 µV	
	(20 to 30) MHz	0.93 % of output + 8.4 µV	
	(11 to 33) mV		
	(10 to 30 Hz)	0.52 % of output + 12 µV	
	30 Hz to 500 kHz	0.46 % of output + 12 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 14 µV	
	(1.2 to 2) MHz	0.47 % of output + 14 µV	
	(2 to 12) MHz	0.49 % of output + 14 µV	
	(12 to 20) MHz	0.55 % of output + 14 µV	
	(20 to 30) MHz	0.89 % of output + 14 µV	
	(33 to 110) mV		
	(10 to 30 Hz)	0.52 % of output + 30 µV	
	30 Hz to 500 kHz	0.46 % of output + 30 µV	
	(0.5 to 1.2) MHz	0.47 % of output + 33 µV	
	(1.2 to 2) MHz	0.47 % of output + 33 µV	
	(2 to 12) MHz	0.49 % of output + 33 µV	
	(12 to 20) MHz	0.55 % of output + 33 µV	
	(20 to 30) MHz	0.89 % of output + 33 µV	
	(110 to 330) mV		
	(10 to 30 Hz)	0.45 % of output + 0.1 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.1 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.1 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.1 mV	
	(2 to 12) MHz	0.42 % of output + 0.1 mV	
	(12 to 20) MHz	0.49 % of output + 0.1 mV	
	(20 to 30) MHz	0.85 % of output + 0.1 mV	
	(0.33 to 1.1) V		
	(10 to 30 Hz)	0.45 % of output + 0.3 mV	
	30 Hz to 500 kHz	0.38 % of output + 0.3 mV	
	(0.5 to 1.2) MHz	0.4 % of output + 0.3 mV	
	(1.2 to 2) MHz	0.4 % of output + 0.3 mV	
	(2 to 12) MHz	0.42 % of output + 0.3 mV	
	(12 to 20) MHz	0.49 % of output + 0.3 mV	
	(20 to 30) MHz	0.85 % of output + 0.3 mV	

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate [1] Wideband Absolute	(1.1 to 3.5) V (10 to 30 Hz) 30 Hz to 500 kHz (0.5 to 1.2) MHz (1.2 to 2) MHz (2 to 12) MHz (12 to 20) MHz (20 to 30) MHz	 0.39 % of output + 0.4 mV 0.3 % of output + 0.4 mV 0.32 % of output + 0.4 mV 0.32 % of output + 0.4 mV 0.35 % of output + 0.4 mV 0.44 % of output + 0.4 mV 0.82 % of output + 0.4 mV	Fluke 5730A Option 003 Multifunction Calibrator
AC Voltage – Measure [1]	(1.2 to 12.12) mV 1 to 2000 Hz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1 MHz) (12.12 to 121.2) mV 1 to 2000 Hz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1 MHz) (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz (12.12 to 121.2) mV 1 to 2000 Hz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1 MHz) (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz	 0.06 % of reading + 2.0 µV 0.045 % of reading + 2.0 µV 0.046 % of reading + 2.0 µV 0.42 % of reading + 2.0 µV 1.58 % of reading + 5.9 µV 2.47 % of reading + 5.9 µV 0.011 % of reading + 1 µV 0.015 % of reading + 1 µV 0.025 % of reading + 2 µV 0.057 % of reading + 20 µV 0.34 % of reading + 50 µV 1.38 % of reading + 0.2mV 1.6 % of reading + 0.7mV 4.6 % of reading + 1.2 mV 9.2 % of reading + 1.2 mV 18 % of reading + 1.2 mV 0.011 % of reading + 1 µV 0.015 % of reading + 1 µV 0.025 % of reading + 2 µV 0.057 % of reading + 20 µV 0.34 % of reading + 49.5 µV 1.38 % of reading + 0.2mV 1.6 % of reading + 0.7mV 4.6 % of reading + 1.2 mV 9.2 % of reading + 1.2 mV 18 % of reading + 1.2 mV	Fluke 8588A Multimeter

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(0.1212 to 1.212)V		Fluke 8588A Multimeter
	(1 to 2 000) Hz	0.01 % of reading + 0.01mV	
	(2 to 10) kHz	0.014 % of reading + 0.01 mV	
	(10 to 30) kHz	0.025 % of reading + 0.02 mV	
	(30 to 100) kHz	0.057 % of reading + 0.20 mV	
	(100 to 300) kHz	0.26 % of reading + 0.5 mV	
	(0.3 to 1 MHz)	1.4 % of reading + 2mV	
	(1 to 2) MHz	1.6 % of reading + 7mV	
	(2 to 4) MHz	4.6 % of reading + 12 mV	
	(4 to 8) MHz	9.1 % of reading + 12 mV	
	(8 to 10) MHz	18 % of reading + 12 mV	
	(1.212 to 12.12)V		
	1 to 2000 Hz	0.01 % of reading + 0.1mV	
	(2 to 10) kHz	0.014 % of reading + 0.1 mV	
	(10 to 30) kHz	0.025 % of reading + 0.2 mV	
	(30 to 100) kHz	0.057 % of reading + 2 mV	
	(100 to 300) kHz	0.26 % of reading + 5 mV	
	(0.3 to 1 MHz)	1.4 % of reading + 20mV	
	(1 to 2) MHz	1.6 % of reading + 70mV	
	(2 to 4) MHz	4.6 % of reading + 120 mV	
	(4 to 8) MHz	9.1 % of reading + 120 mV	
	(8 to 10) MHz	18 % of reading + 120 mV	
	(12.12 to 121.2)V		
	(1 to 2 000) Hz	0.011 % of reading + 1mV	
	(2 to 10) kHz	0.015 % of reading + 1 mV	
	(10 to 30) kHz	0.025 % of reading + 2 mV	
	(30 to 100) kHz	0.063 % of reading + 20 mV	
	(100 to 200) kHz	0.43 % of reading + 100 mV	
	(121.2 to 1 050)V		
	(1 to 1000 Hz	0.016 % of reading + 30mV	
	(2 to 10) kHz	0.018 % of reading + 30 mV	
	(10 to 30) kHz	0.032 % of reading + 30 mV	
AC Voltage – Measure [1]	(1 to 10) mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.02 % of reading + 2 µV	
	40 Hz to 1 kHz	0.013 % of reading + 0.7 µV	
	(1 to 20) kHz	0.02 % of reading + 0.7 µV	
	(20 to 50) kHz	0.065 % of reading + 0.7 µV	
	(50 to 100) kHz	0.33 % of reading + 0.7 µV	
	100 kHz to 1 MHz	0.78 % of reading + 3.3 µV	
	(1 to 4) MHz	4.6 % of reading + 4.6 µV	
	(4 to 8) MHz	13 % of reading + 5.3 µV	

