



CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

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

This is to certify that

Transcat – Los Angeles

1503 E. Orangethorpe Ave., Unit A

Fullerton, CA 92831

(and satellite location as listed on the scope)

has been assessed by ANAB

and meets the requirements of international standard

ISO/IEC 17025:2005

and national standard

ANSI/NCSL Z540-1-1994 (R2002)

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-2489.08

Certificate Number


ANAB Approval

Certificate Valid: 03/27/2018-09/07/2019
Version No. 002 Issued: 03/27/2018



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

Transcat – Los Angeles

1503 E. Orangethorpe Ave., Unit A
Fullerton, CA 92831
Joshua Underwood
714-447-4445

CALIBRATION

Valid to: **September 7, 2019**

Certificate Number: **AC-2489.08**

Chemical Quantities

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
pH – Measuring Equipment ¹	4 pH	0.011 pH	Standard Buffer Solutions
	7 pH	0.01 pH	
	10 pH	0.011 pH	
Conductivity Meters	10 µS	0.5 µS	Standard Solutions
	100 µS	2.2 µS	
	1000 µS	3.7 µS	
	10 000 µS	36 µS	
	100 000 µS	430 µS	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Sine Wave Flatness	0 V to 3 V		Thermal Voltage Converters
	10 Hz to 1 MHz	0.059 %	
	1 MHz to 10 MHz	0.099 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Sine Wave Flatness	10 MHz to 30 MHz	0.18 %	Thermal Voltage Converters
	30 MHz to 50 MHz	0.41 %	
	50 MHz to 80 MHz	0.71 %	
	80 MHz to 100 MHz	0.84 %	
AC Current – Measuring Equipment ¹	0 μ A to 220 μ A		Fluke 5700A-EP
	10 Hz to 20 Hz	0.03 % + 16 nA	
	20 Hz to 40 Hz	0.019 % + 10 nA	
	40 Hz to 1 kHz	0.015 % + 8 nA	
	1 kHz to 5 kHz	0.027 % + 10 nA	
	5 kHz to 10 kHz	0.11 % + 65 nA	
	0.22 mA to 2.2 mA		
	10 Hz to 20 Hz	0.03 % + 40 nA	
	20 Hz to 40 Hz	0.018 % + 35 nA	
	40 Hz to 1 kHz	0.013 % + 35 nA	
	1 kHz to 5 kHz	0.021 % + 110 nA	
	5 kHz to 10 kHz	0.11 % + 650 nA	
	2.2 mA to 22 mA		
	10 Hz to 20 Hz	0.039 % + 400 nA	
	20 Hz to 40 Hz	0.019 % + 350 nA	
	40 Hz to 1 kHz	0.014 % + 350 nA	
	1 kHz to 5 kHz	0.021 % + 0.55 μ A	
	5 kHz to 10 kHz	0.11 % + 5 μ A	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Generate ¹	22 mA to 220 mA		Fluke 5700A-EP
	10 Hz to 20 Hz	0.033 % + 4 µA	
	20 Hz to 40 Hz	0.018 % + 3.5 µA	
	40 Hz to 1 kHz	0.014 % + 2.5 µA	
	1 kHz to 5 kHz	0.021 % + 3.5 µA	
	5 kHz to 10 kHz	0.11 % + 10 µA	
	0.22 A to 2.2 A		Fluke 5700A-EP with 5725A
	20 Hz to 1 kHz	0.027 % + 35 µA	
	1 kHz to 5 kHz	0.046 % + 80 µA	
	5 kHz to 10 kHz	0.7 % + 160 µA	
	2.2 A to 11 A		Fluke 5522A
	40 Hz to 1 kHz	0.048 % + 170 µA	
	1 kHz to 5 kHz	0.096 % + 380 µA	
	5 kHz to 10 kHz	0.36 % + 750 µA	
	11 A to 20.5 A		Ohms Labs CS-100 w/3458A with Source
	45 Hz to 100 Hz	0.092 % + 3.9 mA	
	100 Hz to 1 kHz	0.12 % + 3.9 mA	
	1 kHz to 5 kHz	2.3 % + 3.9 mA	
	0 A to 10 A		Ohms Labs CS-100 w/3458A with Source
	50 Hz to 999 Hz	0.05 % + 1.3 mA	
	1 kHz	0.12 % + 1.3 mA	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Generate ¹	10 A to 100 A		Ohms Labs CS-100 w/3458A with Source
	50 to 100 Hz	0.038 % + 2.3 mA	
	100 to 999 Hz	0.042 % + 2.3 mA	
Extended Frequency Ranges ¹	29 µA to 329.99 µA 10 kHz to 30 kHz	1.2 % + 0.31 µA	
	330 µA to 3.299 mA 10 kHz to 30 kHz	0.78 % + 0.47 µA	
	3.3 mA to 32.99 mA 10 kHz to 30 kHz	0.31 % + 3.1 µA	
	33 mA to 329.99 mA 10 kHz to 30 kHz	0.31 % + 0.16 mA	
Clamp-on Ammeter (Toroidal Type) Transformer Type ¹	20 A to 150 A 45 Hz to 65 Hz	0.34 % + 35 mA	Fluke 5520A with 5500A/Coil
	65 Hz to 440 Hz	0.95 % + 66 mA	
	150 A to 1 000 A 45 Hz to 65 Hz	0.38 % + 0.17 A	
	65 Hz to 440 Hz	1.2 % + 0.29 A	
Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	20 A to 150 A 45 Hz to 65 Hz	0.66 % + 0.26 A	Fluke 5520A with 5500A/Coil
	65 Hz to 440 Hz	1.2 % + 0.29 A	



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	150 A to 1000 A 45 Hz to 65 Hz 65 Hz to 440 Hz	0.68 % + 1.0 A 1.4 % + 1.1 A	Fluke 5520A with 5500A/Coil
AC Current – Measure ¹	0 μ A to 100 μ A		Agilent 3458A
	10 Hz to 20 Hz	0.46 % + 35 nA	
	20 Hz to 45 Hz	0.17 % + 35 nA	
	45 Hz to 100 Hz	0.072 % + 35 nA	
	100 Hz to 5 kHz	0.072 % + 35 nA	
	100 μ A to 1 mA		
	10 Hz to 20 Hz	0.46 % + 230 nA	
	20 Hz to 45 Hz	0.17 % + 230 nA	
	45 Hz to 100 Hz	0.071 % + 230 nA	
	100 Hz to 5 kHz	0.038 % + 230 nA	
	1 mA to 10 mA		
	10 Hz to 20 Hz	0.46 % + 2.3 μ A	
	20 Hz to 45 Hz	0.17 % + 2.3 μ A	
	45 Hz to 100 Hz	0.071 % + 2.3 μ A	
	100 Hz to 5 kHz	0.038 % + 2.3 μ A	
	10 mA to 100 mA		
	10 Hz to 20 Hz	0.46 % + 23 μ A	
	20 Hz to 45 Hz	0.17 % + 23 μ A	
	45 Hz to 100 Hz	0.071 % + 23 μ A	
	100 Hz to 5 kHz	0.037 % + 23 μ A	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Measure ¹	100 mA to 1 A		Agilent 3458A
	10 Hz to 20 Hz	0.46 % + 0.23 mA	
	20 Hz to 45 Hz	0.19 % + 0.23 mA	
	45 Hz to 100 Hz	0.097 % + 0.23 mA	
	100 Hz to 1 kHz	0.12 % + 0.23 mA	
	0 A to 10 A		Ohms Labs CS-100 w/3458A
	50 Hz to 999 Hz	0.05 % + 1.3 mA	
	1 kHz	0.12 % + 1.3 mA	
	10 A to 100 A		
	50 to 100 Hz	0.038 % + 2.3 mA	
	100 to 999 Hz	0.042 % + 2.3 mA	
	1 kHz	0.13 % + 2.3 mA	
DC Resistance – Measuring Equipment and Measure ¹	0 Ω to 10 Ω	18 $\mu\Omega/\Omega$ + 58 $\mu\Omega$	Agilent 3458A with Decade Resistor
	10 Ω to 100 Ω	15 $\mu\Omega/\Omega$ + 0.58 m Ω	
	100 Ω to 1 k Ω	12 $\mu\Omega/\Omega$ + 0.58 m Ω	
	1 k Ω to 10 k Ω	12 $\mu\Omega/\Omega$ + 5.8 m Ω	
	10 k Ω to 100 k Ω	12 $\mu\Omega/\Omega$ + 58 m Ω	
	100 k Ω to 1 M Ω	19 $\mu\Omega/\Omega$ + 2.3 Ω	
	1 M Ω to 10 M Ω	62 $\mu\Omega/\Omega$ + 120 Ω	
	10 M Ω to 100 M Ω	0.059 % + 1.2 k Ω	
	100 M Ω to 1 G Ω	0.58 % + 12 k Ω	
	0 Ω to 25 Ω	0.042 m Ω	Hart 1590 Super Thermometer



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Resistance – Measuring Equipment and Measure ¹	25 Ω to 400 Ω	1.3 $\mu\Omega/\Omega$	Hart 1590 Super Thermometer
	400 Ω to 1 k Ω	4.1 $\mu\Omega/\Omega$	
	1 k Ω to 40 k Ω	10 $\mu\Omega/\Omega$	
DC Resistance – Measuring Equipment ¹	1 m Ω	18 $\mu\Omega/\Omega$	L&N 4221B
	10 m Ω	18 $\mu\Omega/\Omega$	L&N 4222B
	100 m Ω	22 $\mu\Omega/\Omega$	L&N 4223B
	2 G Ω to 10 G Ω	0.59 %	IET HRRS-B-3-1G-5KV
	20 G Ω to 100 G Ω	1.2 %	
	200 G Ω to 1 T Ω	2.6 %	
DC Current – Measuring Equipment and Measure ¹	0 μ A to 100 μ A	26 μ A/A + 0.92 nA	Agilent 3458A with Current Source
	100 μ A to 1 mA	26 μ A/A + 5.8 nA	
	1 mA to 10 mA	26 μ A/A + 58 nA	
	10 mA to 100 mA	43 μ A/A + 0.58 μ A	
	100 mA to 1 A	0.012 % + 12 μ A	
	1 A to 100 A	0.012 % + 500 μ A	CS-100 with 3458A
	100 A to 300 A	0.047 %	Shunts with DVM & Source
DC Current – Measuring Equipment ¹	0 μ A to 220 μ A	41 μ A/A + 6 nA	Fluke 5700A-EP with 5725A
	0.22 mA to 2.2 mA	36 μ A/A + 7 nA	
	2.2 mA to 22 mA	36 μ A/A + 40 nA	
	22 mA to 220 mA	57 μ A/A + 0.7 μ A	
	0.22 A to 2.2 A	202 μ A/A + 12 μ A	
	2.2 A to 11 A	403 μ A/A + 0.48 mA	



