CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

Technical Maintenance, Inc.
12530 Telecom Drive
Temple Terrace, FL 33637

has been assessed by ANAB and meets the requirements of international standard

ISO/IEC 17025:2005

and national standards

ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)

while demonstrating technical competence in the field of

CALIBRATION

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations to which this accreditation applies.

AC-2080
Certificate Number

ANAB Approval

Certificate Valid: 10/09/2017-09/20/2019
Version No. 006 Issued: 10/09/2017

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. 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).

ANSI-ASQ National Accreditation Board

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)

Technical Maintenance, Inc.
12530 Telecom Drive
Temple Terrace, FL 33637
Scott Chamberlain 813-978-3054

CALIBRATION

Valid to: **September 20, 2019** Certificate Number: **AC-2080**

Acoustics and Vibration

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	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]	(4, 7, 10) pH	0.02 pH	pH buffer solutions
Conductivity Meters[1]	2 µS 10 µS 100 µS 1 000 µS 10 000 µS	0.52 µS 0.25 µS 0.47 µS 2.8 µS 95 µS	Conductivity solutions

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Angle – Generate 1 Hz to 1 kHz 1 to 6.25 kHz 6.25 to 50 kHz 50 to 200 kHz 1 Hz to 1 kHz 1 to 6.25 kHz 6.25 to 50 kHz 50 to 200 kHz	 (0 to 360) ° 5 V Equal Amplitude (0 to 360) ° 50 mV to 100 V	 0.005 ° 0.01 ° 0.016 ° 0.04 ° 0.006 ° 0.01 ° 0.017 ° 0.057 °	Clarke-Hess 5500-2
Phase Angle – Measure 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° to 360° 10 mV to 350 V	0.02 ° 0.03 ° 0.04 ° 0.05 ° 0.1 ° 0.2 °	Clarke-Hess 6000A
DC Current – Generate[1]	Up to 220 µA 220 µA to 2.2 mA 2.2 to 22 mA 22 to 220 mA 220 mA to 2.2 A	40 µA/A + 6 nA 35 µA/A + 7 nA 36 µA/A + 40 nA 48 µA/A + 0.7 µA 81 µA/A + 12 µA	Fluke 5730A
	(2.2 to 11) A	370 µA/A + 480 µA	Fluke 5730A/5725A
	(11 to 20.5) A (20 to 100) A	77 µA/A + 1 mA 79 µA/A + 6 mA	Fluke 5522A/52120A
DC Current Clamp Meters Toroidal	(100 to 550) A (500 to 1 025) A	0.20 % of reading + 0.08A 0.21 % of reading + 0.09A	Fluke 5522A/Coil5500A
DC Current Clamp Meters Non-Toroidal	(100 to 550) A (500 to 1 025) A	0.38 % of reading + 0.53A 0.39 % of reading + 0.54A	Fluke 5522A/52120A/6KA/Coil
DC Current – Measure[1]	(0.004 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA	6 µA/A 5 µA/A 6 µA/A 10 µA/A	Fluke 8508A/5450A
	(0.22 to 2.2) A (2.2 to 25) A	37 µA/A 25 µA/A	Fluke 8508A/Guildline 9230A
	(25 to 100) A (100 to 1 000) A	0.25 % of reading 1.5 % of reading + 0.5A	Fluke 8508A/Empro 250A Fluke 376 Clamp

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage[1] – Generate	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	11 µV/V + 0.4 µV 5.2 µV/V + 0.7 µV 3.5 µV/V + 2.5 µV 3.5 µV/V + 4 µV 5.0 µV/V + 40 µV 6.5 µV/V + 400 µV	Fluke 5730A
DC Voltage[1] – Measure	Up to 200 mV 200 mV to 2 V (2 to 20) V (20 to 200) V (200 to 1 000) V	15 µV/V + 100 nV 3.8 µV/V + 400 nV 3.5 µV/V + 4 µV 5.5 µV/V + 40 µV 5.5 µV/V + 500 µV	Fluke 8508A
	(1 to 120) kV	0.23 % of reading	Ross VD120/ HP34401A
DC Voltage[1] – Measure Fixed Points	100 mV 1V 10V 100V 1 000V	2.9 µV/V 0.83 µV/V 0.33 µV/V 0.5 µV/V 0.73 µV/V	Fluke 732A/752A
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	 0.027 % of reading + 4 µV 0.014 % of reading + 4 µV 0.013 % of reading + 4 µV 0.022 % of reading + 4 µV 0.052 % of reading + 5 µV 0.11 % of reading + 10 µV 0.14 % of reading + 20 µV 0.27 % of reading + 20 µV 0.024 % of reading + 4 µV 91 µV/V + 4 µV 81 µV/V + 4 µV 0.02 % of reading + 4 µV 0.05 % of reading + 5 µV 0.1 % of reading + 10 µV 0.14 % of reading + 20 µV 0.27 % of reading + 20 µV	Fluke 5730A