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	10 mV to 100 mV		Agilent 3458A Multimeter
	(1 to 40) Hz	0.005 % of reading + 2.6 µV	
	40 Hz to 1 kHz	0.005 % of reading + 1.3 µV	
	(1 to 20) kHz	0.009 % of reading + 1.3 µV	
	(20 to 50) kHz	0.02 % of reading + 1.3 µV	
	(50 to 100) kHz	0.052 % of reading + 1.3 µV	
	(100 to 300) kHz	0.20 % of reading + 6.5 µV	
	300 kHz to 1 MHz	0.70 % of reading + 6.5 µV	
	(1 to 2) MHz	0.98 % of reading + 46 µV	
	(2 to 4) MHz	2.6 % of reading + 46 µV	
	(4 to 8) MHz	2.6 % of reading + 52 µV	
	(8 to 10) MHz	9.8 % of reading + 65 µV	
	(0.10 to 1) V		
	(1 to 40) Hz	0.005 % of reading + 26 µV	
	40 Hz to 1 kHz	0.005 % of reading + 13 µV	
	(1 to 20) kHz	0.009 % of reading + 13 µV	
	(20 to 50) kHz	0.02 % of reading + 13 µV	
	(50 to 100) kHz	0.052 % of reading + 13 µV	
	(100 to 300) kHz	0.2 % of reading + 65 µV	
	300 kHz to 1 MHz	0.65 % of reading + 65 µV	
	(1 to 2) MHz	0.98 % of reading + 0.5 mV	
	(2 to 4) MHz	2.6 % of reading + 0.5 mV	
	(4 to 8) MHz	2.6 % of reading + 0.5 mV	
	(8 to 10) MHz	9.8 % of reading + 0.7 mV	
	(1 to 10) V		
	(1 to 40) Hz	0.005 % of reading + 0.3 mV	
	40 Hz to 1 kHz	0.005 % of reading + 0.1 mV	
	(1 to 20) kHz	0.009 % of reading + 0.1 mV	
	(20 to 50) kHz	0.02 % of reading + 0.1 mV	
	(50 to 100) kHz	0.052 % of reading + 0.1 mV	
	(100 to 300) kHz	0.2 % of reading + 0.7 mV	
	300 kHz to 1 MHz	0.65 % of reading + 0.7 mV	
	(1 to 2) MHz	0.98 % of reading + 4.6 mV	
	(2 to 4) MHz	2.6 % of reading + 4.6 mV	
	(4 to 8) MHz	2.6 % of reading + 5.2 mV	
	(8 to 10) MHz	9.8 % of reading + 6.5 mV	

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(10 to 100) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (100 to 700) V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.013 % of reading + 2.6 mV 0.013 % of reading + 1.3 mV 0.013 % of reading + 1.3 mV 0.023 % of reading + 1.3 mV 0.08 % of reading + 1.3 mV 0.26 % of reading + 6.5 mV 0.98 % of reading + 6.5 mV 0.026 % of reading + 26 mV 0.026 % of reading + 13 mV 0.039 % of reading + 13 mV 0.078 % of reading + 13 mV 0.2 % of reading + 13 mV	Agilent 3458A Multimeter
AC Voltage – Measure [1]	(1 to 5) kV 60 Hz (5 to 21) kV 60 Hz	 0.5 % of reading 0.5 % of reading	Ross VD30 Voltage Divider, HP 34401A Multimeter
AC Current – Generate [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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 (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	 228 µA/A + 15 nA 152 µA/A + 10 nA 91 µA/A + 8 nA 266 µA/A + 12 nA 989 µA/A + 61 nA 228 µA/A + 39 nA 152 µA/A + 31 nA 91 µA/A + 31 nA 183 µA/A + 99 nA 989 µA/A + 609 nA 228 µA/A + 385 nA 152 µA/A + 310 nA 91 µA/A + 310 nA 183 µA/A + 536 nA 989 µA/A + 4566 nA	Fluke 5730A Multifunction Calibrator

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Generate [1]	(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	 228 µA/A + 4 µA 152 µA/A + 3 µA 91 µA/A + 2 µA 183 µA/A + 3 µA 989 µA/A + 9 µA	Fluke 5730A Multifunction Calibrator
AC Current – Generate [1]	(0.22 to 1.2) A (3 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (1.2 to 3.1) A (3 to 45) Hz (45 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (3.1 to 12) A (3 to 45) Hz (45 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (3 to 45) Hz (45 to 1 000) Hz (1 to 5) kHz	 0.019 % of output + 0.08 mA 0.019 % of output + 0.04 mA 0.019 % of output + 0.06 mA 0.19 % of output + 0.23 mA 0.38 % of output + 0.23 mA 0.029 % of output + 0.4 mA 0.023 % of output + 0.27 mA 0.029 % of output + 0.27 mA 0.19 % of output + 0.40 mA 0.029 % of output + 0.8 mA 0.023 % of output + 0.4 mA 0.029 % of output + 0.6 mA 0.19 % of output + 0.8 mA 0.076 % of output + 7.7 mA 0.053 % of output + 6.2 mA 0.38 % of output + 6.2 mA	Fluke 5560A Multiproduct Calibrator
AC Current – Generate [1] Clamp Meters	(3.1 to 300.2) A (3 to 440) Hz	0.65 % of output + 0.077 A	Fluke 5560A Multiproduct Calibrator 55xxA x1/2/10 Coil
AC Current – Measure [1]	(2.02 to 20.2) µA (1 to 2 000) Hz (2 to 10) kHz (10 Hz to 30) kHz (2.02 to 20.2) µA (1 to 2 000) Hz (2 to 10) kHz (10 Hz to 30) kHz (0.202 to 2.02) mA (1 to 2 000) Hz (2 to 10) kHz (10 Hz to 30) kHz	 0.38 % of reading + 2.9 nA 0.38 % of reading + 2.9 nA 0.38 % of reading + 2.9 nA 0.044 % of reading + 9.8 nA 0.087 % of reading + 9.8 nA 0.11 % of reading + 9.8 nA 0.044 % of reading + 98 nA 0.087 % of reading + 98 nA 0.11 % of reading + 98 nA	Fluke 8588A Multimeter