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Current – Measuring Equipment ¹	11 A to 20 A	0.096 % + 580 μ A	Fluke 5522A
Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	20 A to 150 A	0.2 % + 0.14 A	Fluke 5520A with 5500A/Coil
	150 A to 1000 A	0.52 % + 0.52 A	
DC Voltage – Measure Equipment ¹	0 to 220 mV	8.0 μ V/V + 0.4 μ V	Fluke 5700A-EP with 5725A
	220 mV to 2.2 V	5.4 μ V/V + 0.7 μ V	
	2.2 V to 11 V	4 μ V/V + 2.5 μ V	
	11 V to 22 V	4 μ V/V + 4 μ V	
	22 V to 220 V	6.2 μ V/V + 40 μ V	
	220 V to 1100 V	7.6 μ V/V + 400 μ V	
DC Voltage – Measure and Measuring Equipment ¹	0 mV to 100 mV	8.3 μ V/V + 0.5 μ V	Agilent 3458A opt 2 with Fluke 5700A-EP
	0.1 V to 10 V	5.1 μ V/V + 0.5 μ V	
	10 V to 100 V	7.6 μ V/V + 35 μ V	
	100 V to 500 V	11 μ V/V + 0.12 mV	
	500 V to 800 V	16 μ V/V + 0.12 mV	
	800 V to 1 kV	21 μ V/V + 0.12 mV	
	1 kV to 10 kV	0.035 % + 0.035 V	Vitretek 4700
	10 kV to 35 kV	0.031 % + 0.081 V	Vitretek 4700 w/HVL-35
	35 kV to 70 kV	0.038 % + 0.023 V	Vitretek 4700 w/HVL-70
	70 kV to 100 kV	0.063 % + 0.035 V	Vitretek 4700 w/HVL-100
AC Voltage – Measure ¹	0 to 1 mV		R&S URE3
	100 kHz to 1MHz	1.8 % + 2.4 μ V	
	1 MHz to 3 MHz	3.5 % + 2.4 μ V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure ¹	3 MHz to 10 MHz	9.3 % + 2.4 μ V	R&S URE3
	10 MHz to 20 MHz	23 % + 2.4 μ V	
	1 mV to 3 mV		
	100 kHz to 1MHz	0.97 % + 2 μ V	
	1 MHz to 3 MHz	3.5 % + 2 μ V	
	3 MHz to 10 MHz	9.3 % + 2 μ V	
	10 MHz to 20 MHz	23 % + 2 μ V	
	3 mV to 100 mV		
	100 kHz to 1MHz	0.91 % + 3 μ V	
	1 MHz to 3 MHz	1.8 % + 3 μ V	
	3 MHz to 10 MHz	2.9 % + 3 μ V	
	10 MHz to 20 MHz	7.0 % + 3 μ V	
	20 MHz to 30 MHz	14 % + 3 μ V	
	0 mV to 10 mV		Agilent 3458A
	1 Hz to 40 Hz	0.039 % + 3.5 μ V	
	40 Hz to 1 kHz	0.028 % + 1.2 μ V	
	1 kHz to 20 kHz	0.038 % + 1.2 μ V	
	20 kHz to 50 kHz	0.15 % + 1.2 μ V	
	50 kHz to 100 kHz	0.59 % + 1.2 μ V	
	100 kHz to 300 kHz	4.6 % + 2.3 μ V	
	300 kHz to 1 MHz	1.5 % + 5.8 μ V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure ¹	10 mV to 100 mV		Agilent 3458A
	1 Hz to 40 Hz	0.013 % + 4.6 μ V	
	40 Hz to 1 kHz	0.0094 % + 2.3 μ V	
	1 kHz to 20 kHz	0.017 % + 2.3 μ V	
	20 kHz to 50 kHz	0.037 % + 2.3 μ V	
	50 kHz to 100 kHz	0.093 % + 2.3 μ V	
	100 kHz to 300 kHz	0.36 % + 12 μ V	
	300 kHz to 1 MHz	1.2 % + 12 μ V	
	100 mV to 1 V		
	1 Hz to 40 Hz	0.0098 % + 46 μ V	
	40 Hz to 1 kHz	0.0094 % + 23 μ V	
	1 kHz to 20 kHz	0.017 % + 23 μ V	
	20 kHz to 50 kHz	0.036 % + 23 μ V	
	50 kHz to 100 kHz	0.093 % + 23 μ V	
	100 kHz to 300 kHz	0.35 % + 0.12 mV	
	300 kHz to 1 MHz	1.2 % + 0.12 mV	
	1 V to 10 V		
	1 Hz to 40 Hz	0.015 % + 0.46 mV	
	40 Hz to 1 kHz	0.0095 % + 0.23 mV	
	1 kHz to 20 kHz	0.017 % + 0.23 mV	
	20 kHz to 50 kHz	0.036 % + 0.23 mV	
	50 kHz to 100 kHz	0.093 % + 0.23 mV	
	100 kHz to 300 kHz	0.35 % + 1.2 mV	
	300 kHz to 1 MHz	1.2 % + 1.2 mV	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure ¹	10 V to 100 V		Agilent 3458A
	1 Hz to 40 Hz	0.024 % + 4.6 mV	
	40 Hz to 1 kHz	0.024 % + 2.3 mV	
	1 kHz to 20 kHz	0.024 % + 2.3 mV	
	20 kHz to 50 kHz	0.041 % + 2.3 mV	
	50 kHz to 100 kHz	0.14 % + 2.3 mV	
	100 kHz to 300 kHz	0.46 % + 12 mV	
	300 kHz to 1 MHz	1.7 % + 12 mV	
	100 V to 700 V		
	1 Hz to 40 Hz	0.047 % + 46 mV	
	40 Hz to 1 kHz	0.047 % + 23 mV	
	1 kHz to 20 kHz	0.071 % + 23 mV	
	20 kHz to 50 kHz	0.14 % + 23 mV	
	50 kHz to 100 kHz	0.35 % + 23 mV	
	700 V to 70 kV		Hipotronics KVM100-DO with Agilent 34401A
	60 Hz	0.22 %	
AC Voltage – Measuring Equipment ¹	0 mV to 2.2 mV		Fluke 5700A-EP
	10 Hz to 20 Hz	0.036 % + 4.1 μV	
	20 Hz to 40 Hz	0.033 % + 4.1 μV	
	40 Hz to 20 kHz	0.033 % + 4.1 μV	
	20 kHz to 50 kHz	0.033 % + 4.1 μV	
	50 kHz to 100 kHz	0.057 % + 5.1 μV	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	100 kHz to 300 kHz	0.13 % + 10 μ V	Fluke 5700A-EP
	300 kHz to 500 kHz	0.2 % + 20 μ V	
	500 kHz to 1 MHz	0.31 % + 20 μ V	
	2.2 mV to 22 mV		
	10 Hz to 20 Hz	0.037 % + 4.1 μ V	
	20 Hz to 40 Hz	0.026 % + 4.1 μ V	
	40 Hz to 20 kHz	0.009 9 % + 4.1 μ V	
	20 kHz to 50 kHz	0.024 % + 4.1 μ V	
	50 kHz to 100 kHz	0.053 % + 5.1 μ V	
	100 kHz to 300 kHz	0.11 % + 10 μ V	
	300 kHz to 500 kHz	0.14 % + 20 μ V	
	500 kHz to 1 MHz	0.28 % + 20 μ V	
	22 mV to 220 mV		
	10 Hz to 20 Hz	0.025 % + 12 μ V	
	20 Hz to 40 Hz	0.009 3 % + 7.1 μ V	
	40 Hz to 20 kHz	0.008 2 % + 7.1 μ V	
	20 kHz to 50 kHz	0.021 % + 7.1 μ V	
	50 kHz to 100 kHz	0.047 % + 17 μ V	
	100 kHz to 300 kHz	0.092 % + 20 μ V	
	300 kHz to 500 kHz	0.14 % + 26 μ V	
	500 kHz to 1 MHz	0.28 % + 46 μ V	



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	220 mV to 2.2 V		Fluke 5700A-EP
	10 Hz to 20 Hz	0.025 % + 41 μ V	
	20 Hz to 40 Hz	0.009 3 % + 15 μ V	
	40 Hz to 20 kHz	0.004 6 % + 8.2 μ V	
	20 kHz to 50 kHz	0.007 7 % + 10 μ V	
	50 kHz to 100 kHz	0.011 % + 31 μ V	
	100 kHz to 300 kHz	0.043 % + 82 μ V	
	300 kHz to 500 kHz	0.1 % + 0.2 mV	
	500 kHz to 1 MHz	0.17 % + 0.31 mV	
	2.2 V to 22 V		
	10 Hz to 20 Hz	0.025 % + 0.41 mV	
	20 Hz to 40 Hz	0.009 2 % + 0.15 mV	
	40 Hz to 20 kHz	0.004 6 % + 51 μ V	
	20 kHz to 50 kHz	0.007 8 % + 0.1 mV	
	50 kHz to 100 kHz	0.01 % + 0.2 mV	
	100 kHz to 300 kHz	0.028 % + 0.61 mV	
	300 kHz to 500 kHz	0.1 % + 2 mV	
	500 kHz to 1 MHz	0.15 % + 3.3 mV	
	22 V to 220 V		
	10 Hz to 20 Hz	0.025 % + 4.1 mV	
	20 Hz to 40 Hz	0.009 2 % + 1.5 mV	
	40 Hz to 20 kHz	0.005 3 % + 0.61 mV	