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate[1]	(22 to 220) mV		Fluke 5730A/5725A
	(10 to 20) Hz	0.024 % of reading + 12 µV	
	(20 to 40) Hz	90 µV/V + 7 µV	
	40 Hz to 20 kHz	58 µV/V + 7 µV	
	(20 to 50) kHz	0.012 % of reading + 7 µV	
	(50 to 100) kHz	0.031 % of reading + 17 µV	
	(100 to 300) kHz	0.066 % of reading + 20 µV	
	(300 to 500) kHz	0.14 % of reading + 25 µV	
	500 kHz to 1 MHz	0.27 % of reading + 45 µV	
	220 mV to 2.2 V		
	(10 to 20) Hz	0.024 % of reading + 40 µV	
	(20 to 40) Hz	90 µV/V + 15 µV	
	40 Hz to 20 kHz	43 µV/V + 8 µV	
	(20 to 50) kHz	67 µV/V + 10 µV	
	(50 to 100) kHz	85 µV/V + 30 µV	
	(100 to 300) kHz	0.034 % of reading + 80 µV	
	(300 to 500) kHz	0.1 % of reading + 200 µV	
	500 kHz to 1 MHz	0.17 % of reading + 300 µV	
	(2.2 to 22) V		
	(10 to 20) Hz	0.024 % of reading + 400 µV	
	(20 to 40) Hz	91 µV/V + 150 µV	
	40 Hz to 20 kHz	43 µV/V + 50 µV	
	(20 to 50) kHz	67 µV/V + 100 µV	
	(50 to 100) kHz	83 µV/V + 200 µV	
	(100 to 300) kHz	0.025 % of reading + 600 µV	
	(300 to 500) kHz	0.1 % of reading + 2 mV	
	500 kHz to 1 MHz	0.15 % of reading + 3.2 mV	
	(22 to 220) V		
	(10 to 20) Hz	0.024 % of reading + 4 mV	
	(20 to 40) Hz	90 µV/V + 1.5 mV	
	40 Hz to 20 kHz	52 µV/V + 0.6 mV	
	(20 to 50) kHz	80 µV/V + 1 mV	
	(50 to 100) kHz	0.015 % of reading + 2.5 mV	
AC Voltage – Generate[1]	(220 to 750) V		Fluke 5730A/5725A
	40 Hz to 1 kHz	91 µV/V + 4 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
	(20 to 50) kHz	0.06 % of reading + 11 mV	
	(50 to 100) kHz	0.23 % of reading + 45 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Generate[1]	(750 to 1 000) V		Fluke 5730A/5725A
	40 Hz to 1 kHz	91 µV/V + 4 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
	(20 to 30) kHz	0.06 % of reading + 11 mV	
AC Voltage – Measure[1]	Up to 2.2 mV		Fluke 5790A
	(10 to 20) Hz	0.13 % of reading + 1.3 µV	
	(20 to 40) Hz	0.058 % of reading + 1.3 µV	
	40 Hz to 20 kHz	0.034 % of reading + 1.3 µV	
	(20 to 50) kHz	0.063 % of reading + 2 µV	
	(50 to 100) kHz	0.093 % of reading + 2.5 µV	
	(100 to 300) kHz	0.18 % of reading + 4 µV	
	(300 to 500) kHz	0.18 % of reading + 8 µV	
	500 kHz to 1 MHz	0.24 % of reading + 8 µV	
	(2.2 to 7) mV		
	(10 to 20) Hz	0.065 % of reading + 1.3 µV	
	(20 to 40) Hz	0.028 % of reading + 1.3 µV	
	40 Hz to 20 kHz	0.016 % of reading + 1.3 µV	
	(20 to 50) kHz	0.031 % of reading + 2 µV	
	(50 to 100) kHz	0.046 % of reading + 2.5 µV	
	(100 to 300) kHz	0.091 % of reading + 4 µV	
	(300 to 500) kHz	0.099 % of reading + 8 µV	
	500 kHz to 1 MHz	0.18 % of reading + 8 µV	
	(7 to 22) mV		
	(10 to 20) Hz	0.022 % of reading + 1.3 µV	
	(20 to 40) Hz	0.015 % of reading + 1.3 µV	
	40 Hz to 20 kHz	84 µV/V + 1.3 µV	
	(20 to 50) kHz	0.016 % of reading + 2 µV	
	(50 to 100) kHz	0.024 % of reading + 2.5 µV	
	(100 to 300) kHz	0.062 % of reading + 4 µV	
	(300 to 500) kHz	0.068 % of reading + 8 µV	
	500 kHz to 1 MHz	0.13 % of reading + 8 µV	
	(22 to 70) mV		
	(10 to 20) Hz	0.018 % of reading + 1.5 µV	
	(20 to 40) Hz	91 µV/V + 1.5 µV	
	40 Hz to 20 kHz	50 µV/V + 1.3 µV	
	(20 to 50) kHz	99 µV/V + 2 µV	
	(50 to 100) kHz	0.02 % of reading + 2.5 µV	
	(100 to 300) kHz	0.039 % of reading + 4 µV	
	(300 to 500) kHz	0.051 % of reading + 8 µV	
	500 kHz to 1 MHz	0.084 % of reading + 8 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure[1]	(70 to 220) mV		Fluke 5790A
	(10 to 20) Hz	0.016 % of reading + 1.5 µV	
	(20 to 40) Hz	65 µV/V + 1.5 µV	
	40 Hz to 20 kHz	31 µV/V + 1.3 µV	
	(20 to 50) kHz	27 µV/V + 2 µV	
	(50 to 100) kHz	0.012 % of reading + 2.5 µV	
	(100 to 300) kHz	0.019 % of reading + 4 µV	
	(300 to 500) kHz	0.029 % of reading + 8 µV	
	500 kHz to 1 MHz	0.076 % of reading + 8 µV	
	(220 to 700) mV		
	(10 to 20) Hz	0.022 % of reading + 1.5 µV	
	(20 to 40) Hz	91 µV/V + 1.5 µV	
	40 Hz to 20 kHz	60 µV/V + 1.3 µV	
	(20 to 50) kHz	72 µV/V + 2 µV	
	(50 to 100) kHz	94 µV/V + 2.5 µV	
	(100 to 300) kHz	0.019 % of reading + 4 µV	
	(300 to 500) kHz	0.031 % of reading + 8 µV	
	500 kHz to 1 MHz	0.097 % of reading + 8 µV	
	700 mV to 2.2 V		
	(10 to 20) Hz	0.015 % of reading	
	(20 to 40) Hz	50 µV/V	
	40 Hz to 20 kHz	20 µV/V	
	(20 to 50) kHz	35 µV/V	
	(50 to 100) kHz	54 µV/V	
	(100 to 300) kHz	0.012 % of reading	
	(300 to 500) kHz	0.02 % of reading	
	500 kHz to 1 MHz	0.069 % of reading	
	(2.2 to 7) V		
	(10 to 20) Hz	0.015 % of reading	
	(20 to 40) Hz	51 µV/V	
	40 Hz to 20 kHz	19 µV/V	
	(20 to 50) kHz	37 µV/V	
	(50 to 100) kHz	63 µV/V	
	(100 to 300) kHz	0.015 % of reading	
	(300 to 500) kHz	0.031 % of reading	
	500 kHz to 1 MHz	0.091 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure[1]	(7 to 22) V		Fluke 5790A
	(10 to 20) Hz	0.015 % of reading	
	(20 to 40) Hz	52 µV/V	
	40 Hz to 20 kHz	22 µV/V	
	(20 to 50) kHz	37 µV/V	
	(50 to 100) kHz	62 µV/V	
	(100 to 300) kHz	0.015 % of reading	
	(300 to 500) kHz	0.031 % of reading	
	500 kHz to 1 MHz	0.091 % of reading	
	(22 to 70) V		
	(10 to 40) Hz	0.015 % of reading	
	40 Hz to 20 kHz	52 µV/V	
	(20 to 50) kHz	25 µV/V	
	(50 to 100) kHz	44 µV/V	
	(100 to 300) kHz	72 µV/V	
	(300 to 500) kHz	0.015 % of reading	
	(70 to 220) V		
	(10 to 20) Hz	0.015 % of reading	
	(20 to 40) Hz	53 µV/V	
	40 Hz to 20 kHz	24 µV/V	
	(20 to 50) kHz	53 µV/V	
	(50 to 100) kHz	75 µV/V	
	(220 to 700) V		
	40 Hz to 20 kHz	35 µV/V	
	(20 to 50) kHz	0.01 % of reading	
	(50 to 100) kHz	0.038 % of reading	
	(700 to 1 000) V		
	40 Hz to 20 kHz	33 µV/V	
	(20 to 30) kHz	0.01 % of reading	
AC Voltage – Measure[1]	(1 to 85) kV		Ross VD120/ HP 34401A
	(50, 60) Hz	0.67 % of reading	
AC Current – Measure[1]	(9 to 220) µA		Fluke 5730A
	(10 to 20) Hz	0.025 % of reading + 16 nA	
	(20 to 40) Hz	0.016 % of reading + 10 nA	
	40 Hz to 1 kHz	0.01 % of reading + 8 nA	
	(1 to 5) kHz	0.028 % of reading + 12 nA	
	(5 to 10) kHz	0.11 % of reading + 65 nA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure[1]	(0.22 to 2.2) mA		Fluke 5730A
	(10 to 20) Hz	0.025 % of reading + 40 nA	
	(20 to 40) Hz	0.016 % of reading + 35 nA	
	40 Hz to 1 kHz	0.01 % of reading + 35 nA	
	(1 to 5) kHz	0.02 % of reading + 110 nA	
	(5 to 10) kHz	0.011 % of reading + 650 nA	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.025 % of reading + 400 nA	
	(20 to 40) Hz	0.016 % of reading + 350 nA	
	40 Hz to 1 kHz	0.01 % of reading + 350 nA	
	(1 to 5) kHz	0.02 % of reading + 550 nA	
	(5 to 10) kHz	0.011 % of reading + 5 µA	
	(22 to 220) mA		
	(10 to 20) Hz	0.025 % of reading + 4 µA	
	(20 to 40) Hz	0.016 % of reading + 3.5 µA	
	40 Hz to 1 kHz	0.01 % of reading + 2.5 µA	
	(1 to 5) kHz	0.02 % of reading + 3.5 µA	
	(5 to 10) kHz	0.11 % of reading + 10 µA	
AC Current – Generate[1]	(0.22 to 2.2) A		Fluke 5730A/5725A
	20 Hz to 1 kHz	0.025 % of reading + 35 µA	
	(1 to 5) kHz	0.045 % of reading + 80 µA	
	(5 to 10) kHz	0.7 % of reading + 160 µA	
	(2.2 to 11) A		
	40 Hz to 1 kHz	0.046 % of reading + 170 µA	
	(1 to 5) kHz	0.095 % of reading + 380 µA	
	(5 to 10) kHz	0.36 % of reading + 750 µA	
AC Current – Generate[1]	(11 to 20.5) A		Fluke 5520A
	(45 to 100) Hz	0.1 % of reading + 2 mA	
	100 Hz to 1 kHz	0.12 % of reading + 5 mA	
	(1 Hz to 5) kHz	2.3 % of reading + 5 mA	
AC Current Clamps – Toroidal	(10 to 125) A		Fluke 5522A/x50 Coil
	(45 to 65) Hz	0.24 % of reading +0.34A	
	(10 to 150) A		
	(65 to 440) Hz	0.61 % of reading +0.11A	
Clamps -Non-Toroidal	(10 to 125) A		
	(45 to 65) Hz	0.44 % of reading +0.95A	
	(10 to 150) A		
	(65 to 440) Hz	0.76 % of reading +0.91A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Clamps - Rogowski	(100 to 6000)A (20 to 1 000) Hz	0.6 % of reading +0.3 A	Fluke 52120/6KA/Coil
AC Current – Measure[1]	Up to 200 µA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz 200 µA to 2 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	 0.054 % of reading + 0.02 µA 0.054 % of reading + 0.02 µA 0.074 % of reading + 0.02 µA 0.4 % of reading + 0.02 µA 0.032 % of reading + 0.2 µA 0.031 % of reading + 0.2 µA 0.072 % of reading+ 0.2 µA 0.4 % of reading + 0.2 µA	Fluke 8508A
AC Current – Measure[1]	(2 to 22) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 50) kHz (22 to 220) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 50) kHz	 0.021 % of reading 0.012 % of reading 0.01 % of reading 0.01 % of reading 0.014 % of reading 0.045 % of reading 0.042 % of reading 0.041 % of reading 0.041 % of reading 0.019 % of reading	Fluke 5790A / Holt HCS-1 Current Shunts
AC Current – Measure[1]	(0.22 to 2.2) A (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (10 to 50) kHz (2.2 to 20) A (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz	 86 µA/A 54 µA/A 48 µA/A 76 µA/A 0.019 % of reading 97 µA/A 64 µA/A 60 µA/A 91 µA/A	Fluke 5790A / Holt HCS-1 Current Shunts
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

