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Hereby attests that

Transcat - Houston
1181 Brittmoore Road, Suite 600
Houston, TX 77043

Fulfills the requirements of

ISO/IEC 17025:2017

and national standard

ANSI/NCSL Z540-1-1994 (R2002)

In the field of

CALIBRATION

This certificate is valid only when accompanied by a current scope of accreditation document.
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R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 07 September 2021
Certificate Number: AC-2489.02



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)

Transcat - Houston
1181 Brittmoore Road, Suite 600
Houston, TX 77043
Scott Caine
713-465-4399

CALIBRATION

Valid to: **September 7, 2021**

Certificate Number: **AC-2489.02**

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Measuring and Measuring Equipment ¹	0 µA to 220 µA		Fluke 5720A
	10 Hz to 20 Hz	0.031 % + 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	0.03 % + 12 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	0.014 % + 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	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current – Measuring and Measuring Equipment ¹	20 Hz to 40 Hz	0.019 % + 350 nA	Fluke 5720A
	40 Hz to 1 kHz	0.014 % + 350 nA	
	1 kHz to 5 kHz	0.021 % + 550 nA	
	5 kHz to 10 kHz	0.11 % + 5 µA	
	22 mA to 220 mA		
	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 5720A w/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 5520A
	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 5520A
	45 Hz to 100 Hz	0.097 % + 3.8 mA	
	100 Hz to 1 kHz	0.12 % + 3.8 mA	
	1 kHz to 5 kHz	2.3 % + 3.8 mA	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Extended Frequency Ranges	29 μ A to 330 μ A 10 kHz to 30 kHz	1.2 % + 0.31 μ A	Fluke 5520A
	0.33 mA to 3.3 mA 10 kHz to 30 kHz	0.78 % + 0.47 μ A	
	3.3 mA to 33 mA 10 kHz to 30 kHz	0.31 % + 3.1 μ A	
	33 mA to 330 mA 10 kHz to 30 kHz	0.31 % + 0.16 mA	
Clamp-on Ammeter Toroidal Type ¹ Transformer Type	20 A to 150 A 45 Hz to 65 Hz	0.3 % + 26 mA	Fluke 5520A, 1 kA Coil
	20 A to 150 A 65 Hz to 440 Hz	0.83 % + 47 mA	
	150 A to 1 000 A 45 Hz to 65 Hz	0.35 % + 0.12 A	
	150 A to 1000 A 65 Hz to 440 Hz	1.1 % + 0.22 A	
Clamp-on Ammeter Non-Toroidal Type ¹ Hall Effect Sensor	20 A to 150 A 45 Hz to 65 Hz	0.57 % + 0.25 A	Fluke 5520A, 1 kA Coil
	20 A to 150 A 65 Hz to 440 Hz	1 % + 0.25 A	
	150 A to 1 000 A 45 Hz to 65 Hz	0.6 % + 0.9 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 ¹ Hall Effect Sensor	150 A to 1 000 A 65 Hz to 440 Hz	1.3 % + 0.92 A	Fluke 5520A, 1 kA Coil
	1 000 A to 6 000 A 10 Hz to 300 Hz	0.62 %	Fluke 52120A, 5520A, 6 kA Coil
	1 000 A to 2 000A 300 Hz to 440 Hz	0.8 %	
	2 000A to 6 000 A 300 Hz to 440 Hz	0.66 %	
AC Current – Measure ¹	0 µA to 100 µA 10 Hz to 20 Hz	0.46 % + 35 nA	Agilent 3458A opt 2
	20 Hz to 45 Hz	0.18 % + 35 nA	
	45 Hz to 5 kHz	0.072 % + 35 nA	
	0.1 mA to 1 mA 10 Hz to 20 Hz	0.46 % + 0.23 µA	
	20 Hz to 45 Hz	0.17 % + 0.23 µA	
	45 Hz to 100 Hz	0.071 % + 0.23 µA	
	100 Hz to 5 kHz	0.038 % + 0.23 µA	
	1 mA to 10 mA 10 Hz to 20 Hz	0.48 % + 2.3 µA	
	20 Hz to 45 Hz	0.17 % + 2.3 µA	
	45 Hz to 100 Hz	0.071 % + 2.3 µA	
	100 Hz to 5 kHz	0.038 % + 2.3 µA	