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(2.02 to 20.2) mA (1 to 2 000) Hz (2 to 10) kHz (10 Hz to 30) kHz (20.2 to 202) mA (1 to 2 000) Hz (2 to 10) kHz (10 Hz to 30) kHz (0.202 to 2.02)A (1 to 2 000) Hz (2 to 10) kHz (10 Hz to 30) kHz	 0.044 % of reading + 0.98 µA 0.087 % of reading + 0.98 µA 0.11 % of reading + 0.98 µA 0.044 % of reading + 9.8 µA 0.087 % of reading + 9.8 µA 0.11 % of reading + 9.8 µA 0.044 % of reading + 148 µA 0.076 % of reading + 148 µA 0.12 % of reading + 148 µA	Fluke 8588A Multimeter
AC Current – Measure [1]	(5 to 100) µA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz 100 µA to 1 mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.26 % of reading + 0.02 µA 0.1 % of reading + 0.02 µA 0.04 % of reading + 0.02 µA 0.26 % of reading + 0.13 µA 0.1 % of reading + 0.13 µA 0.04 % of reading + 0.13 µA 0.02 % of reading + 0.13 µA 0.26 % of reading + 1.3 µA 0.1 % of reading + 1.3 µA 0.04 % of reading + 1.3 µA 0.02 % of reading + 1.3 µA 0.26 % of reading + 13 µA 0.1 % of reading + 13 µA 0.04 % of reading + 13 µA 0.02 % of reading + 13 µA 0.26 % of reading + 0.13 mA 0.1 % of reading + 0.13 mA 0.05 % of reading + 0.13 mA 0.07 % of reading + 0.13 mA	Agilent 3458A Multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz (3 to 10) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (5 to 10) kHz	 0.84 % of reading + 1.4 mA 0.27 % of reading + 1.4 mA 0.11 % of reading + 1.4 mA 0.27 % of reading + 16 mA 0.84 % of reading + 4.6 mA 0.27 % of reading + 4.6 mA 0.11 % of reading + 4.6 mA 0.27 % of reading + 53 mA	Fluke 8845A Multimeter
Resistance – Generate [1] Fixed Points	(1, 1.9) Ω (10, 19) Ω (100, 190) Ω (1, 1.9) kΩ (10, 19) kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	84 μΩ/Ω + 0.1 μΩ 21 μΩ/Ω + 1 μΩ 9.1 μΩ/Ω + 6 μΩ 6.1 μΩ/Ω + 60 μΩ 6.1 μΩ/Ω + 0.6 mΩ 7.6 μΩ/Ω + 6 mΩ 9.1 μΩ/Ω + 6 mΩ 11.4 μΩ/Ω + 60 mΩ 16 μΩ/Ω + 60 mΩ 35 μΩ/Ω + 0.6 Ω 42 mΩ/Ω + 0.6 Ω 91 mΩ/Ω + 6 Ω	Fluke 5730A Multifunction Calibrator
Resistance – Generate [1]	Up to 12 Ω (12 to 120) Ω (0.12 to 1.20) kΩ (1.2 to 12.0) kΩ (12 to 120) kΩ (0.12 to 1.2) MΩ (1.2 to 12) MΩ (12 to 120) MΩ (120 to 1 200) MΩ	19 μΩ/Ω + 0.001 Ω 19 μΩ/Ω + 0.001 Ω 19 μΩ/Ω + 0.002 Ω 19 μΩ/Ω + 0.02 Ω 19 μΩ/Ω + 0.2 Ω 19 μΩ/Ω + 2.0Ω 27 μΩ/Ω + 24 Ω 327 μΩ/Ω + 2 kΩ 3 mΩ/Ω + 76 Ω	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1]	Up to 2.02 Ω 2.02 to 20.2 Ω (20.2 to 202) Ω (0.202 to 2.02) kΩ (2.02 to 20.2) kΩ (20.2 to 202) kΩ (0.202 to 2.02) MΩ (2.02 to 20.2) MΩ (20.2 to 202) MΩ (0.202 to 2.02) GΩ (2.02 to 20.2) GΩ	21 μΩ/Ω + 4.4 μΩ 15 μΩ/Ω + 20 μΩ 12 μΩ/Ω + 53 μΩ 12 μΩ/Ω + 0.53 mΩ 12 μΩ/Ω + 5.3 mΩ 12 μΩ/Ω + 53 mΩ 12.9 μΩ/Ω + 1.0 Ω 17 μΩ/Ω + 9.8 Ω 67 μΩ/Ω + 0.98 kΩ 228 μΩ/Ω + 98 kΩ 1.3 mΩ/Ω + 9.8 MΩ	Fluke 8588A Multimeter
Resistance – Measure [1]	Up to 12 Ω (10 to 120) Ω (0.1 to 1.2) kΩ (1 to 12) kΩ (10 to 120) kΩ (0.1 to 1.2) MΩ (1 to 12) MΩ (10 to 120) MΩ (0.1 to 1.2) GΩ	9.8 μΩ/Ω + 38 μΩ 7.8 μΩ/Ω + 0.3 mΩ 6.5 μΩ/Ω + 0.4 mΩ 6.5 μΩ/Ω + 3.8 mΩ 6.5 μΩ/Ω + 38 mΩ 9.8 μΩ/Ω + 1.5 Ω 33 μΩ/Ω + 100 Ω 327 μΩ/Ω + 1 kΩ 0.33 % of reading + 70 kΩ	Agilent 3458A Multimeter
Capacitance – Generate [1]	(0.2 to 1.2) nF (1.2 to 12.0) nF (12 to 120.0) nF (0.12 to 1.2) μF (1.2 to 12.0) μF (12 to 120.0) μF (0.12 to 1.2) mF (1.2 to 12.0) mF (12 to 120.0) mF	0.09% of output + 1.5 pF 0.09 % of output + 0.004 nF 0.1 % of output + 0.023 nF 0.1 % of output + 0.23 nF 0.1 % of output + 2.3 nF 0.11 % of output + 19 nF 0.19 % of output + 190 nF 0.19 % of output + 2.3 μF 0.38 % of output + 23 μF	Fluke 5560A Multiproduct Calibrator
Inductance – Generate [1]	(13 to 120.0) μH (0.12 to 1.2) mH (1.2 to 12.0) mH (12 to 120.0) mH (0.12 to 1.2) H (1.2 to 12.0) H (12 to 120.0) H	0.15% of output + 0.15 μH 0.09 % of output + 0.76 μH 0.09 % of output + 7.6 μH 0.09 % of output + 76 μH 0.11 % of output + 0.76 mH 0.15 % of output + 7.6 mH 0.19 % of output + 76 mH	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Calibration[1] – Generate Voltage DC - 50Ω DC - 1MΩ Square Wave 10Hz to 10kHz – 1MΩ	 1 mV to 5 V 1 mV to 200 V 1 mV to 200 Vpp	 0.025 % of output + 25 µV 0.025 % of output + 2 5uV 0.1 % of output + 10 µV	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration[1] – Generate Leveled Sine Flatness 50 kHz to 10 MHz Reference	(5mV to 5Vpp) 0.1 Hz to 300 MHz (300 to 550) MHz 5 mV to 3 Vpp (550 to 1 100) MHz	 0.18 dB 0.22 dB 0.3 dB	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration[1] – Generate Time Marker	9 ns to 55 s	0.25 µs/s	Fluke 9500B with 9510 Active Head
Oscilloscopes Calibration[1] – Measure Input Impedance Resistance	(10 to 40) Ω (40 to 90) Ω (90 to 150) Ω (50 to 800) KΩ (0.8 to 1.2) MΩ (1.2 to 12) MΩ	0.5 % of reading 0.1 % of reading 0.5 % of reading 0.5 % of reading 0.1 % of reading 0.5 % of reading	Fluke 9500B with 9510 Active Head
Electrical Calibration of Thermocouple Indicators/Sources [1]	Type B (600 to 800) °C (800 to 1000) °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 1 000) °C (1 000 to 1 800) °C (1 800 to 2 315) °C Type D (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 315) °C	 0.33 °C 0.26 °C 0.23 °C 0.25 °C 0.19 °C 0.16 °C 0.20 °C 0.34 °C 0.60 °C 0.19 °C 0.16 °C 0.2 °C 0.33 °C 0.59 °C	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators/Sources [1]	Type E		Fluke 5560A Multiproduct Calibrator
	(-250 to -150) °C	0.3 °C	
	(-150 to -25) °C	0.11 °C	
	(-25 to 350) °C	0.08 °C	
	(350 to 650) °C	0.12 °C	
	(650 to 1 000) °C	0.16 °C	
	Type G		
	(0 to 150) °C	0.38 °C	
	(150 to 650) °C	0.25 °C	
	(650 to 1 000) °C	0.2 °C	
	(1 000 to 1 800) °C	0.33 °C	
	(1 800 to 2 315) °C	0.59 °C	
	Type J		
	(-210 to -100) °C	0.18 °C	
	(-100 to -30) °C	0.1 °C	
	(-30 to 150) °C	0.08 °C	
	(150 to 760) °C	0.11 °C	
	(760 to 1 200) °C	0.15 °C	
	Type K		
	(-200 to -100) °C	0.21 °C	
	(-100 to -25) °C	0.1 °C	
	(-25 to 120) °C	0.08 °C	
	(120 to 1 000) °C	0.16 °C	
	(1 000 to 1 372) °C	0.27 °C	
	Type L		
	(-200 to -100) °C	0.24 °C	
	(-100 to 800) °C	0.15 °C	
	(800 to 900) °C	0.08 °C	
Electrical Calibration of Thermocouple Indicators [1]	Type N		Fluke 7526A Process Calibrator
	(-200 to -100) °C	0.25 °C	
	(-100 to -25) °C	0.11 °C	
	(-25 to 120) °C	0.09 °C	
	(120 to 410) °C	0.08 °C	
	(410 to 1 300) °C	0.15 °C	
	Type R		
	(0 to 250) °C	0.39 °C	
	(250 to 400) °C	0.22 °C	
	(400 to 1 000) °C	0.21 °C	
	(1 000 to 1 767 °C	0.26 °C	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicators [1]	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 Type BP (0 to 1 000) °C (1 000 to 2 000) °C (2 000 to 2 500) °C Type XK (-200 to 300) °C (300 to 800) °C	 0.32 °C 0.24 °C 0.24 °C 0.31 °C 0.46 °C 0.16 °C 0.1 °C 0.08 °C 0.3 °C 0.08 °C 0.3 °C 0.46 °C 0.61 °C 0.15 °C 0.23 °C	Fluke 7526A Process Calibrator
Electrical Calibration of RTD Indicators [1]	Cu 10 (427) (-80 to 260) °C Cu 50 (428) (-180 to 200) °C Cu 100 (428) (-180 to 40) °C (-40 to 200) °C	 0.23 °C 0.30 °C 0.3 °C 0.49 °C	Fluke 5560A Multiproduct Calibrator
Electrical Calibration of RTD Indicators [1]	Ni 120 (672) (-80 to 0) °C (0 to 100) °C (100 to 260) °C Pt 100 (385) (-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	 0.06 °C 0.06 °C 0.11 °C 0.04 °C 0.04 °C 0.05 °C 0.07 °C 0.08 °C 0.09 °C 0.18 °C	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of RTD Indicators [1]	Pt 100 (3916)		Fluke 5560A Multiproduct Calibrator
	(-200 to -190)°C	0.19 °C	
	(-190 to -80)°C	0.03 °C	
	(-80 to 0)°C	0.04 °C	
	(0 to 100)°C	0.05 °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	0.08 °C	
	(600 to 630)°C	0.18 °C	
	Pt 100 (3926)		
	(-200 to -80)°C	0.04 °C	
	(-80 to 0)°C	0.04 °C	
	(0 to 100)°C	0.05 °C	
	(100 to 300)°C	0.07 °C	
	(300 to 400)°C	0.08 °C	
	(400 to 630)°C	0.09 °C	
	Pt 200 (385)		
	(-200 to-80)°C	0.03 °C	
	(-80 to 0)°C	0.03 °C	
	(0 to 100)°C	0.03 °C	
	(100 to 260)°C	0.04 °C	
	(260 to 300)°C	0.09 °C	
	(300 to 400)°C	0.10 °C	
	(400 to 600)°C	0.11 °C	
	(600 to 630)°C	0.12 °C	
Electrical Calibration of RTD Indicators [1]	Pt 500 (385)		Fluke 5560A Multiproduct Calibrator
	(-200 to-80)°C	0.03 °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	0.06 °C	
	(300 to 400)°C	0.06 °C	
	(400 to 600)°C	0.07 °C	
	(600 to 630)°C	0.08 °C	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of RTD Indicators [1]	Pt 1000 (385) (-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	 0.02 °C 0.02 °C 0.03 °C 0.04 °C 0.05 °C 0.05 °C 0.05 °C 0.18 °C	Fluke 5560A Multiproduct Calibrator
AC Power – Generate [1] (12 to 120) mV *Power Factor = 1*	(1.2 to 12) mA (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 120) mA (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (0.12 to 1.2) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (1.2 to 3.1) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	 0.022 % of Output + 0.9 µW 0.022 % of Output + 0.9 µW 0.022 % of Output + 0.9 µW 0.115 % of Output + 0.9 µW 0.022 % of Output + 9.2 µW 0.016 % of Output + 4.7 µW 0.022 % of Output + 7.4 µW 0.115 % of Output + 9.2 µW 0.022 % of Output + 92 µW 0.022 % of Output + 47 µW 0.022 % of Output + 74 µW 0.19 % of Output + 0.27 mW 0.03 % of Output + 0.46 mW 0.025 % of Output + 0.27 mW 0.03 % of Output + 0.27 mW 0.19 % of Output + 0.46 mW	Fluke 5560A Multiproduct Calibrator
AC Power – Generate [1] (12 to 120) mV Power Factor = 1	(3.1 to 12) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz	 0.03 % of Output + 0.92 mW 0.025 % of Output + 0.47 mW 0.03 % of Output + 0.74 mW 0.19 % of Output + 0.92 mW 0.077 % of Output + 9.1 mW 0.054 % of Output + 7.3 mW 0.38 % of Output + 7.3 mW	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Generate [1] (0.12 to 1.2) V *Power Factor = 1*	(1.2 to 12) mA (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 120) mA (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (0.12 to 1.2) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (1.2 to 3.1) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (3.1 to 12) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (10 to 40) Hz (40 to 1000) Hz (1 to 5) kHz	 0.022 % of Output + 0.9 µW 0.022 % of Output + 0.9 µW 0.022 % of Output + 0.9 µW 0.12 % of Output + 0.9 µW 0.022 % of Output + 9.2 µW 0.016 % of Output + 4.7 µW 0.022 % of Output + 7.4 µW 0.12 % of Output + 9.2 µW 0.022 % of Output + 92 µW 0.022 % of Output + 47 µW 0.022 % of Output + 74 µW 0.19 % of Output + 0.27 mW 0.03 % of Output + 0.46 mW 0.025 % of Output + 0.27 mW 0.03 % of Output + 0.27 mW 0.19 % of Output + 0.46 mW 0.03 % of Output + 0.92 mW 0.025 % of Output + 0.47 mW 0.03 % of Output + 0.74 mW 0.19 % of Output + 0.92 mW 0.077 % of Output + 9.1 mW 0.054 % of Output + 7.3 mW 0.38 % of Output + 7.3 mW	Fluke 5560A Multiproduct Calibrator
AC Power – Generate [1] (1.2 to 12) V Power Factor = 1	(1.2 to 12) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 120) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz	 0.022 % of Output + 9.2 µW 0.022 % of Output + 9.2 µW 0.022 % of Output + 9.2 µW 0.12 % of Output + 9.2 µW 0.022 % of Output + 92 µW 0.016 % of Output + 46 µW 0.022 % of Output + 74 µW 0.12 % of Output + 92 µW	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Generate [1] (1.2 to 12) V Power Factor = 1	(0.12 to 1.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (1.2 to 3.1) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (3.1 to 12) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz	 0.022 % of Output + 0.92 mW 0.022 % of Output + 0.46 mW 0.022 % of Output + 0.74 mW 0.19 % of Output + 2.7 mW 0.03 % of Output + 4.6 mW 0.025 % of Output + 2.7 mW 0.03 % of Output + 2.7 mW 0.19 % of Output + 4.6 mW 0.03 % of Output + 9.2 mW 0.025 % of Output + 4.6 mW 0.03 % of Output + 7.4 mW 0.19 % of Output + 9.2 mW 0.077 % of Output + 91 mW 0.054 % of Output + 73 mW 0.38 % of Output + 73 mW	Fluke 5560A Multiproduct Calibrator
AC Power – Generate [1] (12 to 120) V Power Factor = 1	(1.2 to 12) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 120) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (0.12 to 1.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (1.2 to 3.1) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz	 0.022 % of Output + 92 µW 0.022 % of Output + 92 µW 0.022 % of Output + 92 µW 0.12 % of Output + 92 µW 0.022 % of Output + 0.92 mW 0.016 % of Output + 0.46 mW 0.022 % of Output + 0.74 mW 0.12 % of Output + 0.92 mW 0.022 % of Output + 9.2 mW 0.022 % of Output + 4.6 mW 0.022 % of Output + 7.4 mW 0.19 % of Output + 27 mW 0.03 % of Output + 46 mW 0.025 % of Output + 27 mW 0.03 % of Output + 27 mW 0.19% of Output + 46 mW	Fluke 5560A Multiproduct Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Generate [1] (12 to 120) V *Power Factor = 1*	(3.1 to 12) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz	 0.03 % of Output + 92 mW 0.025 % of Output + 46 mW 0.03 % of Output + 74 mW 0.19 % of Output + 92 mW 0.077 % of Output + 0.91 W 0.054 % of Output + 0.73 W 0.38 % of Output + 0.73 W	Fluke 5560A Multiproduct Calibrator
AC Power – Generate [1] (120 to 330) V Power Factor = 1	(1.2 to 12) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 120) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (0.12 to 1.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (1.2 to 3.1) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (3.1 to 12) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz	 0.022 % of Output + 0.26 mW 0.022 % of Output + 0.26 mW 0.022 % of Output + 0.26 mW 0.12 % of Output + 0.26 mW 0.022 % of Output + 2.6 mW 0.016 % of Output + 1.5 mW 0.022 % of Output + 2.1 mW 0.12 % of Output + 2.6 mW 0.022 % of Output + 26 mW 0.022 % of Output + 15 mW 0.022 % of Output + 21 mW 0.19 % of Output + 76 mW 0.03 % of Output + 0.13 W 0.025 % of Output + 0.08 W 0.03 % of Output + 0.08 W 0.19 % of Output + 0.13 W 0.03 % of Output + 0.26 W 0.025 % of Output + 0.15 W 0.03 % of Output + 0.21 W 0.19 % of Output + 0.26 W 0.077 % of Output + 2.5 W 0.054 % of Output + 2.0 W 0.38 % of Output + 2.0 W	Fluke 5560A Multiproduct Calibrator