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 W/i2500 flex probe
Resistance – Generate, Fixed Points[1]	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 19 MΩ 100 MΩ 1 GΩ	1.7 μΩ/Ω 1.6 μΩ/Ω 2.1 μΩ/Ω 1.3 μΩ/Ω 1.1 μΩ/Ω 4.2 μΩ/Ω 2.4 μΩ/Ω 5.6 μΩ/Ω 7.3 μΩ/Ω 34 μΩ/Ω 104 μΩ/Ω	Fluke 742A/ IET SRL
	(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	98 μΩ/Ω 23μΩ/Ω 10 μΩ/Ω 6.5 μΩ/Ω 6.5 μΩ/Ω 8.5 μΩ/Ω 13 μΩ/Ω 18 μΩ/Ω 40 μΩ/Ω 48 μΩ/Ω 100 μΩ/Ω	Fluke 5730A
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	40 μΩ/Ω + 0.01 Ω 30 μΩ/Ω + 0.015 Ω 28 μΩ/Ω + 0.015 Ω 28 μΩ/Ω + 0.02 Ω 29 μΩ/Ω + 0.02 Ω 29 μΩ/Ω + 0.2 Ω 29 μΩ/Ω + 0.1 Ω 29 μΩ/Ω + 1 Ω 29 μΩ/Ω + 1 Ω 33 μΩ/Ω + 10 Ω	Fluke 5520A