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 opt 2
	10 Hz to 20 Hz	0.46 % + 23 µA	
	20 Hz to 45 Hz	0.17 % + 23 µA	
	45 Hz to 100 Hz	0.071 % + 23 µA	
	100 Hz to 5 kHz	0.037 % + 23 µA	
	0.1 A to 1 A		
	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 5 kHz	0.12 % + 0.23 mA	
	1 A to 3 A		Fluke 8846A
	3 Hz to 5 Hz	1.3 % + 2 mA	
	5 Hz to 10 Hz	0.41 % + 2 mA	
	10 Hz to 5 kHz	0.2 % + 2 mA	
	5 kHz to 10 kHz	0.54 % + 24 mA	
	3 A to 10 A		
	3 Hz to 5 Hz	1.3 % + 7 mA	
	5 Hz to 10 Hz	0.41 % + 7 mA	
	10 Hz to 5 kHz	0.2 % + 7 mA	
	5 kHz to 10 kHz	0.54 % + 81 mA	
	10 A to 100 A		Shunt
	10 Hz to 1 kHz	0.12 % + 1mA	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Resistance – Measuring Equipment and Measure	0 Ω (floor) to 100 $\mu\Omega$	0.63 n Ω	Standard Resistors with Current Source and DMM
	100 $\mu\Omega$ to 1 m Ω	6.1 $\mu\Omega/\Omega$	
	1 m Ω to 10 m Ω	7.2 $\mu\Omega/\Omega$	
	10 m Ω to 100 m Ω	2.5 $\mu\Omega/\Omega$	
	0.1 Ω to 1 Ω	4.4 $\mu\Omega/\Omega$	
	1 Ω to 10 Ω	0.41 $\mu\Omega/\Omega$	Standard Resistors with MI 6242B Bridge
	10 Ω to 100 Ω	0.67 $\mu\Omega/\Omega$	
	100 Ω to 1 k Ω	0.82 $\mu\Omega/\Omega$	
	1 k Ω to 10 k Ω	2.4 $\mu\Omega/\Omega$	
	10 k Ω to 100 k Ω	0.29 $\mu\Omega/\Omega$	
	100 k Ω to 1 M Ω	1.4 $\mu\Omega/\Omega$	
	1 M Ω to 10 M Ω	16 $\mu\Omega/\Omega$	
	10 M Ω to 100 M Ω	19 $\mu\Omega/\Omega$	
DC Resistance – Measure	100 M Ω to 1 G Ω	32 $\mu\Omega/\Omega$	Standard Resistors with 8508 (Double Substitution)
	1 G Ω to 20 G Ω	140 $\mu\Omega/\Omega$	
DC Resistance – Measuring Equipment	10 M Ω	19 $\mu\Omega/\Omega$	Standard Resistor
	100 M Ω	30 $\mu\Omega/\Omega$	
	1 G Ω	53 $\mu\Omega/\Omega$	
Resistance Ratio	1 Ω to 1 k Ω	0.16 $\mu\Omega/\Omega$	MI 6242B Bridge
DC Resistance – Measuring Equipment and Measure ¹	0 m Ω to 10 Ω	18 $\mu\Omega/\Omega$ + 58 $\mu\Omega$	HP3458A with Decade Resistor
	10 Ω to 100 Ω	15 $\mu\Omega/\Omega$ + 580 $\mu\Omega$	
	100 Ω to 1 k Ω	12 $\mu\Omega/\Omega$ + 580 $\mu\Omega$	
	1 k Ω to 10 k Ω	12 $\mu\Omega/\Omega$ + 5.8 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	10 k Ω to 100 k Ω	12 $\mu\Omega/\Omega$ + 58 m Ω	HP3458A with Decade Resistor
	100 k Ω to 1 M Ω	20 $\mu\Omega/\Omega$ + 2.3 Ω	
	1 M Ω to 10 M Ω	62 $\mu\Omega/\Omega$ + 120 Ω	
	10 M Ω to 100 M Ω	590 $\mu\Omega/\Omega$ + 1.2 k Ω	
	100 M Ω to 1 G Ω	0.82 % + 12 k Ω	
DC Resistance – Measuring Equipment and Measure ¹	1 G Ω to 10 G Ω	0.073 % + 10 k Ω	Keithley 6430 Source / Meter with Voltage Source
	10 G Ω to 100 G Ω	0.074 % + 0.10 M Ω	
	100 G Ω to 1 T Ω	0.075 % + 1.0 M Ω	
	1 T Ω to 10 T Ω	0.19 % + 10 M Ω	
	10 T Ω to 100 T Ω	0.59 % + 0.10 G Ω	
DC Resistance – Measuring Equipment and Measure ¹	10 M Ω to 100 M Ω	0.08 %	IET HRRS-B-7-100k-5kV