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Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	20 kHz to 50 kHz	0.008 2 % + 1.0 mV	Fluke 5700A-EP
	50 kHz to 100 kHz	0.015 % + 2.5 mV	
	100 kHz to 300 kHz	0.092 % + 16 mV	
	300 kHz to 500 kHz	0.45 % + 41 mV	
	500 kHz to 1 MHz	0.82 % + 82 mV	
	220 V to 750 V		Fluke 5700A-EP with 5725A
	30 kHz to 50 kHz	0.061 % + 11 mV	
	50 kHz to 100 kHz	0.24 % + 46 mV	Fluke 5700A-EP with 5725A
	220 V to 1100 V		
	40 Hz to 1 kHz	0.011 % + 4.1 mV	
	1 kHz to 20 kHz	0.017 % + 6.1 mV	
	20 kHz to 30 kHz	0.061 % + 11 mV	Vitretek 4700 with associated probes
	7 kV to 10 kV 60 Hz	0.14 % + 0.12 V	
	10 kV to 30 kV 60 Hz	0.064 % + 0.23 V	
	30 kV to 50 kV 60 Hz	0.091 % + 0.46 V	
	50 kV to 70 kV 60 Hz	0.14 % + 0.7 V	
Capacitance – Measure ¹ 1 kHz	0 pF to 10 pF	0.47 % + 0.05 pF	GenRad 1689-9700
	10 pF to 100 pF	0.059 % + 0.05 pF	
	100 pF to 25 µF	0.024 % + 0.05 pF	
	25 µF to 100 µF	0.035 %	
	100 µF to 1000 µF	0.24 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Capacitance – Measuring Equipment ¹ 1 kHz	1 nF	0.017 %	GenRad 1409 Series Capacitors
	2 nF	0.017 %	
	5 nF	0.017 %	
	10 nF	0.017 %	
	20 nF	0.017 %	
Capacitance – Measuring Equipment 1 1 kHz	50 nF	0.017 %	GenRad 1409 Series Capacitors
	0.1 µF	0.017 %	
	0.2 µF	0.017 %	
	0.5 µF	0.017 %	
	1 µF	0.017 %	
	0.19 nF to < 1.1 nF 10 Hz to 10 kHz	0.39 % + 7.8 pF	Fluke 5520A
	1.1 nF to < 3.3 nF 10 Hz to 3 kHz	0.39 % + 7.8 pF	
	3.3 nF to < 11 nF 10 Hz to 1 kHz	0.2 % + 7.8 pF	
	11 nF to < 110 nF 10 Hz to 1 kHz	0.2 % + 78 pF	
	110 nF to < 330 nF 10 Hz to 1 kHz	0.2 % + 0.23 nF	
	0.33 µF to < 1.1 µF 10 Hz to 600 Hz	0.2 % + 0.78 nF	
	1.1 µF to < 3.3 µF 10 Hz to 300 Hz	0.2 % + 2.3 nF	
	3.3 µF to < 11 µF 10 Hz to 150 Hz	0.20 % + 7.8 nF	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Capacitance – Measuring Equipment 1 1 kHz	11 μ F to < 33 μ F 10 Hz to 120 Hz	0.31 % + 23 nF	Fluke 5520A
	33 μ F to < 110 μ F 10 Hz to 80 Hz	0.35 % + 78 nF	
	110 μ F to < 330 μ F DC to 50 Hz	0.35 % + 0.23 μ F	
	0.33 mF to < 1.1 mF DC to 20 Hz	0.35 % + 0.78 μ F	
	1.1 mF to < 3.3 mF DC to 6 Hz	0.35 % + 2.3 μ F	
	3.3 mF to < 11 mF DC to 2 Hz	0.35 % + 7.8 μ F	
	11 mF to < 33 mF DC to 0.6 Hz	0.58 % + 23 μ F	
	33 mF to < 110 mF DC to 0.2 Hz	0.86 % + 78 μ F	
Inductance Measure ¹	1 mH to 10m H 0.1 to 1 kHz	0.026 % + 0.1 μ H	GenRad 1689-9700
	10mH to 10 H 0.1 to 1 kHz	0.026 % + 1.4 μ H	
Inductance Measuring Equipment ¹ 1 kHz	100 μ H	0.025 %	GenRad 1689-9700 with fixed sources
	1 mH	0.025 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Inductance Measuring Equipment ¹ 1 kHz	10 mH	0.025 %	GenRad 1689-9700 with fixed sources
	100 mH	0.025 %	
	1 H	0.025 %	
	10 H	0.025 %	
Frequency Response Oscilloscopes ¹	50 kHz Reference		Fluke 5520A/1100
	5 mV to 5.5 V		
	50 kHz to 100 MHz	1.7 % + 0.1 mV	
	100 MHz to 300 MHz	2 % + 0.1 mV	
	300 MHz to 600 MHz	3.5 % + 0.1 mV	
	600 MHz to 1100 MHz	4.2 % + 0.1 mV	
Electrical Calibration of Thermocouple Devices ¹ Type B	250 °C to 350 °C	0.95 °C	Ectron 1140A
	350 °C to 445 °C	0.74 °C	
	445 °C to 580 °C	0.58 °C	
	580 °C to 750 °C	0.45 °C	
	750 °C to 1 000 °C	0.37 °C	
	1 000 °C to 1 820 °C	0.29 °C	
Type C	0 °C to 250 °C	0.2 °C	
	250 °C to 1 000 °C	0.16 °C	
	1 000 °C to 1 500 °C	0.18 °C	
	1 500 °C to 1 800 °C	0.21 °C	
	1 800 °C to 2 000 °C	0.23 °C	
	2 000 °C to 2 250 °C	0.29 °C	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Type C	2 250 °C to 2 315 °C	0.32 °C	Ectron 1140A
Type E	-270 °C to -245 °C	1.2 °C	
	-245 °C to -195 °C	0.18 °C	
	-195 °C to -155 °C	0.11 °C	
	-155 °C to 1 000 °C	0.09 °C	
Type J	-210 °C to -180 °C	0.13 °C	
	-180 °C to -120 °C	0.11 °C	
	-120 °C to -50 °C	0.09 °C	
	-50 °C to 1 200 °C	0.08 °C	
Type K	-270 °C to -255 °C	2.2 °C	
	-255 °C to -195 °C	0.7 °C	
	-195 °C to -115 °C	0.13 °C	
	-115 °C to -55 °C	0.1 °C	
	-55 °C to 1 000 °C	0.08 °C	
	1 000 °C to 1 372 °C	0.09 °C	
Type N	-270 °C to -260 °C	5 °C	
	-260 °C to -200 °C	1 °C	
	-200 °C to -140 °C	0.23 °C	
	-140 °C to -70 °C	0.16 °C	
	-70 °C to 25 °C	0.13 °C	
	-25 °C to 1 300 °C	0.11 °C	
Type R	-50 °C to -30 °C	0.65 °C	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Type R	-30 °C to 45 °C	0.55 °C	Ectron 1140A
	45 °C to 160 °C	0.40 °C	
	160 °C to 775 °C	0.30 °C	
	775 °C to 1 768.1 °C	0.22 °C	
Type S	-50 °C to -30 °C	0.62 °C	
	-30 °C to 45 °C	0.56 °C	
	45 °C to 105 °C	0.4 °C	
	105 °C to 310 °C	0.33 °C	
	310 °C to 1 768.1 °C	0.29 °C	
Type T	-270 °C to -255 °C	1.8 °C	
	-255 °C to -240 °C	0.5 °C	
	-240 °C to -210 °C	0.3 °C	
	-210 °C to -150 °C	0.18 °C	
	-150 °C to -40 °C	0.13 °C	
	-40 °C to 100 °C	0.09 °C	
	100 °C to 400 °C	0.08 °C	

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF Phase – Generate Measuring Equipment ¹	0° to 90°		Fluke 5520A
	10 Hz to 65 Hz	0.11°	
	65 Hz to 500 Hz	0.2°	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF Phase – Generate Measuring Equipment ¹	500 Hz to 1 kHz	0.39°	Fluke 5520A
	1 kHz to 5 kHz	1.9°	
	5 kHz to 10 kHz	3.9°	
	10 kHz to 30 kHz	7.8°	
Power – Measuring Equipment DC Power 0.33 mA to 3.3 mA	11 µW to 3.4 W	0.024 %	
3.3 mA to 33 mA	0.11W to 34 W	0.012 %	
33 mA to 330 mA	1.1 mW to 340 W	0.0093 %	
330 mA to 1.1 A	11 mW to 3.4 kW	0.026 %	
1.1 A to 3 A	36 mW to 3.1 kW	0.033 %	
3 to 11 A	0.99 W to 11 kW	0.064 %	
11 to 20.5 A	360 mW to 21 kW	0.089 %	
AC Power ⁶ (PF = 1) 3.3 mA to 9 mA	0.11 mW to 9.2 W		
	45 Hz to 65 Hz	0.089 %	
	9 mA to 33 mA	3 mW to 34W	
	45 Hz to 65 Hz	0.061 %	
	33 mA to 90 mA	1.1 mW to 92 W	
	45 Hz to 65 Hz	0.089 %	
90 mA to 330 mA	3 mW to 340W		
	45 Hz to 65 Hz	0.061 %	
0.33 A to 1.1 A	11 mW to 1.1 kW		
	45 Hz to 65 Hz	0.071 %	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Power ⁶ (PF = 1) 1.1 A to 3.0 A 3.0 A to 5.4 A 5.4 A to 11 A 11 A to 15 A 15 A to 20.5 A	36 mW to 3.1 kW 45 Hz to 65 Hz	0.064 %	Fluke 5520A
	99 mW to 5.5 kW 45 Hz to 65 Hz	0.11 %	
	180 mW to 11 kW 45 Hz to 65 Hz	0.084 %	
	360 mW to 15 kW 45 Hz to 100 Hz	0.14 %	
	100 Hz to 1 kHz	0.16 %	
	500 mW to 21 kW 45 Hz to 100 Hz	0.13 %	
	100 Hz to 1 kHz	0.13 %	