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Generate[1]	(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	33 μΩ/Ω + 10 Ω 60 μΩ/Ω + 150 Ω 0.013 % of reading + 250 Ω 0.025 % of reading + 2.5 kΩ 0.05 % of reading + 3 kΩ 0.3 % of reading + 100 kΩ 1.5 % of reading + 500 kΩ	Fluke 5520A
Resistance – Measure[1] Fixed Points	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ	9.2 μΩ/Ω 3.7 μΩ/Ω 2.3 μΩ/Ω 1.5 μΩ/Ω 1.4 μΩ/Ω 4.4 μΩ/Ω 3.2 μΩ/Ω 6.1 μΩ/Ω 34 μΩ/Ω 194 μΩ/Ω	Fluke 8508A/ Fluke 742A/ IET SRL
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	19 μΩ/Ω + 4 μΩ 9.5 μΩ/Ω + 14 μΩ 8 μΩ/Ω + 50 μΩ 8 μΩ/Ω + 500 μΩ 8 μΩ/Ω + 5 mΩ 8 μΩ/Ω + 50 mΩ 9.0 μΩ/Ω + 1 Ω 17 μΩ/Ω + 10Ω 65 μΩ/Ω + 1kΩ 0.018 % of reading + 100 kΩ 0.15 % of reading + 10 MΩ	Fluke 8508A
Capacitance – Generate[1]	(0.19 to 0.109) nF (1.1 to 3.299) nF (3.3 to 329.999) nF (0.33 to 1.099) μF (1.1 to 3.299) μF (3.3 to 10.999) μF (11 to 32.999) μF (33 to 109.999) μF	1.2 % of reading + 0.01 nF 1.2 % of reading + 0.01 nF 0.39 % of reading + 0.3 nF 0.38 % of reading + 3 nF 0.37 % of reading + 3 nF 0.38 % of reading + 10 nF 0.53 % of reading + 30 nF 0.58 % of reading + 100 nF	Fluke 5522A