	100 M Ω to 1 G Ω	0.25 %	
	1 G Ω to 10 G Ω	0.41 %	
	10 G Ω to 100 G Ω	0.84 %	
	100 G Ω to 1 T Ω	2.5 %	
DC Current – Measuring Equipment and Measure	0 A to 1 pA	1.4 % + 0.007 pA	Keithley 6430
	1 pA to 100 pA	0.53 % + 0.007 pA	
	10 pA to 100 pA	0.18 % + 0.003 pA	
	100 pA to 1 nA	0.059 % + 0.000 2 nA	
	1 nA to 10 nA	0.057 % + 0.002 nA	
	10 nA to 100 nA	0.056 % + 0.02 nA	
	100 nA to 1 μ A	0.054 % + 0.000 3 μ A	
	1 μ A to 10 μ A	0.050 % + 0.002 μ A	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Current – Measuring Equipment and Measure	0 A (floor) $\leq$ I < 100nA	1.5 pA	Standard Shunts with Current Source
	100 nA $\leq$ I < 1 μ A	21 μ A/A	
	1 μ A $\leq$ I < 10 μ A	7.2 μ A/A	
	10 μ A $\leq$ I < 100 μ A	6.5 μ A/A	
	100 μ A $\leq$ I < 1 mA	2.8 μ A/A	
	1 mA $\leq$ I < 10 mA	5.1 μ A/A	
	10 mA $\leq$ I < 100 mA	2.0 μ A/A	
	100 mA $\leq$ I < 1 A	2.4 μ A/A	
	1 A $\leq$ I < 10 A	4.8 μ A/A	
	10 A $\leq$ I < 20 A	4.0 μ A/A	
	20 A $\leq$ I $\leq$ 30 A	10 μ A/A	
	30 A < I $\leq$ 100 A	36 μ A/A	
DC Current – Measuring Equipment and Measure ¹	0 μ A to 100 μ A	26 μ A/A + 0.92 nA	HP3458A 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	130 μ A/A + 12 μ A	
DC Current – Measure ¹	1 A to 3 A	0.12 % + 1.2 mA	Fluke 8846A
	3 to 10	0.18 % + 1.3 mA	
	10 A to 20 A	0.023 % + 0.9mA	Current Shunt
	20 A to 25 A	5.5 mA	
	25 A to 100 A	0.012 %	
Clamp-on Ammeter Non-Toroidal Type ¹	20 A to 150 A	0.51 % + 0.14 A	Fluke 5520A w/ 5500A/Coil, 55120A w/ 1 kA and 6 kA Coils
	150 A to 1 000 A	0.51 % + 0.5 A	
	1 000 A to 5 000 A	0.58 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Voltage – Fixed Points Measuring Equipment and Measure	0 V (floor)	59 nV	Ratio Metric with Zener
	100 mV	0.80 μ V/V	
	1 V	0.29 μ V/V	
	10 V	0.2 μ V/V	
	19 V	0.46 μ V/V	
	100 V	0.28 μ V/V	
	1 000 V	0.54 μ V/V	
	1 mV $\leq$ V < 10mV	100 μ V/V	Fluke 8508
	10 mV	13 μ V/V	
DC Voltage – Fixed Points Measuring Equipment and Measure	10 mV < V < 100 mV	8.6 μ V/V	Fluke 8508 Ratio Metric with Zener
	100 mV < V $\leq$ 1 kV	7.4 μ V/V + 0.059 μ V	
DC Voltage – Measuring Equipment and Measure ¹	0 V to 100 mV	8.3 μ V/V + 0.58 μ V	HP3458A opt 2 with 5720A
	100 mV to 10 V	5.3 μ V/V + 0.58 μ V	
	10 V to 100 V	7.6 μ V/V + 35 μ V	
	100 V to 500 V	14 μ V/V + 120 μ V	
	500 V to 800 V	18 μ V/V + 120 μ V	
	800 V to 1 100 V	21 μ V/V + 120 μ V	
DC Voltage- Measure ¹	1 kV to 10 kV	0.049 % + 0.62 V	Vitretek 4700
	10 kV to 20 kV	0.08 % + 0.35 V	4700A w/HVP-35
	20 kV to 35 kV	0.14 % + 1 V	
	15 kV to 30 kV	0.065 % + 1 V	4700A w/HVL-70
	30 kV to 45 kV	0.09 % + 3 V	
	45 kV to 70 kV	0.17 % + 1 V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