Electrical – DC/Low Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Generate [1] (330 to 1020) V *Power Factor = 1*	(1.2 to 12) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 120) mA (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (0.12 to 1.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (1.2 to 3.1) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (3.1 to 12) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (10 to 40) Hz (40 to 1 000) Hz (1 to 5) kHz	 0.022 % of Output + 1.1 mW 0.022 % of Output + 1.1 mW 0.022 % of Output + 1.1 mW 0.12 % of Output + 1.1 mW 0.022 % of Output + 11 mW 0.016 % of Output + 8.3 mW 0.022 % of Output + 9.6 mW 0.12 % of Output + 11 mW 0.022 % of Output + 107 mW 0.022 % of Output + 83 mW 0.022 % of Output + 96 mW 0.19 % of Output + 244 mW 0.03 % of Output + 0.43 W 0.025 % of Output + 0.3 W 0.03 % of Output + 0.3 W 0.19 % of Output + 0.43 W 0.03 % of Output + 1.1 W 0.025 % of Output + 0.8 W 0.03 % of Output + 1 W 0.19 % of Output + 1.1 W 0.077 % of Output + 8 W 0.054 % of Output + 6.5 W 0.38 % of Output + 6.5 W	Fluke 5560A Multiproduct Calibrator
Phase Angle – Generate [1]	(-180 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	 0.08° 0.19° 0.38° 1.9° 3.8° 7.6°	Fluke 5560A Multiproduct Calibrator
Power Meter Range Calibration [1]	3 µW to 100 mW	0.25 % of reading	HP 11683A Power Meter Calibrator