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Generate[1]	(110 to 329.999) µF (0.33 to 1.099) mF (1.1 to 3.299) mF (3.3 to 10.999) mF (11 to 32.999) mF (33 to 110) mF	0.58 % of reading + 300 nF 0.57 % of reading + 1 µF 0.58 % of reading + 3 µF 0.59 % of reading + 10 µF 0.65 % of reading + 30 µF 1.3 % of reading + 100 µF	Fluke 5522A
Capacitance – Measure 12 Hz to 200 kHz	0.000 01 pf to 99 999 µf	0.026 % of reading	IET 1693
Capacitance – Generate[1] Fixed Points	1 pF 10 pF 100 pf 1 000 pF	0.41 % of reading 0.17 % of reading 0.13 % of reading 0.32 % of reading	Agilent 16380A
Inductance – Measure 12 Hz to 200 kHz	0.01 µH to 99 999 H	0.025 % of reading	IET 1693
Inductance – Generate 1 kHz	0.07 µH 0.1 µH 0.28 µH 0.52 µH 1 µH 2.5 µH 5.2 µH 10 µH 28 µH 56 µH 100 µH 250 µH 520 µH 1 mH 2.8 mH 5.2 mH	0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading 0.032 % of reading	Agilent 16470A
Inductance – Generate 1 kHz	10 mH 25 mH 52 mH	0.032 % of reading 0.032 % of reading 0.032 % of reading	Agilent 16470A