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ⁵	Reference Standard, Method and/or Equipment
Angles	< 90 °	4.4"	Sine Bar w/Plate
	90°	1.4"	Master Square w/Plate
Micrometers and Calipers– Outside, Inside, Depth ¹	0 in to 0.4 in	13 μin	Comparison to Gage Blocks
	0.4 in to 1 in	(13 + 1L) μin	
	1 in to 4 in	(10 + 3.7L) μin	
	4 in to 15 in	(12 + 4L) μin	
	15 in to 40 in	(16 + 4L) μin	

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ⁵	Reference Standard, Method and/or Equipment
Anvil Flatness ¹	0 in to 1 in diameter	6.5 µin	Optical Flats
Anvil Parallelism ¹	0 in to 1 in	6.5 µin	Optical Parallel
Linear Displacement	0 feet to 12 feet	(1 + 2.1L) µin	Laser Interferometer
Dial Indicators ¹	0 in to 0.1 in	4.5 µin	Gage Blocks
	0.1 in to 6 in	(4 + 4L) µin	
Single Axis - Inside	0.06 in to 4.7 in	(3 + 4L) µin	Horizontal Comparator
Single Axis - Outside	0.06 in to 4.7 in	(3 + 4L) µin	Horizontal Comparator
	0 in to 1 in	(15 + 0.5L) µin	Super Micrometer
	1 in to 10 in	(12 + 4L) µin	
Height Measuring Equipment	0 in to 8 in	(6 + 4L) µin	Gage Blocks w/Surface Plate
	8 in to 26 in	(12 + 4L) µin	
Tapes & Rulers	0 ft to 6 ft	(400 + 2L) µin	Accu-Gage
	6 ft to 12 ft	(400 + 7L) µin	
	12 ft to 100 ft	(400 + 6L) µin	
Threaded Plug Pitch Diameter	0 in to 6 in	83 µin	Super Micrometer/ Thread Wires
Major Diameter	0 in to 1 in	(15 + 0.5L) µin	Super Micrometer
	1 in to 6 in	(12 + 4L) µin	
Threaded Ring Inner Pitch Diameter	0 in to 6 in	150 µin	Comparison to Set Plugs



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Force Measuring Equipment ¹ Tension and Compression	0.03 lbf to 600 lbf	0.017 %	Deadweights – Class F
	0 lbf to 500 lbf	0.036 lbf	Load Cell
	500 lbf to 2 000 lbf	0.12 lbf	
	2 000 lbf to 10 000 lbf	1.4 lbf	
	10 000 lbf to 25 000 lbf	5.6 lbf	
	25 000 lbf to 100 000 lbf	32 lbf	
Mass – Metric	30 kg	13 mg	Echelon II
	25 kg	12 mg	
	20 kg	10 mg	
	10 kg	3.5 mg	
	5 kg	1.6 mg	
	3 kg	1.2 mg	
	2 kg	0.66 mg	
	1 kg	0.32 mg	
	500 g	0.15 mg	
	300 g	0.1 mg	
	200 g	67 µg	
	100 g	36 µg	
	50 g	16 µg	
	30 g	12 µg	
	20 g	11 µg	
	10 g	8.2 µg	

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Mass – Metric	5 g	4.7 µg	Echelon II
	3 g	4.7 µg	
	2 g	4.7 µg	
	1 g	4.7 µg	
	500 mg	2 µg	
	300 mg	2 µg	
	200 mg	2 µg	
	100 mg	2 µg	
	50 mg	2 µg	
	30 mg	2 µg	
	20 mg	2 µg	
	10 mg	2 µg	
	5 mg	2 µg	
	3 mg	2 µg	
	2 mg	2 µg	
	1 mg	2 µg	
	50 kg	150 mg	Echelon III
	30 kg	100 mg	
	25 kg	100 mg	
	20 kg	100 mg	
	10 kg	12 mg	
	5 kg	5.8 mg	



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Mass – Metric	3 kg	4 mg	Echelon III
	2 kg	2.5 mg	
	1 kg	1.1 mg	
	500 g	0.51 mg	
	300 g	0.37 mg	
	200 g	0.21 mg	
	100 g	0.1 mg	
	50 g	45 µg	
	30 g	30 µg	
	20 g	27 µg	
	10 g	24 µg	
	5 g	12 µg	
	3 g	12 µg	
	2 g	12 µg	
	1 g	12 µg	
	500 mg	4.9 µg	
	300 mg	4.9 µg	
	200 mg	4.9 µg	
	100 mg	4.9 µg	
	50 mg	4.9 µg	
	30 mg	4.9 µg	
	20 mg	4.9 µg	

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Mass – Metric	10 mg	4.9 µg	Echelon III
	5 mg	4.9 µg	
	3 mg	4.9 µg	
	2 mg	4.9 µg	
	1 mg	4.9 µg	
Mass – Avoirdupois	50 lb	100 mg	Echelon III
	30 lb	13 mg	
	20 lb	12 mg	
	10 lb	5.8 mg	
	5 lb	2.6 mg	
	3 lb	1.2 mg	
	2 lb	1.1 mg	
	1 lb	0.51 mg	
	8 oz	0.22 mg	
	4 oz	0.1 mg	
	2 oz	51 µg	
	1 oz	36 µg	
	0.5 oz	27 µg	
Torque – Measure ¹	2 lbf·in to 250 lbf·in	1 %	CDI 2000-400-02 with Loader
	250 lbf·in to 250 lbf·ft	1 %	
	250 lbf·ft to 600 lbf·ft	1%	CDI 2000-12-02 with Loader
Torque – Measuring Equipment	5 ozf·in to 250 lbf·ft	0.058 %	Torque Wheels with Weights



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Balances - Metric ¹	5 kg	3.7 mg	ASTM Class 1 Weights
	2 kg	1.4 mg	
	1 kg	0.72 mg	
	500 g	0.38 mg	
	300 g	0.21 mg	
	200 g	0.14 mg	
	100 g	0.08 mg	
	50 g	0.042 mg	
	30 g	0.024 mg	
	20 g	0.02 mg	
	10 g	0.014 mg	
	5 g	8.3 µg	
	3 g	7.8 µg	
	2 g	7.7 µg	
	1 g	7.7 µg	
	500 mg	2.4 µg	
	200 mg	2.4 µg	
	100 mg	2.4 µg	
	50 mg	2.4 µg	
	20 mg	2.4 µg	
	10 mg	2.4 µg	
	5 mg	2.4 µg	
	1 mg	2.4 µg	

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Balances – Avoirdupois ¹	50 lb	2.3 g	Class F Weights
	30 lb	1.4 g	
	20 lb	0.91 g	
	10 lb	0.45 g	
	5 lb	0.23 g	
	3 lb	0.14 g	
	2 lb	91 mg	
	1 lb	45 mg	
	8 oz	23 mg	
	4 oz	12 mg	
	2 oz	5.7 mg	
	1 oz	2.8 mg	
	0.5 oz	1.4 mg	
Absolute Pressure – Source	0 psia to 25 psia	0.001 9 psia	Ruska 7250xi
	25 psia to 500 psia	0.006 5 % + 0.001 psia	
Gage Pressure Measuring Equipment – Pneumatic ¹	-14.7 psig to -0.5 psig	0.006 8 %	Pressurements T3500
	0.5 psig to 3 psig	0.006 8 %	
	3 psig to 500 psig	0.006 8 %	
In – Lab Only	-60 inH ₂ O to -22 inH ₂ O	0.009 % + 150 µinH ₂ O	DHI PPC4-ui
	-22 inH ₂ O to 22 inH ₂ O	0.002 inH ₂ O	
	22 inH ₂ O to 60 inH ₂ O	0.009 % + 150 µinH ₂ O	



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
In – Lab Only	60 inH ₂ O to 72 inH ₂ O	0.006 5 inH ₂ O	DHI PPC4-ui
	72 inH ₂ O to 804 inH ₂ O	0.009 % + 150 µinH ₂ O	
Pressure Measuring Equipment – Hydraulic ¹	5 psig to 1 500 psig	0.008 %	Ametek T-150
	1500 psig to 15 000 psig	0.008 %	

Thermodynamic

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Relative Humidity – Measuring Equipment (-10 °C to 70 °C)	10 % RH to 95 % RH	0.5 % RH	Thunder Scientific 2500
Relative Humidity – Measure ¹ (10 °C to 30 °C)	20 % RH to 90 % RH	1.3 % RH	Vaisala HMI41/HMP46
Laboratory Thermometers Measure ¹	-195 °C to 660 °C	0.008 7 °C + 0.003 %	Hart 5628 w/Black Stack
	660 °C to 1 000 °C	0.93 °C	Accu-Mac AM1210 and Hart 2565 w/Black Stack
	1000 °C to 1 200 °C	1.2 °C	
Measuring Equipment ¹	-80 °C to 0 °C	0.014 °C + 0.003 %	Hart 5628 w/Black Stack and Fluke 7381, 7321, and 6331 Baths
	0 °C to 100 °C	0.017 °C + 0.003 %	
	100 °C to 200 °C	0.025 °C + 0.003 %	
	200 °C to 300 °C	0.035 °C + 0.003 %	
	300 °C to 425 °C	0.043 °C + 0.003 %	Hart 5628 w/Black Stack and Fluke 9173 Dry Well
	425 °C to 660 °C	0.06 °C + 0.003 %	
	660 °C to 1 200 °C	3.1 °C	Accu-Mac AM1210, Hart 2565 w/Black Stack and Furnace