Electrical – RF/Microwave Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Flatness – Measure [1]	9 kHz to 2 000 MHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (2 to 14) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm (14 to 18) GHz (20 to -10) dBm (-10 to -30) dBm (-30 to -40) dBm (-40 to -42) dBm	 0.1 dB 0.1 dB 0.11 dB 0.12 dB 0.1 dB 0.09 dB 0.1 dB 0.11 dB 0.11 dB 0.12 dB 0.12 dB 0.13 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power Measure [1]	9 kHz to 14 000 MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB (14 000 to 18 000) MHz (20 to 0) dB (0 to -40) dB (-40 to -50) dB (-50 to -55) dB	 0.13 dB 0.15 dB 0.35 dB 0.93 dB 0.12 dB 0.16 dB 0.35 dB 0.93 dB	Agilent EPM Series Power Meter w/E9304A H18 Power Sensor
RF Power Measure [1]	(50 to 100) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB (100 to 6 000) MHz (20 to 10) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -25) dB	 0.08 dB 0.07 dB 0.07 dB 0.07 dB 0.11 dB 0.08 dB 0.07 dB 0.07 dB 0.08 dB 0.11 dB	Agilent EPM Series Power Meter w/N8487A Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(6 000 to 12 400) MHz		Agilent EPM Series Power Meter w/N8487A Power Sensor
	(20 to 10) dB	0.08 dB	
	(10 to 0) dB	0.08 dB	
	(0 to -10) dB	0.08 dB	
	(-10 to -20) dB	0.08 dB	
	(-20 to -25) dB	0.12 dB	
	(12 400 to 18 000) MHz		
	(20 to 10) dB	0.09 dB	
	(10 to 0) dB	0.09 dB	
	(0 to -10) dB	0.08 dB	
	(-10 to -20) dB	0.09 dB	
	(-20 to -25) dB	0.12 dB	
	(18 000 to 26 500) MHz		
	(20 to 10) dB	0.11 dB	
	(10 to 0) dB	0.11 dB	
	(0 to -10) dB	0.1 dB	
	(-10 to -20) dB	0.11 dB	
	(-20 to -25) dB	0.14 dB	
	(26 5000 to 33 000) MHz		
	(20 to 10) dB	0.12 dB	
	(10 to 0) dB	0.12 dB	
	(0 to -10) dB	0.12 dB	
	(-10 to -20) dB	0.12 dB	
	(-20 to -25) dB	0.15 dB	
	(33 000 to 40 000) MHz		
	(20 to 10) dB	0.13 dB	
	(10 to 0) dB	0.13 dB	
	(0 to -10) dB	0.12 dB	
	(-10 to -20) dB	0.13 dB	
	(-20 to -25) dB	0.15 dB	
	(40 000 to 50 000) MHz		
	(20 to 10) dB	0.19 dB	
	(10 to 0) dB	0.18 dB	
	(0 to -10) dB	0.18 dB	
	(-10 to -20) dB	0.19 dB	
	(-20 to -25) dB	0.20 dB	

Electrical – RF/Microwave Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	100 kHz to 30 MHz (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB	 0.12 dB 0.13 dB 0.15 dB 0.19 dB 0.26 dB 0.39 dB 0.59 dB	Agilent N5531S Measuring Receiver N1912A w/E9304A H18 Power Sensor
RF Power Measure [1]	(30 to 2 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (2 000 to 3 050) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB (-120 to -125) dB (3 050 to 6 600) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -115) dB (-115 to -120) dB	 0.36 dB 0.2 dB 0.22 dB 0.23 dB 0.25 dB 0.27 dB 0.33 dB 0.7 dB 0.37 dB 0.21 dB 0.23 dB 0.24 dB 0.26 dB 0.28 dB 0.34 dB 0.7 dB 0.37 dB 0.21 dB 0.23 dB 0.24 dB 0.29 dB 0.38 dB 0.53 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor