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscope Calibration – Vertical Deflection[1]			
50 Ω, 1 kHz square wave	1 mV to 6.6 V	0.25 % of reading + 40 µV	
1 MΩ, 1 kHz square wave	1 mV to 130 V	0.1 % of reading + 40 µV	
Flatness – Leveled Sine Wave	5 mV to 5.5 V		
	50 kHz to 100 MHz	1.7 % of reading + 100 µV	Fluke 5522A/SC1100
	(100 to 300) MHz	2.2 % of reading + 100 µV	
	(300 to 600) MHz	4.2 % of reading + 100 µV	
	(600 to 1100) MHz	5.2 % of reading + 100 µV	
Bandwidth	<300 ps	+ 13 ps / -101 ps	
Rise Time	1 ns to 20 ms	2.7 µs/s	
Time Interval[2]	50 ms to 5 s	(26 + 1 000*t*) µs/s	
Power Meter Range Calibration[1]	3 µW to 100 mW	0.25 % of reading	HP 11683A
Electrical Calibration of Thermocouple Indicating Devices[1] –	Type B		Fluke 7526A
	(600 to 1 820) °C	0.41 °C	
	Type C		
	(0 to 2 316) °C	0.38 °C	
	Type E		
	(-250 to 1 000) °C	0.29 °C	
	Type J		
	(-210 to 1 200) °C	0.19 °C	
	Type K		
	(-200 to 1 372) °C	0.21 °C	
	Type L		
	(-200 to 900) °C	0.12 °C	
	Type N		
	(-200 to 1 300) °C	0.26 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of Thermocouple Indicating Devices[1] –	Type R (0 to 1 767) °C Type S (0 to 1 767) °C Type T (-250 to -200) °C (-200 to 400) °C Type U (-200 to 600) °C	 0.45 °C 0.44 °C 0.41 °C 0.2 °C 0.19 °C	Fluke 7526A

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Flatness – Measure	1mV to 7 V (10 to 30) Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 0.16 % of reading 0.04 % of reading 0.04 % of reading 0.04 % of reading 0.04 % of reading 0.06 % of reading 0.06 % of reading 0.12 % of reading 0.19 % of reading 0.43 % of reading	Fluke 5790A
Flatness – Measure	Up to 7 V 30 MHz to 50 GHz	 6 % of reading	HP 8487A/8482A
Attenuation[1] – Measure 100 kHz to 50 GHz 100 kHz to 50 GHz 100 kHz to 50 GHz 100 kHz to 50 GHz 100 kHz to 50 GHz 100 kHz to 50 GHz 100 kHz to 50 GHz 100 kHz to 45 GHz 100 kHz to 41 GHz	 (-10 to 0) dB (-20 to -11) dB (-30 to -21) dB (-40 to -31) dB (-50 to -41) dB (-60 to -51) dB (-70 to -61) dB (-80 to -71) dB (-90 to -81) dB	 0.019 dB 0.022 dB 0.027 dB 0.032 dB 0.037 dB 0.055 dB 0.06 dB 0.064 dB 0.069 dB	Agilent N5531S

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation[1] – Measure 100 kHz to 31.15 GHz 100 kHz to 26.5 GHz 100 kHz to 3.05 GHz	 (-100 to -91) dB (-110 to -101) dB (-120 to -111) dB	 0.074 dB 0.086 dB 0.091 dB	Agilent N5531S
Amplitude Modulation[1] – Measure 100 kHz to 10 MHz 10 MHz to 3 GHz 10 MHz to 3 GHz (3 to 26.5) GHz (3 to 26.5) GHz (26.5 to 31.5) GHz (26.5 to 31.5) GHz (31.5 to 50) GHz (31.5 to 50) GHz	 (5 to 99) % Depth (5 to 20) % Depth (20 to 99) % Depth (5 to 20) % Depth (20 to 99) % Depth (5 to 20) % Depth (20 to 99) % Depth (5 to 20) % Depth (20 to 99) % Depth	 1 % Depth 2.9 % Depth 0.8 % Depth 5.2 % Depth 1.8 % Depth 7.9 % Depth 2.3 % Depth 30 % Depth 7 % Depth	Agilent N5531S
Frequency Modulation[1] – Measure 250 kHz to 10 MHz 10 MHz to 6.6 GHz (6.6 to 13.2) GHz (13.2 to 31.15) GHz (31.15 to 50) GHz	 20 Hz to 10 kHz (50 to 200) Hz	 3.1 % of reading 3.1 % of reading 3.8 % of reading 5 % of reading 11 % of reading	Agilent N5531S
Phase Modulation[1] – Measure	100 kHz to 50 GHz	9.7 % of reading	Agilent N5531S
AM Distortion[1] – Measure	(0.1 to 10) MHz 10 MHz to 26.5 GHz (26.5 to 50) GHz	0.8 % of reading 1 % of reading 6.2 % of reading	Agilent N5531S
FM Distortion[1] – Measure	1 MHz to 50 GHz	0.3 % of reading	Agilent N5531S
Attenuation Generate 30 MHz 30 MHz 30 MHz 30 MHz 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
RF Power[1] – Measure 50 MHz	1.0 mW	0.0032 mW	HP 478A/Opt H76
RF Power[1] – Measure 100 kHz-4.2 GHz	(-30 to 0.01) dBm (0.01 to 20) dBm	1.1 % of reading	HP 8482A-H84