Time and Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Frequency – Measuring Equipment and Measure ³ In Lab	10 MHz	3.7×10^{-12} Hz/Hz	Fluke 910R
Field Service ¹	10 MHz	6.6×10^{-9} Hz/Hz	Agilent 53131A (010)
Total Harmonic Distortion ¹ 0 dB to -100 dB	20 Hz to 20 kHz	1.1 dB	Agilent 8903B
	20 kHz to 100 kHz	2 dB	
Total Harmonic Distortion ¹ 5 Hz to 600 kHz 100 % to 0.3 %	10 Hz to 1 MHz	3 %	Agilent 334A
	1 MHz to 3 MHz	6 %	
0.1 % Voltage Range < 30 V	10 Hz to 20 Hz	12 %	
	20 Hz to 30 Hz	6 %	
	30 Hz to 300 kHz	3 %	
	300 kHz to 500 kHz	6 %	
100 % to 0.3 % Voltage Range > 30 V	500 kHz to 1.2 MHz	12 %	
	10 Hz to 300 kHz	3 %	
	300 kHz to 500 kHz	6 %	
	500 kHz to 3 MHz	12 %	
0.1 %	20 Hz to 30 Hz	12 %	
	30 Hz to 300 kHz	3 %	
	300 kHz to 500 kHz	6 %	
	500 kHz to 1.2 MHz	12 %	
Rise Time – Measuring Equipment ¹	250 ps	51 ps ^{NOTE4}	5520A/1100
Rise Time – Measure ¹	≥ 5 ns	4 ns	Agilent DSO5012



Services performed at satellite location

9201 Irvine Blvd.
Irvine, CA 92618

Chemical Quantities

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
pH – Measuring Equipment ¹	4 pH	0.011 pH	Standard Buffer Solutions
	7 pH	0.011 pH	
	10 pH	0.012 pH	
Conductivity Meters	10 μ S	0.5 μ S	Standard Solutions
	100 μ S	2.2 μ S	
	1000 μ S	3.7 μ S	
	10 000 μ S	36 μ S	
	100 000 μ S	430 μ S	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Measuring Equipment ¹	0 μ A to 220 μ A		Fluke 5700A-EP
	10 Hz to 20 Hz	0.03 % + 16 nA	
	20 Hz to 40 Hz	0.019 % + 10 nA	
	40 Hz to 1 kHz	0.015 % + 8 nA	
	1 kHz to 5 kHz	0.027 % + 10 nA	
	5 kHz to 10 kHz	0.11 % + 65 nA	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Measuring Equipment ¹	0.22 mA to 2.2 mA		Fluke 5700A-EP
	10 Hz to 20 Hz	0.03 % + 40 nA	
	20 Hz to 40 Hz	0.018 % + 35 nA	
	40 Hz to 1 kHz	0.013 % + 35 nA	
	1 kHz to 5 kHz	0.021 % + 110 nA	
	5 kHz to 10 kHz	0.11 % + 650 nA	
	2.2 mA to 22 mA		
	10 Hz to 20 Hz	0.039 % + 400 nA	
	20 Hz to 40 Hz	0.019 % + 350 nA	
	40 Hz to 1 kHz	0.014 % + 350 nA	
	1 kHz to 5 kHz	0.021 % + 0.55 µA	
	5 kHz to 10 kHz	0.11 % + 5 µA	
AC Current – Generate ¹	22 mA to 220 mA		Fluke 5700A-EP
	10 Hz to 20 Hz	0.033 % + 4 µA	
	20 Hz to 40 Hz	0.018 % + 3.5 µA	
	40 Hz to 1 kHz	0.014 % + 2.5 µA	
	1 kHz to 5 kHz	0.021 % + 3.5 µA	
	5 kHz to 10 kHz	0.11 % + 10 µA	
	0.22 A to 2.2 A		
	20 Hz to 1 kHz	0.027 % + 35 µA	
	1 kHz to 5 kHz	0.046 % + 80 µA	
	5 kHz to 10 kHz	0.7 % + 160 µA	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Generate ¹	2.2 A to 11 A		Fluke 5700A-EP with 5725A
	40 Hz to 1 kHz	0.048 % + 170 µA	
	1 kHz to 5 kHz	0.096 % + 380 µA	
	5 kHz to 10 kHz	0.36 % + 750 µA	
	11 A to 20.5 A		Fluke 5522A
	45 Hz to 100 Hz	0.092 % + 3.9 mA	
	100 Hz to 1 kHz	0.12 % + 3.9 mA	
	1 kHz to 5 kHz	2.3 % + 3.9 mA	
	0 A to 10 A		Ohms Labs CS-100 w/3458A with Source
	50 Hz to 999 Hz	0.05 % + 1.3 mA	
	1 kHz	0.12 % + 1.3 mA	
AC Current – Generate ¹	10 A to 100 A		Ohms Labs CS-100 w/3458A with Source
	50 to 100 Hz	0.038 % + 2.3 mA	
	100 to 999 Hz	0.042 % + 2.3 mA	
Clamp-on Ammeter (Toroidal Type) Transformer Type ¹	20 A to 150 A		Fluke 5520A with 5500A/Coil
	45 Hz to 65 Hz	0.34 % + 35 mA	
	65 Hz to 440 Hz	0.95 % + 66 mA	
	150 A to 1 000 A		
	45 Hz to 65 Hz	0.38 % + 0.17 A	
	65 Hz to 440 Hz	1.2 % + 0.29 A	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	20 A to 150 A		Fluke 5520A with 5500A/Coil
	45 Hz to 65 Hz	0.66 % + 0.26 A	
	65 Hz to 440 Hz	1.2 % + 0.29 A	
Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	150 A to 1000 A		Fluke 5520A with 5500A/Coil
	45 Hz to 65 Hz	0.68 % + 1.0 A	
	65 Hz to 440 Hz	1.4 % + 1.1 A	
AC Current – Measure ¹	0 μ A to 100 μ A		Agilent 3458A
	10 Hz to 20 Hz	0.46 % + 35 nA	
	20 Hz to 45 Hz	0.17 % + 35 nA	
	45 Hz to 100 Hz	0.072 % + 35 nA	
	100 Hz to 5 kHz	0.072 % + 35 nA	
	100 μ A to 1 mA		
	10 Hz to 20 Hz	0.46 % + 230 nA	
	20 Hz to 45 Hz	0.17 % + 230 nA	
	45 Hz to 100 Hz	0.071 % + 230 nA	
	100 Hz to 5 kHz	0.038 % + 230 nA	
	1 mA to 10 mA		
	10 Hz to 20 Hz	0.46 % + 2.3 μ A	
	20 Hz to 45 Hz	0.17 % + 2.3 μ A	
	45 Hz to 100 Hz	0.071 % + 2.3 μ A	
	100 Hz to 5 kHz	0.038 % + 2.3 μ A	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Measure ¹	10 mA to 100 mA		Agilent 3458A
	10 Hz to 20 Hz	0.46 % + 23 μ A	
	20 Hz to 45 Hz	0.17 % + 23 μ A	
	45 Hz to 100 Hz	0.071 % + 23 μ A	
	100 Hz to 5 kHz	0.037 % + 23 μ A	
AC Current – Measure ¹	100 mA to 1 A		Agilent 3458A
	10 Hz to 20 Hz	0.46 % + 0.23 mA	
	20 Hz to 45 Hz	0.19 % + 0.23 mA	
	45 Hz to 100 Hz	0.097 % + 0.23 mA	
	100 Hz to 1 kHz	0.12 % + 0.23 mA	
	0 A to 10 A		Ohms Labs CS-100 w/3458A
	50 Hz to 999 Hz	0.05 % + 1.3 mA	
	1 kHz	0.12 % + 1.3 mA	
	10 A to 100 A		
DC Resistance – Measuring Equipment and Measure ¹	50 to 100 Hz	0.038 % + 2.3 mA	Agilent 3458A with Decade Resistor
	100 to 999 Hz	0.042 % + 2.3 mA	
	1 kHz	0.13 % + 2.3 mA	
	0 Ω to 10 Ω	18 $\mu\Omega/\Omega$ + 58 $\mu\Omega$	
	10 Ω to 100 Ω	15 $\mu\Omega/\Omega$ + 0.58 m Ω	
	100 Ω to 1 k Ω	12 $\mu\Omega/\Omega$ + 0.58 m Ω	
	1 k Ω to 10 k Ω	12 $\mu\Omega/\Omega$ + 5.8 m Ω	
	10 k Ω to 100 k Ω	12 $\mu\Omega/\Omega$ + 58 m Ω	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Resistance – Measuring Equipment and Measure ¹	100 kΩ to 1 MΩ	19 μΩ/Ω + 2.3 Ω	Agilent 3458A with Decade Resistor
	1 MΩ to 10 MΩ	62 μΩ/Ω + 120 Ω	
	10 MΩ to 100 MΩ	0.059 % + 1.2 kΩ	
	100 MΩ to 1 GΩ	0.58 % + 12 kΩ	
DC Resistance – Measuring Equipment ¹	1 mΩ	18 μΩ/Ω	L&N 4221B
	10 mΩ	18 μΩ/Ω	L&N 4222B
	100 mΩ	22 μΩ/Ω	L&N 4223B
DC Current – Measuring Equipment and Measure ¹	0 μA to 100 μA	26 μA/A + 0.92 nA	Agilent 3458A with Current Source
	100 μA to 1 mA	26 μA/A + 5.8 nA	
	1 mA to 10 mA	26 μA/A + 58 nA	
	10 mA to 100 mA	43 μA/A + 0.58 μA	
	100 mA to 1 A	0.012 % + 12 μA	
	1 A to 100 A	0.012 % + 500 μA	CS-100 with 3458A
	100 A to 1 000 A	0.018 %	Shunts with DVM & Source
DC Current – Measuring Equipment ¹	0 μA to 220 μA	41 μA/A + 6 nA	Fluke 5700A-EP with 5725A
	0.22 mA to 2.2 mA	36 μA/A + 7 nA	
	2.2 mA to 22 mA	36 μA/A + 40 nA	
	22 mA to 220 mA	57 μA/A + 0.7 μA	
	0.22 A to 2.2 A	202 μA/A + 12 μA	
	2.2 A to 11 A	403 μA/A + 0.48 mA	
	11 A to 20 A	0.096 % + 580 μA	Fluke 5522A