Electrical – RF/Microwave Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(6 600 to 13 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -110) dB	0.34 dB	
	(-110 to -115) dB	0.46 dB	
	(-115 to -120) dB	0.65 dB	
	(13 200 to 18 000) MHz		
	(30 to 20) dB	0.37 dB	
	(20 to 0) dB	0.21 dB	
	(0 to -58) dB	0.23 dB	
	(-58 to -78) dB	0.24 dB	
	(-78 to -90) dB	0.26 dB	
	(-90 to -95) dB	0.26 dB	
	(-95 to -100) dB	0.26 dB	
	(-100 to -105) dB	0.29 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	
	(18 000 to 19 200) MHz		
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.27 dB	
	(-90 to -95) dB	0.27 dB	
	(-95 to -100) dB	0.27 dB	
	(-100 to -105) dB	0.3 dB	
	(-105 to -110) dB	0.38 dB	
	(-110 to -115) dB	0.53 dB	
	(-115 to -120) dB	0.75 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(19 200 to 26 500) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(30 to 20) dB	0.39 dB	
	(20 to 0) dB	0.25 dB	
	(0 to -58) dB	0.24 dB	
	(-58 to -78) dB	0.25 dB	
	(-78 to -90) dB	0.28 dB	
	(-90 to -95) dB	0.33 dB	
	(-95 to -100) dB	0.43 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.85 dB	
	(-110 to -115) dB	1.2 dB	
	(-115 to -120) dB	1.5 dB	
	(26 500 to 31 150) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.34 dB	
	(-78 to - 90) dB	0.36 dB	
	(-90 to -95) dB	0.39 dB	
	(-95 to -100) dB	0.46 dB	
	(-100 to -105) dB	0.61 dB	
	(-105 to -110) dB	0.82 dB	
	(-110 to -115) dB	1.1 dB	
	(31 150 to 41 000) MHz		
	(30 to 20) dB	0.42 dB	
	(20 to 0) dB	0.3 dB	
	(0 to -58) dB	0.34 dB	
	(-58 to -78) dB	0.35 dB	
	(-78 to -90) dB	0.48 dB	
	(-90 to -95) dB	0.64 dB	
	(-95 to -100) dB	0.87 dB	
	(-100 to -105) dB	1.2 dB	
	(-105 to -110) dB	1.5 dB	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Measure [1]	(41 000 to 45 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB (-90 to -95) dB (-95 to -100) dB (-100 to -105) dB (45 000 to 50 000) MHz (30 to 20) dB (20 to 0) dB (0 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.42 dB 0.3 dB 0.34 dB 0.38 dB 0.68 dB 0.93 dB 1.2 dB 1.6 dB 0.42 dB 0.3 dB 0.34 dB 0.67 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
RF Attenuation – Measure [1]	(30 to 3 050) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (3 050 to 6 600) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.13 dB 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.076 dB 0.081 dB 0.12 dB 0.12 dB 0.13 dB 0.19 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(6 600 to 13 200) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.25 dB	
	(13 200 to 19 200) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.12 dB	
	(90 to 100) dB	0.13 dB	
	(100 to 110) dB	0.31 dB	
	(19 200 to 26 500) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.14 dB	
	(90 to 100) dB	0.36 dB	
	(100 to 110) dB	0.82 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(26 500 to 31 150) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.12 dB	
	(80 to 90) dB	0.13 dB	
	(90 to 100) dB	0.33 dB	
	(100 to 110) dB	0.77 dB	
	(31 150 to 41 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.081 dB	
	(70 to 80) dB	0.14 dB	
	(80 to 90) dB	0.36 dB	
	(41 000 to 45 000) MHz		
	(0 to 10) dB	0.02 dB	
	(10 to 20) dB	0.025 dB	
	(20 to 30) dB	0.03 dB	
	(30 to 40) dB	0.035 dB	
	(40 to 50) dB	0.04 dB	
	(50 to 60) dB	0.076 dB	
	(60 to 70) dB	0.11 dB	
	(70 to 80) dB	0.24 dB	
	(80 to 90) dB	0.6 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Attenuation – Measure [1]	(45 000 to 50 000) MHz (0 to 10) dB (10 to 20) dB (20 to 30) dB (30 to 40) dB (40 to 50) dB (50 to 60) dB (60 to 70) dB (70 to 80) dB (80 to 90) dB	 0.02 dB 0.025 dB 0.03 dB 0.035 dB 0.04 dB 0.11 dB 0.29 dB 0.7 dB 1.4 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor
Amplitude Modulation Measure [1]	100 kHz to 10 MHz Rate 50 Hz to 10 kHz (5 to 99) % Depth 10 MHz to 3 GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (3 to 26.5) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (26.5 to 31.15) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth (31.15 to 50) GHz Rate 50 Hz to 100 kHz (5 to 20) % Depth (20 to 99) % Depth	 0.75 % of reading + 0.3 digits 2.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 4.5 % of reading + 0.4 digits 1.5 % of reading + 0.4 digits 6.8 % of reading + 0.4 digits 1.9 % of reading + 0.4 digits 2.6 % of reading + 0.4 digits 6 % of reading + 0.4 digits	Agilent N5531S Measuring Receiver

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation Measure [1] β = deviation / rate	250 kHz to 10 MHz Rates 20 Hz to 10 kHz Peak Dev 200 to 40 kHz 10 MHz to 6.6 GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (6.6 to 13.2) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (13.2 to 31.15) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz (31.15 to 50) GHz Rates 50 Hz to 200 kHz Peak Dev 250 to 400 kHz	 β > 0.2 - 1.5 % of reading + 2 Hz β > 1.2 - 1 % of reading + 2 Hz β > 0.2 - 1.5 % of reading + 2 Hz β > 0.45 - 1 % of reading + 2 Hz β > 0.2 - 2.5 % of reading + 4 Hz β > 8 - 1 % of reading + 4 Hz β > 0.2 - 3.8 % of reading + 9 Hz β > 16 - 1 % of reading + 9 Hz β > 0.2 – 8.5 % of reading + 17 Hz β > 16 - 1 % of reading + 17 Hz	Agilent N5531S Measuring Receiver
Phase Modulation – Measure [1]	100 kHz to 6.6 GHz Deviations > 0.3 rad Deviations > 0.7 rad (6.6 to 13.2) GHz Deviations > 0.6 rad Deviations > 2.0 rad (13.2 to 26.5) GHz Deviations: > 1.2 rad Deviations > 4.0 rad (26.5 to 31.15) GHz Deviations: > 1.3 rad Deviations > 4.0 rad (31.15 to 50) GHz Deviations: > 2.4 rad Deviations > 8.0 rad	 3 % of reading + 0.002 rad 1 % of reading + 0.002 rad 3 % of reading + 0.005 rad 1 % of reading + 0.005 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.009 rad 1 % of reading + 0.009 rad 3 % of reading + 0.018 rad 1 % of reading + 0.018 rad	Agilent N5531S Measuring Receiver
RF Power Generate [1]	10 to 30 MHz (0 to -58) dB (-58 to -78) dB (-78 to -110) dB (-110 to -120) dB	 0.23 dB 0.25 dB 0.27 dB 0.43 dB	Agilent N5531S Measuring Receiver N1912A w/E9304A Power Sensor, 83650B Signal Generator