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power[1] – Measure 10 MHz-18 GHz	(-30 to -0.01) dBm (0.01 to 20) dBm	1.3 % of reading	HP 8481A-H84
RF Power[1] – Measure 10 MHz-26.5GHz	(-20 to -0.01) dBm 0.01 to 30) dBm	4.7 % of reading	Agilent N5531S
RF Power[1] – Measure 100 kHz to 4.2 GHz	(0.01 to 44) dBm	4.1% of reading	HP 8482B
RF Power[1] – Measure 50 MHz to 50 GHz	(-30 to -0.01) dBm (0.01 to 20) dBm	2.7 % of reading	HP 8487A-H84
RF Power – Generate 10 Hz - 100 kHz 100 kHz - 10 MHz 10 MHz - 128 MHz 128 MHz - 300 MHz	(-48 to 24) dBm (-48 to 24) dBm (-74 to -48) dBm (-94 to -74) dBm (-48 to 24) dBm (-84 to -48) dBm (-94 to -84) dBm (-130 to -94) dBm (-48 to 20) dBm (-74 to -48) dBm (-84 to -74) dBm (-94 to -84) dBm (-130 to -94) dBm	0.035 dB 0.058 dB 0.23 dB 0.58 dB 0.058 dB 0.12 dB 0.35 dB 0.81 dB 0.081 dB 0.12 dB 0.35 dB 0.58 dB 1.8 dB	Fluke 9640A-LPNX
RF Power – Generate 300 MHz - 1.4 GHz 1.4 GHz - 3 GHz 3 GHz - 4 GHz	(-48 to 20) dBm (-74 to -48) dBm (-84 to -74) dBm (-94 to -84) dBm (-130 to -94) dBm (-48 to +14) dBm (-74 to -48) dBm (-94 to -74) dBm (-130 to -94) dBm (-17 to 14) dBm (-74 to -17) dBm (-84 to -74) dBm	0.23 dB 0.46 dB 0.58 dB 1.2 dB 1.8 dB 0.35 dB 0.58 dB 1.2 dB 1.8 dB 0.35 dB 0.58 dB 1.2 dB	Fluke 9640A-LPNX

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Noise[1] – SSB Measure	1 MHz to 50 GHz	0.39 dB	Agilent E4448A
AM/FM Distortion[1]	20 Hz to 20 kHz	1.2 dB	HP 8903B
Harmonic Distortion 20 Hz to 20 kHz 20 kHz to 50 GHz	(0 to -120) dB	 1.2 dB 1.2 dB	HP 8903B Agilent E4448
LISN and CDN Impedance LISN and CDN Phase* *(dependent on reflection magnitude) Insertion Loss 9 kHz – 500 MHz	0.1 Ω to 5 kΩ (-180 to 180) ° (-30 to 10) dB (-40 to -30) dB (-50 to -40) dB (-50 to -40) dB (-70 to -60) dB (-80 to -70) dB	1.7% of reading 1.4 ° 0.034 dB 0.062 dB 0.12 dB 0.35 dB 1 dB 3.5 dB	8751A System w/ 87511A and 85032B
CISPR 16-1-1 Pulse Band A (9 to 150) kHz Band B (0.15 to 30) MHz Band C & D (30 to 1 000) MHz	 (-80 to 80) dB (-80 to 80) dB (-80 to 80) dB	 0.65 dB 0.65 dB 1.1 dB	Schwarzbek IGUU-2918
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
ESD Simulator Current Measure Current Rise Time	 (0.02 to 50) A 10 ps to 10 ms	 4% of reading 3.2 ps + 25 µs/s	Tektronix CSA7404B w/ Haefely PET 4000
EFT/Burst Generator Duration Measure Risetime Measure Amplitude Measure	 (0.05 to 1 000) µs 0.3 ns to 100 ms 10 V to 8 kV	 290 µs/s 0.2 ns + 290 µs/s 3.3% of reading	Lecroy 7100A w/ Teseq CAS 3025 EFT attenuator set

Length – Dimensional metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks[2]	Up to 20 in	(1.7+2.1*L*) µin	Master gage blocks, P&W universal measuring machine
Micrometers[1,2]	Up to 40 in	(32 + 4*L*) µin	Gage blocks (grade 2)
Calipers[1,2]	Up to 40 in	(48 + 7.2*L*) µin	Gage blocks (grade 2)
Dial Indicators[1,2]	Up to 10 in	(86 + 46*L*) µin	Gage blocks (grade 2)
Height Gages[1,2]	Up to 40 in	(194 + 3*L*) µin	Gage blocks (grade 2)
Protractors[1]	(0 to 360) °	0.01 °	Angle blocks
Rulers[1]	Up to 46 in	0.009 in	Gage blocks (grade 2)
Feeler Gage[1]	Up to 1 in	74 µin	Pratt & Whitney Supermicrometer C
Cylindrical Gages[1,2] – Plain Pin, Plugs, Rings	(0.04 to 14) in	(8 + 2*D*) µin	Master gage blocks, P&W universal measuring machine
Cylindrical Gages[1,2] – Plain Rings	(0 to 13) in	(2 + 3*D*) µin	
Thread Plugs[1] – Major Diameter Pitch Diameter	Up to 12 in Up to 12 in	40 µin 91 µin	B & S 599-246-00, Van Keuren thread wire set Gage blocks, Pratt & Whitney Labmaster
Thread Rings	Up to 12 in	107 µin	Pratt & Whitney Labmaster, Thread setting plug gages
Thread Wires	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 Up to 18 x 18 in	95 µin 74 uin	Planekator Repeat-O-Meter
Optical Comparators[1] – Linearity Magnification	 Up to 20 in (20 to 40) in (10 to 100) x	 590 µin 790 µin 590 µin	Gage blocks, SI Industries glass scales