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Clamp-on Ammeter (Non-Toroidal Type) Hall Effect Sensor ¹	20 A to 150 A	0.2 % + 0.14 A	Fluke 5520A with 5500A/Coil
	150 A to 1 000 A	0.52 % + 0.52 A	
DC Voltage – Measure Equipment ¹	0 to 220 mV	8.0 μ V/V + 0.4 μ V	Fluke 5700A-EP with 5725A
	220 mV to 2.2 V	5.4 μ V/V + 0.7 μ V	
	2.2 V to 11 V	4 μ V/V + 2.5 μ V	
	11 V to 22 V	4 μ V/V + 4 μ V	
	22 V to 220 V	6.2 μ V/V + 40 μ V	
	220 V to 1 100 V	7.6 μ V/V + 400 μ V	
DC Voltage – Measure and Measuring Equipment ¹	0 mV to 100 mV	7.1 μ V/V + 0.5 μ V	Agilent 3458A opt 2 with Fluke 5700A-EP
	0.1 V to 10 V	5.1 μ V/V + 0.5 μ V	
	10 V to 100 V	7.6 μ V/V + 35 μ V	
	100 V to 500 V	11 μ V/V + 0.12 mV	
	500 V to 800 V	16 μ V/V + 0.12 mV	
	800 V to 1 kV	21 μ V/V + 0.12 mV	
	0 mV to 10 mV		Agilent 3458A
	1 Hz to 40 Hz	0.039 % + 3.5 μ V	
	40 Hz to 1 kHz	0.028 % + 1.3 μ V	
	1 kHz to 20 kHz	0.038 % + 1.3 μ V	
	20 kHz to 50 kHz	0.15 % + 1.3 μ V	
	50 kHz to 100 kHz	0.59 % + 1.3 μ V	
	100 kHz to 300 kHz	4.6 % + 2.3 μ V	
	300 kHz to 1 MHz	1.5 % + 5.8 μ V	



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Voltage – Measure and Measuring Equipment ¹	10 mV to 100 mV		Agilent 3458A
	1 Hz to 40 Hz	0.013 % + 4.6 µV	
	40 Hz to 1 kHz	0.009 4 % + 2.3 µV	
AC Voltage – Measure ¹	1 kHz to 20 kHz	0.017 % + 2.3 µV	Agilent 3458A
	20 kHz to 50 kHz	0.037 % + 2.3 µV	
	50 kHz to 100 kHz	0.093 % + 2.3 µV	
	100 kHz to 300 kHz	0.36 % + 12 µV	
	300 kHz to 1 MHz	1.2 % + 12 µV	
	100 mV to 1 V		
	1 Hz to 40 Hz	0.009 8 % + 46 µV	
	40 Hz to 1 kHz	0.009 4 % + 23 µV	
	1 kHz to 20 kHz	0.017 % + 23 µV	
	20 kHz to 50 kHz	0.036 % + 23 µV	
	50 kHz to 100 kHz	0.093 % + 23 µV	
	100 kHz to 300 kHz	0.35 % + 0.12 mV	
	300 kHz to 1 MHz	1.2 % + 0.12 mV	
	1 V to 10 V		
	1 Hz to 40 Hz	0.013 % + 0.46 mV	
	40 Hz to 1 kHz	0.009 5 % + 0.23 mV	
	1 kHz to 20 kHz	0.017 % + 0.23 mV	
	20 kHz to 50 kHz	0.036 % + 0.23 mV	
	50 kHz to 100 kHz	0.093 % + 0.23 mV	
	100 kHz to 300 kHz	0.35 % + 1.2 mV	
	300 kHz to 1 MHz	1.2 % + 1.2 mV	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure ¹	10 V to 100 V		Agilent 3458A
	1 Hz to 40 Hz	0.024 % + 4.6 mV	
	40 Hz to 1 kHz	0.024 % + 2.3 mV	
	1 kHz to 20 kHz	0.024 % + 2.3 mV	
	20 kHz to 50 kHz	0.041 % + 2.3 mV	
	50 kHz to 100 kHz	0.14 % + 2.3 mV	
	100 kHz to 300 kHz	0.46 % + 12 mV	
	300 kHz to 1 MHz	1.7 % + 12 mV	
	100 V to 700 V		Fluke 8508A
	1 Hz to 40 Hz	0.047 % + 46 mV	
	40 Hz to 1 kHz	0.047 % + 23 mV	
	1 kHz to 20 kHz	0.071 % + 23 mV	
	20 kHz to 30 kHz	0.025 % + 32 mV	
	30 kHz to 100 kHz	0.06 % + 0.16 V	
	700 V to 1 050 V		
	1 Hz to 10 Hz	0.02 % + 85 mV	
	10 Hz to 40 Hz	0.02 % + 24 mV	
	40 Hz to 10 kHz	0.019 % + 24 mV	
	10 kHz to 30 kHz	0.028 % + 48 mV	
	30 kHz to 100 kHz	0.06 % + 0.24 V	
AC Voltage – Measuring Equipment ¹	0 mV to 2.2 mV		Fluke 5700A-EP
	10 Hz to 20 Hz	0.016 % + 4 μ V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	20 Hz to 40 Hz	0.016 % + 4 μ V	Fluke 5700A-EP
	40 Hz to 20 kHz	0.01 % + 4 μ V	
	20 kHz to 50 kHz	0.021 % + 4 μ V	
	50 kHz to 100 kHz	0.017 % + 5 μ V	
	100 kHz to 300 kHz	0.33 % + 10 μ V	
	300 kHz to 500 kHz	0.47 % + 20 μ V	
	500 kHz to 1 MHz	0.58 % + 20 μ V	
	2.2 mV to 22 mV		
	10 Hz to 20 Hz	0.044 % + 4 μ V	
	20 Hz to 40 Hz	0.035 % + 4 μ V	
	40 Hz to 20 kHz	0.015 % + 4 μ V	
	20 kHz to 50 kHz	0.031 % + 4 μ V	
	50 kHz to 100 kHz	0.059 % + 5 μ V	
	100 kHz to 300 kHz	0.12 % + 10 μ V	
	300 kHz to 500 kHz	0.16 % + 20 μ V	
	500 kHz to 1 MHz	0.3 % + 20 μ V	
	22 mV to 220 mV		
	10 Hz to 20 Hz	0.028 % + 12 μ V	
	20 Hz to 40 Hz	0.017 % + 7 μ V	
	40 Hz to 20 kHz	0.01 % + 7 μ V	
	20 kHz to 50 kHz	0.021 % + 7 μ V	
	50 kHz to 100 kHz	0.047 % + 17 μ V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	100 kHz to 300 kHz	0.092 % + 20 μ V	Fluke 5700A-EP
	300 kHz to 500 kHz	0.14 % + 25 μ V	
	500 kHz to 1 MHz	0.28 % + 45 μ V	
	220 mV to 2.2 V		
	10 Hz to 20 Hz	0.028 % + 40 μ V	
	20 Hz to 40 Hz	0.016 % + 15 μ V	
	40 Hz to 20 kHz	0.006 % + 8 μ V	
	20 kHz to 50 kHz	0.008 % + 10 μ V	
	50 kHz to 100 kHz	0.012 % + 30 μ V	
	100 kHz to 300 kHz	0.043 % + 80 μ V	
	300 kHz to 500 kHz	0.1 % + 0.2 mV	
	500 kHz to 1 MHz	0.18 % + 0.3 mV	
	2.2 V to 22 V		
	10 Hz to 20 Hz	0.028 % + 0.4 mV	
	20 Hz to 40 Hz	0.016 % + 0.15 mV	
	40 Hz to 20 kHz	0.005 % + 50 μ V	
	20 kHz to 50 kHz	0.008 % + 0.1 mV	
	50 kHz to 100 kHz	0.011 % + 0.2 mV	
	100 kHz to 300 kHz	0.03 % + 0.6 mV	
	300 kHz to 500 kHz	0.1 % + 2 mV	
	500 kHz to 1 MHz	0.17 % + 3.2 mV	
	22 V to 220 V		
	10 Hz to 20 Hz	0.028 % + 4 mV	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	20 Hz to 40 Hz	0.01 % + 1.5 mV	Fluke 5700A-EP
	40 Hz to 20 kHz	0.006 % + 0.6 mV	
	20 kHz to 50 kHz	0.009 % + 1.0 mV	
	50 kHz to 100 kHz	0.016 % + 2.5 mV	
	100 kHz to 300 kHz	0.09 % + 16 mV	
	300 kHz to 500 kHz	0.44 % + 40 mV	
	500 kHz to 1 MHz	0.80 % + 80 mV	
	220 V to 750 V		Fluke 5700A-EP with 5725A
	30 kHz to 50 kHz	0.061 % + 11 mV	
	50 kHz to 100 kHz	0.23 % + 45 mV	
	220 V to 1100 V		Fluke 5700A-EP with 5725A
	40 Hz to 1 kHz	0.011 % + 4 mV	
	1 kHz to 20 kHz	0.017 % + 6 mV	
	20 kHz to 30 kHz	0.061 % + 11 mV	
	0.19 nF to < 1.1 nF		Fluke 5520A
	10 Hz to 10 kHz	0.39 % + 7.8 pF	
	1.1 nF to < 3.3 nF		
	10 Hz to 3 kHz	0.39 % + 7.8 pF	
	3.3 nF to < 11 nF		
	10 Hz to 1 kHz	0.21 % + 7.8 pF	
	11 nF to < 110 nF		
	10 Hz to 1 kHz	0.21 % + 78 pF	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	110 nF to < 330 nF 10 Hz to 1 kHz	0.21 % + 0.23 nF	Fluke 5520A
	0.33 µF to < 1.1 µF 10 Hz to 600 Hz	0.2 % + 0.78 nF	
Capacitance – Measuring Equipment ¹ 1 kHz	1.1 µF to < 3.3 µF 10 Hz to 300 Hz	0.2 % + 2.3 nF	Fluke 5520A
	3.3 µF to < 11 µF 10 Hz to 150 Hz	0.20 % + 7.8 nF	
	11 µF to < 33 µF 10 Hz to 120 Hz	0.32 % + 23 nF	
	33 µF to < 110 µF 10 Hz to 80 Hz	0.35 % + 78 nF	
	110 µF to < 330 µF DC to 50 Hz	0.35 % + 0.23 µF	
	0.33 mF to < 1.1 mF DC to 20 Hz	0.35 % + 0.78 µF	
	1.1 mF to < 3.3 mF DC to 6 Hz	0.35 % + 2.3 µF	
	3.3 mF to < 11 mF DC to 2 Hz	0.35 % + 7.8 µF	
	11 mF to < 33 mF DC to 0.6 Hz	0.59 % + 23 µF	
	33 mF to < 110 mF DC to 0.2 Hz	0.86 % + 78 µF	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Frequency Response Oscilloscopes ¹	50 kHz Reference 5 mV to 5.5 V		Fluke 5520A/1100
	50 kHz to 100 MHz	1.7 % + 0.1 mV	
	100 MHz to 300 MHz	2 % + 0.1 mV	
	300 MHz to 600 MHz	3.5 % + 0.1 mV	
	600 MHz to 1100 MHz	4.2 % + 0.1 mV	
Electrical Calibration of Thermocouple Devices ¹	250 °C to 350 °C	0.95 °C	Ectron 1140A
	350 °C to 445 °C	0.74 °C	
	445 °C to 580 °C	0.58 °C	
	580 °C to 750 °C	0.45 °C	
	750 °C to 1 000 °C	0.37 °C	
	1 000 °C to 1 820 °C	0.29 °C	
Type C	0 °C to 250 °C	0.2 °C	
	250 °C to 1 000 °C	0.16 °C	
	1 000 °C to 1 500 °C	0.18 °C	
	1 500 °C to 1 800 °C	0.21 °C	
Type C	1 800 °C to 2 000 °C	0.23 °C	
	2 000 °C to 2 250 °C	0.29 °C	
	2 250 °C to 2 315 °C	0.32 °C	
Type E	-270 °C to -245 °C	1.2 °C	
	-245 °C to -195 °C	0.18 °C	
	-195 °C to -155 °C	0.11 °C	
	-155 °C to 1 000 °C	0.09 °C	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Type J	-210 °C to -180 °C	0.13 °C	Ectron 1140A
	-180 °C to -120 °C	0.11 °C	
	-120 °C to -50 °C	0.09 °C	
	-50 °C to 1 200 °C	0.08 °C	
Type K	-270 °C to -255 °C	2.2 °C	
	-255 °C to -195 °C	0.7 °C	
	-195 °C to -115 °C	0.13 °C	
	-115 °C to -55 °C	0.1 °C	
	-55 °C to 1 000 °C	0.08 °C	
	1 000 °C to 1 372 °C	0.09 °C	
Type N	-270 °C to -260 °C	5 °C	
	-260 °C to -200 °C	1 °C	
	-200 °C to -140 °C	0.23 °C	
	-140 °C to -70 °C	0.16 °C	
	-70 °C to 25 °C	0.13 °C	
	-25 °C to 1 300 °C	0.11 °C	
Type R	-50 °C to -30 °C	0.65 °C	
	-30 °C to 45 °C	0.55 °C	
	45 °C to 160 °C	0.40 °C	
	160 °C to 775 °C	0.30 °C	
	775 °C to 1 768.1 °C	0.22 °C	
Type S	-50 °C to -30 °C	0.62 °C	
	-30 °C to 45 °C	0.56 °C	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Type S	45 °C to 105 °C	0.4 °C	Ectron 1140A
	105 °C to 310 °C	0.33 °C	
	310 °C to 1 768.1 °C	0.29 °C	
Type T	-270 °C to -255 °C	1.8 °C	
	-255 °C to -240 °C	0.5 °C	
	-240 °C to -210 °C	0.3 °C	
	-210 °C to -150 °C	0.18 °C	
	-150 °C to -40 °C	0.13 °C	
	-40 °C to 100 °C	0.09 °C	
	100 °C to 400 °C	0.08 °C	