DC Voltage- Measure ¹	25 kV to 100 kV	0.11 % + 0.5 V	4700 w/HVL-100
AC Voltage – Measure ¹	0 mV to 10 mV		Agilent 3458A opt 2
	1 Hz to 40 Hz	0.04 % + 3.5 μ V	
	40 Hz to 1 kHz	0.03 % + 1.2 μ V	
	1 kHz to 20 kHz	0.04 % + 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	
	1 MHz to 4 MHz	8.1% + 8.1 μ V	
	10 mV to 100 mV		
	1 Hz to 40 Hz	0.013 % + 4.6 μ V	
	40 Hz to 1 kHz	0.009 7 % + 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	
	1 MHz to 2 MHz	1.8 % + 12 μ V	
	2 MHz to 4 MHz	4.7 % + 81 μ V	
	4 MHz to 8 MHz	4.7 % + 92 μ V	
	8 MHz to 10 MHz	17 % + 120 μ V	
	100 mV to 1 V		
	1 Hz to 40 Hz	0.008 8 % + 46 μ V	
	40 Hz to 1 kHz	0.0083 % + 23 μ V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure ¹	100 mV to 1 V		Agilent 3458A opt 2
	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 MHz to 2 MHz	1.8 % + 0.12 mV	
	2 MHz to 4 MHz	4.6 % + 0.81 mV	
	4 MHz to 8 MHz	4.6 % + 0.92 mV	
	8 MHz to 10 MHz	17 % + 1.2 mV	
	1 V to 10 V		
	1 Hz to 40 Hz	0.009 5 % + 0.46 mV	
	40 Hz to 1 kHz	0.023 % + 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	
	1 MHz to 2 MHz	1.8 % + 1.2 mV	
	2 MHz to 4 MHz	4.6 % + 8.1 mV	
	4 MHz to 8 MHz	4.6 % + 9.2 mV	
	8 MHz to 10 MHz	17 % + 12 mV	
	10 V to 100 V		
	1 Hz to 40 Hz	0.024 % + 4.6 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 opt 2
	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		Vitretek 4700A
	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	0.19 % + 23 mV	
	50 kHz to 100 kHz	0.35 % + 23 mV	
	700 V to 10 kV		4700A w/HVP-35
	60 Hz	0.17 % + 0.16 V	
	10 kV to 20 kV		
	60 Hz	0.17 % + 0.6V	4700A w/HVL-70
	20 kV to 35 kV		
	60 Hz	0.23 % + 3.5 V	
	12.5 kV to 25 kV		
	60 Hz	0.15 % + 1.4 V	
	25 kV to 37.5 kV		
	60 Hz	0.16 % + 2.8 V	
	37.5 kV to 50 kV		
	60 Hz	0.2 % + 0.2 V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure ¹	25 kV to 75 kV 60 Hz	0.19 % + 3.5 V	4700A w/HVL-100
AC Voltage – Measuring Equipment ¹	0 mV to 2.2 mV		Fluke 5720A
	10 Hz to 20 Hz	0.16 % + 4 μV	
	20 Hz to 40 Hz	0.1 % + 4 μV	
	40 Hz to 20 kHz	0.078 % + 4 μV	
	20 kHz to 50 kHz	0.13 % + 4 μV	
	50 kHz to 100 kHz	0.17 % + 5 μV	
	100 kHz to 300 kHz	0.33 % + 10 μV	
	300 kHz to 500 kHz	0.47 % + 20 μV	
	500 kHz to 1 MHz	0.58 % + 20 μV	
	2.2 mV to 22 mV		
	10 Hz to 20 Hz	0.042 % + 4 μV	
	20 Hz to 40 Hz	0.03 % + 4 μV	
	40 Hz to 20 kHz	0.014 % + 4 μV	
	20 kHz to 50 kHz	0.03 % + 4 μV	
	50 kHz to 100 kHz	0.058 % + 5 μV	
	100 kHz to 300 kHz	0.12 % + 10 μV	
	300 kHz to 500 kHz	0.16 % + 20 μV	
	500 kHz to 1 MHz	0.27 % + 20 μV	
	22 mV to 220 mV		
	10 Hz to 20 Hz	0.028 % + 12 μV	
	20 Hz to 40 Hz	0.011 % + 7 μV	
	40 Hz to 20 kHz	0.008 5 % + 7 μV	