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Generate [1]	(30 to 2 000) MHz		Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, 83650B Signal Generator
	(0 to -58) dB	0.3 dB	
	(-58 to -78) dB	0.31 dB	
	(-78 to -110) dB	0.32 dB	
	(2 000 to 3 050) MHz		
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.37 dB	
	(3 050 to 6 600) MHz		
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.39 dB	
	(6 600 to 13 200) MHz		
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.42 dB	
	(13 200 to 18 000) MHz		
	(0 to -58) dB	0.35 dB	
	(-58 to -78) dB	0.36 dB	
	(-78 to -110) dB	0.46 dB	
	(18 000 to 19 200) MHz		
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.5 dB	
	(19 200 to 26 500) MHz		
	(0 to -58) dB	0.41 dB	
	(-58 to -78) dB	0.42 dB	
	(-78 to -110) dB	0.9 dB	
	(26 500 to 31 150) MHz		
	(-3 to -58) dB	0.63 dB	
	(-58 to -78) dB	0.64 dB	
	(-78 to -110) dB	0.96 dB	
	(31 150 to 41 000) MHz		
	(-6 to -58) dB	0.83 dB	
	(-58 to -78) dB	0.84 dB	
	(-78 to -100) dB	1.1 dB	
	(41 000 to 45 000) MHz		
	(-6 to -58) dB	0.83 dB	
	(-58 to -78) dB	0.85 dB	
	(-78 to -100) dB	1.4 dB	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Generate [1]	(45 000 to 50 000) MHz (-6 to -58) dB (-58 to -78) dB (-78 to -90) dB	 0.83 dB 1 dB 1.5 dB	Agilent N5531S Measuring Receiver w/N5532A Opt 550 Power Sensor, 83650B Signal Generator
AM Distortion Measure[1] Rate 20 Hz to 1 kHz	(0.1 to 10) MHz AM Depth > 1 % (0 to -20) dB (-20 to -30) dB AM Depth > 3 % (0 to -20) dB (-20 to -30) dB (-30 to -40) dB 10 MHz to 26.5 GHz AM Depth > 1 % (0 to -20) dB (-20 to -30) dB AM Depth > 3% (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (26.5 MHz to 50.0 GHz) AM Depth > 3 % (0 to -20) dB AM Depth > 5% (0 to -20) dB (-20 to -30) dB	 1.2 dB 2.2 dB 1 dB 1.3 dB 2.4 dB 1.3 dB 2.5 dB 1.1 dB 1.4 dB 3 dB 1.8 dB 1.5 dB 3.5 dB	Agilent N5531S Measuring Receiver

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
FM Distortion Measure[1] Rate 20 Hz to 1 kHz	(1 to 6 600) MHz		Agilent N5531S Measuring Receiver
	Dev 500 Hz to 2 kHz		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2 kHz		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.4 dB	
	(6.6 to 13.2) GHz		
	Dev > 2.3 kHz		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 4.5 kHz		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.4 dB	
	(13.2 to 31.15) GHz		
	Dev > 2.7 kHz		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 6.0 kHz		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.4 dB	
	(31.15 to 50.0) GHz		
	Dev > 4 kHz		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 12.0 kHz		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.4 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure[1]	(1 to 6 600) MHz		Agilent N5531S Measuring Receiver
	Rate (20 to 500) Hz		
	Dev > 0.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 2.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.3 dB	
	Rate (500 to 1 000) Hz		
	Dev > 0.4 rad	0.26 dB	
	(0 to -20) dB	0.79 dB	
	(-20 to -30) dB	2.3 dB	
	(-30 to -40) dB	0.09 dB	
	Dev > 1.0 rad		
	(0 to -20) dB	0.27 dB	
	(-20 to -30) dB	0.83 dB	
	(-30 to -40) dB	2.3 dB	
	(-40 to -50) dB	2.3 dB	
	(6.6 to 13.2) GHz		
	Rate (20 to 500) Hz		
	Dev > 1.8 rad		
	(0 to -20) dB	0.26 dB	
	(-20 to -30) dB	0.79 dB	
	(-30 to -40) dB	2.3 dB	
	Dev > 5.5 rad		
	(0 to -20) dB	0.09 dB	
	(-20 to -30) dB	0.27 dB	
	(-30 to -40) dB	0.83 dB	
	(-40 to -50) dB	2.4 dB	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
PM Distortion Measure[1]	(6.6 to 13.2) GHz Rate (500 to 1 000) Hz Dev > 0.8 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 2.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (13.2 to 31.15) GHz Rate (20 to 500) Hz Dev > 3.5 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 10.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB Rate (500 to 1 000) Hz Dev > 3.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB Dev > 8.0 rad (0 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB	 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB 0.26 dB 0.79 dB 2.3 dB 0.09 dB 0.27 dB 0.83 dB 2.3 dB	Agilent N5531S Measuring Receiver

Electrical – RF/Microwave Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Harmonic Distortion (THD)	(0 to -60) dB 20 Hz to 20 kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -65) dB (20 to 50) kHz (0 to -40) dB (-40 to -50) dB (-50 to -60) dB (50 to 100) kHz (0 to -40) dB (-40 to -50) dB	 1 dB 1 dB 1.3 dB 1.7 dB 2 dB 2.1 dB 3 dB 2 dB 2.4 dB	HP 8903B Audio Analyzer
Harmonics Measure[1]	(-80 to -10) dB 2nd through 5th Harmonic 1kHz to 600MHz (600 to 1 320) MHz (1 320 to 2 200) MHz (2 200 to 3 000) MHz (3 000 to 4 400) MHz (4 400 to 5 300) MHz (5 300 to 10 000) MHz 2nd through 4th Harmonic (10 000 to 12 500) MHz 2nd through 3rd Harmonic (12 500 to 16 667) MHz 2nd Harmonic (16 667 to 25 000) MHz	 0.37 dB 1.1 dB 1.4 dB 1.4 dB 1.7 dB 1.9 dB 2.1 dB 2.1 dB 2.1 dB 2.3 dB	Agilent E4448A Measuring Receiver

Length – Dimensional Metrology Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	Up to 13 in	(4 + 1.5*L*) µin	Master gage blocks P&W Universal Measuring Machine
Micrometers [1,2]	Up to 40 in	(28 + 4.4*L*) µin	Gage Blocks

Length – Dimensional Metrology Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bore Micrometers [2] 2 point 3 point	 Up to 12 in Up to 3 in	 (57 + 2.8*L*) µin (52 + 14*L*) µin	Master gage blocks, P&W Labmaster Universal, Master Ring
Calipers [1,2]	Up to 40 in	(280 + 1.7*L*) µin	Gage Blocks
Dial Indicators [1,2] Resolution ≥ 50µin Resolution < 50µin	 Up to 10 in Up to 0.1 in	 (26 + 3.8*L*) µin 8.2 µin	Gage Blocks
Height Gages [1,2]	Up to 40 in	(96 + 2.8*L*) µin	Gage Blocks
Rulers [1]	Up to 46 in	0.009 1 in	Gage Blocks
Tape Measures[2]	Up to 100 ft	(0.000 26*F* + 0.025) in	Standard rule
Protractors[1]	(0 to 360)°	0.013°	Angle Blocks
Feeler Gage	Up to 1 in	31 µin	Pratt & Whitney Supermicrometer C
Cylindrical Gages [2] Plain Pins, Plugs Plain Rings	 (0 to 13) in (0.04 to 14) in	 (6.8 + 3.3*D*) µin (11 + 3.2*D*) µin	Master gage blocks P&W Universal Measuring Machine
Solid Thread Rings Pitch Diameter	Up to 12 in	120 µin	Pratt & Whitney Labmaster Measuring Machine
Thread Plugs Major Diameter Pitch Diameter	 Up to 10 in Up to 10 in	 53 µin 98 µin	Thread Wires Gage Blocks Pratt & Whitney Supermicrometer C
Thread Rings [2] Pitch Diameter	 Up to 1 in	 (350 + 47*D*) µin	Thread Setting Plugs Tactile Fit
Thread Wires	Up to 0.5 in	11 µin	Master gage blocks, P&W universal measuring machine
Surface Plates [1] Overall Flatness Local Area Flatness	 (18 x 18) in to (6 x 6) ft (-0.001 to 0.001) in	 86 µin 72 µin	 Planekator Repeat-o-meter