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
RF Power – Absolute RF, Measure ¹ 10 Hz to 20 kHz	(-10 to 30) dBm	0.13 %	Fluke 8846A
9 kHz to 18 GHz	(-60 to 20) dBm	2.6 %	Agilent E9304A/H18
(18 to 40) GHz	(-70 to -30) dBm	3.8 %	Agilent 8487D
(40 to 50) GHz	(-70 to -30) dBm	5.5 %	
(18 to 40) GHz	(-30 to 20) dBm	4.4 %	Agilent 8487A
(40 to 50) GHz	(-30 to 20) dBm	5.5 %	
30 MHz to 50 GHz	(20 to 30) dBm	4.8 %	N5532A-550



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
RF Power - Generate ¹	(-90 to -70) dBm 250 kHz to 2 GHz	0.93 dBm	Agilent E8257D
	(2 to 20) GHz	1.2 dBm	
	(20 to 40) GHz	2.3 dBm	
	(40 to 50) GHz	2.9 dBm	
	(-70 to -10) dBm 250 kHz to 2 GHz	0.82 dBm	
	(2 to 20) GHz	1.1 dBm	
	(20 to 40) GHz	1.2 dBm	
	(40 to 50) GHz	1.8 dBm	
	(-10 to 0) dBm 250 kHz to 2 GHz	0.71 dBm	
	(2 to 20) GHz	0.95 dBm	
	(20 to 40) GHz	1.1 dBm	
	(40 to 50) GHz	1.1 dBm	
	(0 to 10 dBm) 250 kHz to 2 GHz	0.71 dBm	
	(2 to 20) GHz	0.95 dBm	
	(20 to 40) GHz	1.1 dBm	
	(40 to 50) GHz	1.5 dBm	
	(10 to 14 dBm) 250 kHz to 2 GHz	0.71 dBm	
	(2 to 20) GHz	0.95 dBm	
	(20 to 40) GHz	1.2 dBm	

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Agilent E8257D	(14 to 19 dBm)		Agilent E8257D
	250 kHz to 2 GHz	0.93 dBm	
	(2 to 20) GHz	0.95 dBm	
	(20 to 40) GHz	1.2 dBm	
RF Relative Power (Tuned RF Level) - Measure ¹	100 kHz to 50 GHz		Agilent E4448A
	(0 to -10) dB	0.023 dB	
	(-10 to -20) dB	0.02 dB	
	(-20 to -30) dB	0.035 dB	
	(-30 to -40) dB	0.041 dB	
	(-40 to -50) dB	0.046 dB	
	(-50 to -60) dB	0.095 dB	
	(-60 to -70) dB	0.10 dB	
	(-70 to -80) dB	0.14 dB	
	(-80 to -90) dB	0.15 dB	
	100 kHz to 45 GHz		Agilent E4448A
	(-90 to -100) dB	0.16 dB	
	(-100 to -110) dB	0.29 dB	
	100 kHz to 31.15 GHz		
	(-110 to -120) dB	0.29 dB	
	(-120 to -130) dB	0.29 dB	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Attenuation ¹	DC to 12.4 GHz		Agilent 8494H
	1 dB	0.31 dB	
	2 dB	0.31 dB	
	3 dB	0.4 dB	
	4 dB	0.4 dB	
	5 dB	0.5 dB	
	6 dB	0.5 dB	
	7 dB	0.6 dB	
	8 dB	0.6 dB	
	9 dB	0.6 dB	
	10 dB	0.6 dB	
	11 dB	0.7 dB	
	(12.4 to 18) GHz		
	1 dB	0.7 dB	
	2 dB	0.7 dB	
	3 dB	0.7 dB	
	4 dB	0.7 dB	
	5 dB	0.7 dB	
	6 dB	0.8 dB	
	7 dB	0.8 dB	
	8 dB	0.8 dB	
	9 dB	0.8 dB	
	10 dB	0.9 dB	
	11 dB	0.9 dB	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Attenuation ¹	DC to 12.4 GHz		Agilent 8496H
	10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	0.5 dB 0.7 dB 0.9 dB 1.2 dB 1.5 dB 1.8 dB 2.1 dB 2.4 dB 2.7 dB 3 dB 3.3 dB	
	(12.4 to 18) GHz		
	10 dB 20 dB 30 dB 40 dB 50 dB 60 dB 70 dB 80 dB 90 dB 100 dB 110 dB	0.6 dB 0.8 dB 1.2 dB 1.6 dB 2 dB 2.4 dB 2.8 dB 3.2 dB 3.6 dB 4 dB 4.4 dB	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Reflection S11/S22 – Measure Magnitude ¹	300 kHz to 10 MHz		Agilent E5071C Agilent 85032F
	(0 to 0.5) lin	0.0095 lin	
	(0.5 to 1) lin	0.019 lin	
	(10 to 50) MHz		
	(0 to 0.5) lin	0.012 lin	Agilent N5235A Agilent 85056K
	(0.5 to 1) lin	0.022 lin	
	50 MHz to 2 GHz		
	(0 to 0.5) lin	0.015 lin	
Transmission S12/S21 - Magnitude ¹	(0.5 to 1) lin	0.023 lin	Agilent N5235A Agilent 85056K
	(2 to 40) GHz		
	(0 to 0.5) lin	0.028 lin	
	(0.5 to 1) lin	0.04 lin	
	300 kHz to 10 MHz		Agilent E5071C Agilent 85032F
	(0 to -30) dB	0.092 dB	
	(-30 to -60) dB	0.45 dB	
	(10 to 50) MHz		
	(0 to -30) dB	0.092 dB	Agilent N5235A Agilent 85056K
	(-30 to -60) dB	0.26 dB	
	(50 to 500) MHz		
	(0 to -30) dB	0.072 dB	
	(-30 to -60) dB	1.6 dB	
	500 MHz to 2 GHz		Agilent N5235A Agilent 85056K
	(0 to -30) dB	0.046 dB	
	(-30 to -60) dB	0.018 dB	
	(2 to 40) GHz		
	(0 to -30) dB	0.14 dB	
	(-30 to -60) dB	0.55 dB	
Electrical Fast Transients ¹	0.25 kV to 4 kV	2.7 %	Ametek CA EFT kit



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Amplitude Modulation – Measure ¹ AM Depth:			
100 kHz to 10 MHz	50 Hz to 10 kHz, (5 to 99) %	0.86 %	Agilent E4448A
10 MHz to 3 GHz	50 Hz to 100 kHz, (20 to 99) % (5 to 20) %	0.76 % 2.6 %	
(3 to 26.5) GHz	50 Hz to 100 kHz, (20 to 99) % (5 to 20) %	1.6 % 4.5 %	Agilent E4448A
(26.5 to 31.15) GHz	50 Hz to 100 kHz, (20 to 99) % (5 to 20) %	2.1 % 6.8 %	
(31.15 to 50) GHz	50 Hz to 100 kHz, (20 to 99) % (5 to 20) %	6 % 26 %	
AM Distortion: 100 kHz to 10 GHz	20 Hz to 1 kHz > 1 % > 3 %	0.85 % 0.42 %	
10 MHz to 26.5 GHz	20 Hz to 1 kHz > 1 % > 3 %	1 % 0.5 %	
(26.5 to 50) GHz	20 Hz to 1 kHz > 1 % > 3 % > 5 %	6.2 % 2 % 1.5 %	
Amplitude Modulation – Generate ¹ 250 kHz to 50 GHz	Depths (0 to 90) %	6.6 %	Agilent E8257D