	20 kHz to 50 kHz	0.021 % + 7 μV	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	22 mV to 220 mV		Fluke 5720A
	50 kHz to 100 kHz	0.047 % + 17 µV	
	100 kHz to 300 kHz	0.091 % + 20 µV	
	300 kHz to 500 kHz	0.14 % + 25 µV	
	500 kHz to 1 MHz	0.28 % + 45 µV	
	220 mV to 2.2 V		
	10 Hz to 20 Hz	0.027 % + 40 µV	
	20 Hz to 40 Hz	0.01 % + 15 µV	
	40 Hz to 20 kHz	0.004 8 % + 8.0 µV	
	20 kHz to 50 kHz	0.008 % + 10 µV	
	50 kHz to 100 kHz	0.012 % + 30 µV	
	100 kHz to 300 kHz	0.043 % + 80 µV	
	300 kHz to 500 kHz	0.1 % + 200 µV	
	500 kHz to 1 MHz	0.18 % + 300 µV	
	2.2 V to 22 V		
	10 Hz to 20 Hz	0.028 % + 0.4 mV	
	20 Hz to 40 Hz	0.01 % + 0.15 mV	
	40 Hz to 20 kHz	0.004 9 % + 50 µV	
	20 kHz to 50 kHz	0.008 3 % + 0.1 mV	
	50 kHz to 100 kHz	0.012 % + 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	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measuring Equipment ¹	22 V to 220 V		Fluke 5720A
	10 Hz to 20 Hz	0.028 % + 4 mV	
	20 Hz to 40 Hz	0.01 % + 1.5 mV	
	40 Hz to 20 kHz	0.005 6 % + 0.6 mV	
	20 kHz to 50 kHz	0.009 3 % + 1 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	0.8 % + 40 mV	
	220 V to 1100 V		Fluke 5720A/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	
	220 V to 750 V		Fluke 5720A/5725A
	30 kHz to 50 kHz	0.061 % + 11 mV	
	50 kHz to 100 kHz	0.23 % + 45 mV	
Capacitance – Measure: 10 Hz to 1 MHz	0.33 mF	0.048 %	Time/Charge Method with HP3458A
	0.8 mF	0.027 %	
	1 mF	0.024 %	
	1.2 mF	0.023 %	
	3 mF	0.018 %	
	3.3 mF	0.017 %	
	8 mF	0.016 %	
	10 mF	0.016 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Capacitance – Measure: 10 Hz to 1 MHz	12 mF	0.016 %	Time/Charge Method with HP3458A
	30 mF	0.015 %	
	80 mF	0.014 %	
	100 mF	0.014 %	
Capacitance – Measure	0.1 pF		Agilent E4980A LCR
	100 kHz	1.4 %	
	1 MHz	1.8 %	
	1 pF		
	10 kHz	1.4 %	
	100 kHz	0.37 %	
	1 MHz	0.44 %	
	2 MHz	1.1 %	
	10 pF		
	1 kHz	1.4 %	
	10 kHz	0.28 %	
	100 kHz	0.28 %	
	1 MHz	0.3 %	
	2 MHz	0.75 %	
	100 pF		
	100 Hz	2.1 %	
	1 kHz	0.23 %	
	10 kHz	0.17 %	
	100 kHz	0.21 %	
	1 MHz	0.23 %	
	2 MHz	0.3 %	
	1 nF		
	20 Hz	1.8 %	
	100 Hz	0.3 %	
	1 kHz	0.1 %	
	10 kHz	0.1 %	
	100 kHz	0.1 %	
	1 MHz	0.14 %	
	2 MHz	0.53 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Capacitance – Measure	10 nF		Agilent E4980A LCR
	20 Hz	0.31 %	
	100 Hz	0.12 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.092 %	
	1 MHz	0.25 %	
	2 MHz	0.67 %	
	100 nF		
	20 Hz	0.16 %	
	100 Hz	0.092 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.18 %	
	1 MHz	0.33 %	
	2 MHz	0.97 %	
	1 μF		
	20 Hz	0.15 %	
	100 Hz	0.092 %	
	1 kHz	0.092 %	
	10 kHz	0.18 %	
	100 kHz	0.25 %	
	1 MHz	0.79 %	
	10 μF		
	20 Hz	0.15 %	
	100 Hz	0.092 %	
	1 kHz	0.16 %	
	10 kHz	0.28 %	
	100 kHz	0.73 %	
	100 μF		
	20 Hz	0.16 %	
	100 Hz	0.17 %	