Length – Dimensional Metrology Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Comparators[1] – Angle Linearity Magnification	(0 to 360) ° Up to 20 in (20 to 40) in 10x to 100x	0.016 ° 320 µin 630 µin 430 µin	Gage blocks, Angle blocks, SI Industries glass scales

Mass and Mass Related Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure [1]	(-15 to <0) psi (0 to 100) psi	0.043 psi (0.003 6 psi or 0.12 %RD)* *Whichever is Greater	ADT783 Pressure Controller w/module ADT151-01RD-CP100M
Pressure [1]	(-15 to <0) psi (0 to 300) psi	0.043 psi (0.011 psi or 0.12 %RD)* *Whichever is Greater	ADT783 Pressure Controller w/module ADT151-01RD-CP300M
Pressure [1]	(-15 to <0) psi (0 to 1 000) psi	0.045 psi (0.036 psi or 0.12 %RD)* *Whichever is Greater	ADT783 Pressure Controller w/module ADT151-01RD-CP1KM
Pressure [1]	(-15 to <0) psi (0 to 3 600) psi	0.045 psi (0.14 psi or 0.13 %RD)* *Whichever is Greater	ADT783 Pressure Controller w/module ADT151-01RD-CP3.6KM
Pressure [1]	(0 to 6 000) psi (0 to 15 000) psi	0.72 psi 2 psi	ADT783 Pressure Controller w/module ADT151-01-GP15K
Pipettes [1,2]	(10 to 100) µL (100 to 1 000) µL (1 to 10) mL	(0.58 + 0.004V) µL (0.6 + 0.001V) µL (2.6 + 0.00 12V) µL	Mass Balance
Torque Tools [1]	(10 to 100) ozf-in 4 lbf-in to 1 000 lbf-ft	0.59 % of reading 0.32 % of reading	Torque Testers CDI 1001-O-DDT CDI 5000 ST
Torque Analyzers [1]	Up to 100 ozf-in (4 to 150) lbf-in (12.5 to 1 000) lbf-ft	0.1 % of reading 0.064 % of reading 0.036 % of reading	Torque Arms and Class F Weights
Force [1] Tension and Compression	(0.5 to 500) lbf	0.02% of reading	Class F Weights
Scales and Balances [1,2,4]	1 g to 11 kg (0.001 to 21) lb	(0.16 + 0.003 X) mg (0.000 003 1 W) lb	Class 1 Weights

Mass and Mass Related Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales and Balances [1,2,4]	1 g to 11 kg (0.001 to 531) lb	(0.75 + 0.12 *X*) mg (0.000 12 *W*) lb	Class 6 Weights
Mass - Fixed Points Metric	(1, 2, 5) g 10 g 20g 50 g 100 g 200 g 500 g (1, 2, 5) kg	0.14 mg 0.19 mg 0.18 mg 0.25 mg 0.45 mg 0.65 mg 29 mg 31 mg	Comparison to ASTM E617 Class 1 weights
	(0.001, 0.002) lb (0.005, 0.01, 0.02) lb 0.05 lb 0.1 lb 0.2 lb (0.5, 1, 2) lb (5, 10) lb 50 lb	0.13 mg 0.14 mg 0.2 mg 0.3 mg 0.34 mg 27 mg 28 mg 230 mg	
Rockwell Hardness Testers [1]	HRBW (< 60 (≥ 60 to < 80) ≥ 80 HRC < 35 (≥ 35 to < 60) ≥ 60	 0.8 HRBW 0.85 HRBW 0.69 HRBW 0.58 HRC 0.54 HRC 0.39 HRC	Indirect verification per ASTM E18

Thermodynamic Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity Generate	(10 to 95) %RH	0.5 %RH	Thunder Scientific 2500 Humidity Chamber
Relative Humidity Measure [1]	(0 to 90) %RH (90 to 100) %RH	1.2 %RH 2 %RH	Vaisala MI70/HMP76 Humidity Indicator and Probe
Temperature Measuring Equipment [1]	(-40 to 160) °C (33 to 700) °C	0.13 °C (0.21 + 0.00042*T*) °C	Dry Well Calibrators

Thermodynamic Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Measure [1]	(-200 to 200) °C (200 to 400) °C (400 to 660) °C	0.015 °C 0.023 °C 0.035 °C	Secondary PRT w/ Additel Reference Thermometer Readout
Infrared (IR) Thermometers [1]	(20 to 100) ºC (100 to 300) ºC (300 to 420) ºC (420 to 500) ºC	1.5 ºC 4.3 ºC 6 ºC 7.7 ºC	Fluke 9132 IR Calibrator Ɛ = 0.95, λ = (8 to 14) µm

Time and Frequency Morrisville (Raleigh), NC

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Generate [1]	10 MHz	1 x 1^{e-12} Hz/Hz	HP Z3805A GPS Receiver
Frequency – Generate [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz	1 x 1^{e-12} Hz/Hz + 0.57 µHz 1 x 1^{e-12} Hz/Hz + 5.7 µHz 1 x 1^{e-12} Hz/Hz + 57 µHz 1 x 1^{e-12} Hz/Hz + 0.57 mHz 1 x 1^{e-12} Hz/Hz + 5.7 mHz 1 x 1^{e-12} Hz/Hz + 57 mHz 1 x 1^{e-12} Hz/Hz + 0.57 Hz	Agilent 33250A Function Generator / HP Z3805A GPS Receiver
Frequency – Generate [1]	(10 to 50 000) MHz	1 x 1^{e-12} Hz/Hz + 0.57 mHz	Agilent 83650B Signal Generator / HP Z3805A GPS Receiver
Time – Generate	1 pps	1 x 1^{e-12} s/s + 750 ps	HP Z3805A GPS Receiver
Frequency – Measure [1]	(1 to 10) Hz (10 to 100) Hz (100 to 1 000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 200) kHz (0.2 to 3 000) MHz	4.2 x 1^{e-9} Hz/Hz 1.5 x 1^{e-9} Hz/Hz 0.6 x 1^{e-9} Hz/Hz 0.33 x 1^{e-9} Hz/Hz 0.24 x 1^{e-9} Hz/Hz 0.21 x 1^{e-9} Hz/Hz 0.21 x 1^{e-9} Hz/Hz	Agilent 53131A Opt 030 Frequency Counter / HP Z3805A GPS Receiver
Frequency – Measure [1]	(10 to 50 000) MHz	1 x 1^{e-12} Hz/Hz + 0.1 Hz	Agilent E4448A Spectrum Analyzer / HP Z3805A GPS Receiver
Timer, Stopwatch [1]	10 s to 24 hr	34 ms	Totalize method with counter
Tachometers – RPM [1]	Up to 100 000 RPM	0.001 % of reading + 0.6*R*	HP 33250A Signal Generator & LED

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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. D = diameter in inches, DL = diagonal length in inches, L = length in inches (or millimeters as indicated), F = length in feet, R = resolution of device under test, t = time in seconds, V = Volume in microliters, X = weight in grams, W = weight in pounds, 1 mil = 0.001 inch.
3. The tactile fit of an adjustable thread ring to a thread-setting plug is not a measurement of pitch diameter. The uncertainty for this pitch diameter setting is based on the contributors associated with the thread setting plug and environmental contributors only.
4. The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The uncertainties presented here do not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
5. The nominal values listed are approximate.
6. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2080.

Jason Stine, Vice President