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Frequency Modulation – Measure ¹ FM Deviation:			
250 kHz to 10 MHz	20 Hz to 10 kHz Dev/Rate > 0.2 Dev/Rate > 1.2	1.5 % 1 %	Agilent E4448A
10 MHz to 6.6 GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 0.45	1.5 % 1 %	
(6.6 to 13.2) GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 8	2.5 % 1 %	Agilent E4448A
(13.2 to 31.15) GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 16	3.8 % 1 %	
(31.5 to 50) GHz	50 Hz to 200 kHz Dev/Rate > 0.2 Dev/Rate > 32	8.5 % 1 %	
FM Distortion: 1 MHz to 6.6 GHz	20 Hz to 1 kHz Dev 500 Hz to 2 kHz Dev ≥ 2.0 kHz	0.3 % 0.11 %	
(6.6 to 13.2) GHz	20 Hz to 1 kHz Dev > 2.3 kHz Dev ≥ 4.5 kHz	0.3 % 0.11 %	
(13.2 to 31.15) GHz	20 Hz to 1 kHz Dev > 2.7 kHz Dev ≥ 6.0 kHz	0.31 % 0.12 %	
(31.15 to 50) GHz	20 Hz to 1 kHz Dev > 4.0 kHz Dev ≥ 12.0 kHz	0.32 % 0.14 %	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Frequency Modulation – Generate ¹ 250 kHz to 50 GHz	Rate: DC to 10 MHz Dev.: ≤ 128 MHz	3.9 %	Agilent E8257D
Phase Modulation – Measure ¹ PM Deviation:			Agilent E4448A
100 kHz to 6.6 GHz	>0.7 rad	1.1 %	
	> 0.3 rad	3.2 %	
(6.6 to 13.2) GHz	> 2.0 rad	1.1 %	
	> 0.6 rad	3.2 %	
(13.2 to 26.5) GHz	> 4.0 rad	1.1 %	
	> 1.2 rad	3.2 %	
(26.5 to 31.15) GHz	> 4.0 rad	1.1 %	
	> 1.3 rad	3.2 %	
(31.15 to 50) GHz	> 8.0 rad	1.1 %	
	> 2.4 rad	3.2 %	
PM Distortion: 1 MHz to 6.6 GHz	(20 to 500) Hz > 0.8 rad	0.31 %	
	≥ 2.5 rad	0.13 %	
	500 Hz to 1 kHz > 0.4 rad	0.31 %	
	≥ 1.0 rad	0.13 %	
(6.6 to 13.2) GHz	(20 to 500) Hz > 1.8 rad	0.31 %	
	≥ 5.5 rad	0.13 %	
	500 Hz to 1 kHz ≥ 0.8 rad	0.31 %	
	≥ 2.5 rad	0.13 %	
(13.2 to 31.15) GHz	(20 to 500) Hz > 3.5 rad	0.31 %	
	≥ 10.0 rad	0.13 %	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
(13.2 to 31.15) GHz	500 Hz to 1 kHz > 1.2 rad ≥ 4 rad	0.31 % 0.13 %	Agilent E4448A
(31.15 to 50) GHz	(20 to 500) Hz > 7.5 rad ≥ 19.0 rad	0.31 % 0.13 %	
	500 Hz to 1 kHz > 3.0 rad ≥ 8.0 rad	0.31 % 0.13 %	
Phase Modulation - Generate ¹			Agilent E8257D
(250 to 500) MHz	(0 to 10) rad	5.8 %	
500 MHz to 1 GHz	(0 to 20) rad	5.8 %	
(1 to 2) GHz	(0 to 40) rad	5.8 %	
(2 to 3.2) GHz	(0 to 80) rad	5.8 %	
(3.2 to 10) GHz	(0 to 160) rad	5.8 %	
(10 to 20) GHz	(0 to 320) rad	5.8 %	
(20 to 40) GHz	(0 to 640) rad	5.8 %	
(40 to 50) GHz	(0 to 1 280) rad	5.8 %	
Single Sideband Phase Noise - Measure ¹			Agilent E4448A
CW Frequency: 3 Hz to 3 GHz	Markers: 100 Hz to 1 MHz	0.58 dB	
(3 to 6.6) GHz	100 Hz to 1 MHz	1 dB	
(6.6 to 22) GHz	100 Hz to 1 MHz	1.6 dB	
(22 to 26.8) GHz	100 Hz to 1 MHz	1.7 dB	
(26.8 to 31.15) GHz	100 Hz to 1 MHz	1.1 dB	
(31.15 to 50) GHz	100 Hz to 1 MHz	1.4 dB	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Distortion (THD) ¹	10 Hz to 100 kHz	8.4 % of indicated harmonic distortion	Agilent U8903A
LF Phase – Generate Measuring Equipment ¹	0° to 90°		Fluke 5520A
	10 Hz to 65 Hz	0.11°	
	65 Hz to 500 Hz	0.2°	
	500 Hz to 1 kHz	0.39°	
	1 kHz to 5 kHz	1.9°	
	5 kHz to 10 kHz	3.9°	
	10 kHz to 30 kHz	7.8°	
Power – Measuring Equipment ¹			
DC Power 0.33 mA to 3.3 mA	11 µW to 3.4 W	0.024 %	
3.3 mA to 33 mA	0.11W to 34 W	0.012 %	
33 mA to 330 mA	1.1 mW to 340 W	0.0093 %	
330 mA to 1.1 A	11 mW to 3.4 kW	0.026 %	
1.1 A to 3 A	36 mW to 3.1 kW	0.033 %	
3 to 11 A	0.99 W to 11 kW	0.064 %	
11 to 20.5 A	360 mW to 21 kW	0.089 %	
AC Power ^{6 1} (PF = 1) 3.3 mA to 9 mA	0.11 mW to 9.2 W 45 Hz to 65 Hz	0.089 %	
9 mA to 33 mA	3 mW to 34W 45 Hz to 65 Hz	0.061 %	
33 mA to 90 mA	1.1 mW to 92 W 45 Hz to 65 Hz	0.089 %	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Power ^{6 1} (PF = 1) 90 mA to 330 mA	3 mW to 340W 45 Hz to 65 Hz	0.061 %	Fluke 5520A
0.33 A to 1.1 A	11 mW to 1.1 kW 45 Hz to 65 Hz	0.071 %	
1.1 A to 3.0 A	36 mW to 3.1 kW 45 Hz to 65 Hz	0.064 %	
3.0 A to 5.4 A	99 mW to 5.5 kW 45 Hz to 65 Hz	0.11 %	
5.4 A to 11 A	180 mW to 11 kW 45 Hz to 65 Hz	0.084 %	
11 A to 15 A	360 mW to 15 kW 45 Hz to 100 Hz 100 Hz to 1 kHz	0.14 % 0.16 %	
15 A to 20.5 A	500 mW to 21 kW 45 Hz to 100 Hz 100 Hz to 1 kHz	0.13 % 0.13 %	

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ⁵	Reference Standard, Method and/or Equipment
Micrometers and Calipers– Outside, Inside, Depth ¹	0 in to 0.4 in	18 μin	Comparison to Gage Blocks
	0.4 in to 1 in	(17 + 1L) μin	
	1 in to 8 in	(12 + 6.1L) μin	



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Torque – Measure ¹	4 lbf·in to 250 lbf·in	1 %	CDI 2000-400-02 with Loader
	250 lbf·in to 250 lbf·ft	1 %	
	250 lbf·ft to 600 lbf·ft	1%	CDI 2000-12-02 with Loader
Balances & Scales	Up to 400 lbs	0.001 %	Class F Weights
Pressure Gages	(10 to 1000) psi	0.026 %	Ametek HK-1000

Time and Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Frequency – Measuring Equipment and Measure ³ In Lab	10 MHz	1.6×10^{-10} Hz/Hz	GPS/Datum
Field Service ¹	10 MHz	3.3×10^{-9} Hz/Hz	Agilent 53131A (010)
Rise Time – Measuring Equipment ¹	250 ps	51 ps ^{NOTE4}	5520A/1100
Rise Time – Measure ¹	≥ 5 ns	4 ns	Agilent DSO5012

Acoustics and Vibration

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Acceleration	20 Hz to 99 Hz 100 Hz to 2.5 kHz 2.5 kHz to 10 kHz 10 kHz to 20 kHz	1.45 % 1.37% 2.3 % 5.04%	Standard Accelerometer
Sound Level Calibrators, Fixed Points 31.5 Hz to 16 kHz	94 dB, 104 dB and 114 dB	0.6 dB	Bruel & Kjaer 4226

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. Values listed with percent (%) are percent of reading or generated value unless otherwise noted.
3. Uncertainty values of derivatives of 10 MHz will differ due to resolution, noise and gating errors.
4. The stated uncertainty is the laboratory's ability to source a fast rise pulse that is approximately 250 ps. In the typical application of measuring rise time of an oscilloscope, this value is one of the contributing factors, but other factors are derived from the DUT.
5. L = Length in inches.
6. The uncertainties shown are for the most favorable conditions. There is an increase in uncertainty that corresponds to the laboratory's AC voltage and current uncertainties at different frequencies other than the ones shown. Power factors (PF) other than the one shown contribute to the power uncertainty. PF is related to the cosine of phase. Therefore, uncertainties track the laboratory's phase uncertainty closely at PF near one, but are magnified heavily as PF approaches zero. The lab may also report reactive power, apparent power, and power factor under this accreditation. If needed, contact laboratory for more information regarding uncertainties at frequency and power factor combinations other than the ones shown.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.08.