	1 kHz	0.29 %	
	10 kHz	0.8 %	
Capacitance – Source ¹	0.19 nF to 3.3 nF		Fluke 5520A
	10 Hz to 10 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
Capacitance – Source 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	
	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	0.2 % + 7.8 nF	
	11 µF to 33 µF 10 Hz to 120 Hz	0.31 % + 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	0.58 % + 23 µF	
	33 mF to 110 mF DC to 0.2 Hz	0.85 % + 78 µF	
Inductance – Source ¹	100 mH 1 kHz	0.02 %	Fixed Inductor
	1 µH 10 kHz	1.6 %	
	100 kHz	0.36 %	
	1 MHz	0.27 %	
	2 MHz	0.66 %	
	10 µH 10 kHz	0.37 %	
	100 kHz	0.2 %	
	1 MHz	0.2 %	
	2 MHz	0.3 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Inductance – Measure ³	100 µH		Agilent E4980A LCR
	1 kHz	0.4 %	
	10 kHz	0.2 %	
	100 kHz	0.12 %	
	1 MHz	0.14 %	
	2 MHz	0.72 %	
	1 mH		
	100 Hz	0.55 %	
	1 kHz	0.18 %	
	10 kHz	0.12 %	
	100 kHz	0.092 %	
	1 MHz	0.23 %	
	2 MHz	0.88 %	
	10 mH		
	20 Hz	0.85 %	
	100 Hz	0.22 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.1 %	
	1 MHz	0.35 %	
	2 MHz	1.3 %	
	100 mH		
	20 Hz	0.28 %	
	100 Hz	0.1 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.21 %	
	1 MHz	0.88 %	
	1 H		
	20 Hz	0.16 %	
	100 Hz	0.092 %	
	1 kHz	0.092 %	
	10 kHz	0.1 %	
	100 kHz	0.31 %	
	10 H		
	20 Hz	0.15 %	
	100 Hz	0.092 %	
	1 kHz	0.1 %	
	10 kHz	0.21 %	
	100 kHz	0.69 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Inductance – Measure ³	100 H		
	20 Hz	0.15 %	
	100 Hz	0.1 %	
	1 kHz	0.15 %	
	10 kHz	0.62 %	
DC Voltage – Measuring Equipment	1 mV	2.6 %	
	10 mV	0.68 %	
	100 mV	0.052 %	
	1 V	0.0064 %	
	10 V	0.027 %	
	100 V	0.026 %	
Flatness Relative to 1 kHz 7 V / 3.2 V	10 Hz	0.009 %	
	20 Hz	0.008 %	
	50 Hz	0.006 %	
	105 Hz	0.007 %	
	200 Hz	0.006 %	
	2 kHz	0.006 %	
	10 kHz	0.006 %	
	20 kHz	0.008 %	
	50 kHz	0.007 %	
	100 kHz	0.007 %	
	200 kHz	0.007 %	
	500 kHz	0.009 %	
	700 kHz	0.013 %	
	1 MHz	0.016 %	
	1.2 MHz	0.016 %	
	2 MHz	0.021 %	
	3 MHz	0.024 %	
	4 MHz	0.028 %	
	6 MHz	0.031 %	
	8 MHz	0.034 %	
	9 MHz	0.034 %	
	10 MHz	0.034 %	
	12 MHz	0.042 %	
			Fluke 9500B with Fluke 9530 head
			Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 7 V / 3.2 V	15 MHz	0.046 %	
	17 MHz	0.052 %	
	20 MHz	0.062 %	
	23 MHz	0.087 %	
	26 MHz	0.10 %	
	28 MHz	0.11 %	
	30 MHz	0.12 %	
	35 MHz	0.15 %	
	40 MHz	0.17 %	
	45 MHz	0.20 %	
	50 MHz	0.25 %	
Flatness Relative to 1 kHz 2.2 V / 2 V	10 Hz	0.012 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	20 Hz	0.012 %	
	50 Hz	0.007 %	
	105 Hz	0.008 %	
	200 Hz	0.006 %	
	2 kHz	0.007 %	
	10 kHz	0.007 %	
	20 kHz	0.008 %	
	50 kHz	0.007%	
	100 kHz	0.007 %	
	200 kHz	0.007 %	
	500 kHz	0.009 %	
	700 kHz	0.014 %	
	1 MHz	0.017 %	
	1.2 MHz	0.017 %	