Length – Dimensional metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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
Coating Thickness Shims	(0 to 243) mils	90 µin	Pratt & Whitney Supermicrometer C

Mass

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales & Balances[1,2]	(1 to 20) g (20 to 200) g (200 to 5 000) g (11 to 100) lb	0.09 mg + 0.6*R* 0.58 mg + 0.6*R* 14 mg + 0.6*R* 0.06 g + 0.6*R*	Class 1 weights
	Up to 1 000 lb	55 g + 0.6*R*	Class F weights
Force – Tension and Compression[1]	(0.5 to 500) lbf	0.09 % of reading	Class F weights
	(200 to 10 000) lbf (10 000 to 25 000) lbf (25 000 to 50 000) lbf	0.011 % of reading	Morehouse Press with Load Cells
Pressure[1]	(0 to 24) inH_2O	0.0025 inH_2O	Dwyer 1425-25
	(-15 to 200) psi (0 to 1 000) psi	0.013 % of reading or 0.003 9% of reading of PPC4 Span (whichever is greater)	Fluke PPC4
	(10 to 16 000) psi	0.019 % of reading	Fluke P3125-PSI Dead Weight Tester
Gas Flow	(1 to 10 000) sccm (10 000 to 100 000) sccm	0.29 % of reading 0.64 % of reading	Molbloc flow standards
Torque Tools[1]	(16 to 64) ozf-in 64 ozf-in to 1 000 lbf-ft	1.5% of reading 0.32% of reading	Mountz S320
Torque Analyzers[1]	1 lbf-in to 1 000 lbf-ft	0.1% of reading	CDI 5000 ST

Mass

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Indirect Verification of Rockwell Hardness Testers[1]	(40 to 59) HRBW (59.1 to 79) HRBW (79.1 to 100) HRBW (25 to 30) HRC (35 to 55) HRC (59 to 65) HRC (70 to 79) HR15EW (84 to 90) HR15EW (93 to 100) HR15EW (74 to 80) HR15TW (81 to 86) HR15TW (87 to 93) HR15TW	1.9 HRBW 1.3 HRBW 1.3 HRBW 1.3 HRC 1.3 HRC 0.73 HRC 1.3 HREW 1.3 HREW 1.3 HREW 1.8 HR15TW 1.3 HR15TW 1.3 HR15TW	Indirect verification per ASTM E18
Mass	(1, 2, 5) g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 5 kg 0.03125 oz 0.0625 oz 0.125 oz 0.25 oz 0.5 oz (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	0.09 mg 0.09 mg 0.09 mg 0.33 mg 0.53 mg 0.73 mg 29 mg 30 mg 30 mg 0.18 mg 0.18 mg 0.18 mg 0.19 mg 0.19 mg 0.09 mg 0.10 mg 0.31 mg 0.31 mg 0.36 mg 31 mg 31 mg 0.11 g 0.16 g 0.16 g	Comparison to ASTM E617 Class 1 weights

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Humidity Generate	(10 to 95) % RH	0.51 % RH	Thunder Scientific 2500
Relative Humidity Measure	(0 to 90) % RH (90 to 100) % RH	1.2 % RH 2 % RH	Vaisala MI70/HMP76
Temperature – Measure[1]	(-25 to 600) °C	0.025 °C	Hart 1502A with 5616 PRT
	(800 to 1 550) ºC	2 ºC	Type B Thermocouple
IR Thermometry[1]	(50 to 100) ºC (100 to 300) ºC (300 to 500) ºC	0.51 ºC 0.61 ºC 0.8 ºC	Fluke 9132

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure	10 MHz	1×10^{-11} Hz/Hz	58503A/B GPS
Frequency – Measure[1]	10 Hz to 46 GHz (46 to 50) GHz	1×10^{-9} Hz/Hz 1×10^{-8} Hz/Hz	HP 53152A, E4448A

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. L = length in inches, 1 mil = 0.001 inch, D = diameter in inches, t = time in seconds, R = resolution of device under test.
3. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2080.