	2 MHz	0.021 %	
	3 MHz	0.026 %	
	4 MHz	0.029 %	
	6 MHz	0.033 %	
	8 MHz	0.037 %	
	9 MHz	0.036 %	
	10 MHz	0.036 %	
	12 MHz	0.045 %	
	15 MHz	0.049 %	
	17 MHz	0.054 %	
	20 MHz	0.065 %	
	23 MHz	0.045 %	
	26 MHz	0.049 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 2.2 V / 2 V	28 MHz	0.054 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	30 MHz	0.065 %	
	35 MHz	0.089 %	
	40 MHz	0.10 %	
	45 MHz	0.12 %	
	50 MHz	0.12 %	
Flatness Relative to 1 kHz 2.2 V / 1 V	10 Hz	0.014 %	
	20 Hz	0.013 %	
	50 Hz	0.008 %	
	105 Hz	0.009 %	
	200 Hz	0.007 %	
	2 kHz	0.007 %	
	10 kHz	0.007 %	
	20 kHz	0.008 %	
	50 kHz	0.007 %	
	100 kHz	0.007 %	
	200 kHz	0.007 %	
	500 kHz	0.009 %	
	700 kHz	0.014 %	
	1 MHz	0.017 %	
	1.2 MHz	0.017 %	
	2 MHz	0.022 %	
	3 MHz	0.027 %	
	4 MHz	0.031 %	
	6 MHz	0.035 %	
	8 MHz	0.039 %	
	9 MHz	0.040 %	
	10 MHz	0.040 %	
	12 MHz	0.049 %	
	15 MHz	0.052 %	
	17 MHz	0.056 %	
	20 MHz	0.066 %	
	23 MHz	0.049 %	
	26 MHz	0.052 %	
	28 MHz	0.056 %	
	30 MHz	0.066 %	
	35 MHz	0.090 %	
	40 MHz	0.11 %	
	45 MHz	0.12 %	
	50 MHz	0.13 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 0.7 V / 0.64 V	10 Hz	0.017 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	20 Hz	0.016 %	
	50 Hz	0.009 %	
	105 Hz	0.010 %	
	200 Hz	0.008 %	
	2 kHz	0.007 %	
	10 kHz	0.007 %	
	20 kHz	0.009 %	
	50 kHz	0.008 %	
	100 kHz	0.008 %	
	200 kHz	0.008 %	
	500 kHz	0.010 %	
	700 kHz	0.015 %	
	1 MHz	0.018 %	
	1.2 MHz	0.018 %	
	2 MHz	0.023 %	
	3 MHz	0.028 %	
	4 MHz	0.032 %	
	6 MHz	0.037 %	
	8 MHz	0.041 %	
	9 MHz	0.042 %	
	10 MHz	0.042 %	
	12 MHz	0.052 %	
	15 MHz	0.055 %	
	17 MHz	0.059 %	
	20 MHz	0.069 %	
	23 MHz	0.052 %	
	26 MHz	0.055 %	
	28 MHz	0.059 %	
	30 MHz	0.069 %	
	35 MHz	0.093 %	
	40 MHz	0.11 %	
	45 MHz	0.12 %	
	50 MHz	0.13 %	
Flatness Relative to 1 kHz 0.7 V / 0.32 V	10 Hz	0.014 %	
	20 Hz	0.014 %	
	50 Hz	0.008 %	
	105 Hz	0.008 %	
	200 Hz	0.007 %	
	2 kHz	0.008 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 0.7 V / 0.32 V	10 kHz	0.007 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	20 kHz	0.009 %	
	50 kHz	0.008 %	
	100 kHz	0.008 %	
	200 kHz	0.008 %	
	500 kHz	0.010 %	
	700 kHz	0.015 %	
	1 MHz	0.017 %	
	1.2 MHz	0.018 %	
	2 MHz	0.022 %	
	3 MHz	0.028 %	
	4 MHz	0.031 %	
	6 MHz	0.034 %	
	8 MHz	0.038 %	
	9 MHz	0.038 %	
	10 MHz	0.038 %	
	12 MHz	0.049 %	
	15 MHz	0.053 %	
	17 MHz	0.060 %	
	20 MHz	0.071 %	
	23 MHz	0.049 %	
	26 MHz	0.053 %	
	28 MHz	0.060 %	
	30 MHz	0.071 %	
	35 MHz	0.094 %	
	40 MHz	0.11 %	
	45 MHz	0.12 %	
	50 MHz	0.13 %	
Flatness Relative to 1 kHz 0.22 V / 0.1 V	10 Hz	0.018 %	
	20 Hz	0.017 %	
	50 Hz	0.010 %	
	105 Hz	0.010 %	
	200 Hz	0.008 %	
	2 kHz	0.008 %	
	10 kHz	0.008 %	
	20 kHz	0.009 %	
	50 kHz	0.009 %	
	100 kHz	0.009 %	
	200 kHz	0.009 %	
	500 kHz	0.010 %	
	700 kHz	0.016 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 0.22 V / 0.1 V	1 MHz	0.019 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	1.2 MHz	0.019 %	
	2 MHz	0.023 %	
	3 MHz	0.030 %	
	4 MHz	0.034 %	
	6 MHz	0.038 %	
	8 MHz	0.043 %	
	9 MHz	0.043 %	
	10 MHz	0.044 %	
	12 MHz	0.055 %	
	15 MHz	0.059 %	
	17 MHz	0.064 %	
	20 MHz	0.075 %	
	23 MHz	0.055 %	
	26 MHz	0.059 %	
	28 MHz	0.064 %	
	30 MHz	0.075 %	
	35 MHz	0.098 %	
	40 MHz	0.12 %	
	45 MHz	0.13 %	
	50 MHz	0.14 %	
Flatness Relative to 1 kHz 0.07 V / 32 mV	10 Hz	0.019 %	
	20 Hz	0.018 %	
	50 Hz	0.009 %	
	105 Hz	0.010 %	
	200 Hz	0.008 %	
	2 kHz	0.009 %	
	10 kHz	0.009 %	
	20 kHz	0.010 %	
	50 kHz	0.009 %	
	100 kHz	0.009 %	
	200 kHz	0.01 %	
	500 kHz	0.011 %	
	700 kHz	0.016 %	
	1 MHz	0.020 %	
	1.2 MHz	0.020 %	
	2 MHz	0.024 %	
	3 MHz	0.031 %	
	4 MHz	0.034 %	
	6 MHz	0.039 %	
	8 MHz	0.044 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 0.07 V / 32 mV	9 MHz	0.044 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	10 MHz	0.045 %	
	12 MHz	0.057 %	
	15 MHz	0.063 %	
	17 MHz	0.070 %	
	20 MHz	0.080 %	
	23 MHz	0.057 %	
	26 MHz	0.063 %	
	28 MHz	0.070 %	
	30 MHz	0.080 %	
	35 MHz	0.10 %	
	40 MHz	0.12 %	
	45 MHz	0.13 %	
	50 MHz	0.14 %	
Flatness Relative to 1 kHz 22 mV / 10 mV	10 Hz	0.022 %	
	20 Hz	0.021 %	
	50 Hz	0.011 %	
	105 Hz	0.011 %	
	200 Hz	0.009 %	
	2 kHz	0.009 %	
	10 kHz	0.009 %	
	20 kHz	0.010 %	
	50 kHz	0.010 %	
	100 kHz	0.010 %	
	200 kHz	0.010 %	
	500 kHz	0.012 %	
	700 kHz	0.017 %	
	1 MHz	0.021 %	
	1.2 MHz	0.021 %	
	2 MHz	0.025 %	
	3 MHz	0.033 %	
	4 MHz	0.037 %	
	6 MHz	0.043 %	
	8 MHz	0.048 %	
	9 MHz	0.049 %	
	10 MHz	0.050 %	
	12 MHz	0.063 %	
	15 MHz	0.068 %	
	17 MHz	0.073 %	
	20 MHz	0.084 %	
	23 MHz	0.063 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 22 mV / 10 mV	26 MHz	0.068 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	28 MHz	0.073 %	
	30 MHz	0.084 %	
	35 MHz	0.11 %	
	40 MHz	0.12 %	
	45 MHz	0.14 %	
	50 MHz	0.15 %	
Flatness Relative to 1 kHz 7 mV / 3.2 mV	10 Hz	0.022 %	
	20 Hz	0.022 %	
	50 Hz	0.010 %	
	105 Hz	0.011 %	
	200 Hz	0.009 %	
	2 kHz	0.010 %	
	10 kHz	0.010 %	
	20 kHz	0.011 %	
	50 kHz	0.010 %	
	100 kHz	0.010 %	
	200 kHz	0.010 %	
	500 kHz	0.012 %	
	700 kHz	0.018 %	
	1 MHz	0.021 %	
	1.2 MHz	0.021 %	
	2 MHz	0.025 %	
	3 MHz	0.034 %	
	4 MHz	0.036 %	
	6 MHz	0.042 %	
	8 MHz	0.047 %	
	9 MHz	0.048 %	
	10 MHz	0.049 %	
	12 MHz	0.063 %	
	15 MHz	0.069 %	
	17 MHz	0.076 %	
	20 MHz	0.087 %	
	23 MHz	0.063 %	
	26 MHz	0.069 %	
	28 MHz	0.076 %	
	30 MHz	0.087 %	
	35 MHz	0.11 %	
	40 MHz	0.13 %	
	45 MHz	0.14 %	
	50 MHz	0.15 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Flatness Relative to 1 kHz 2.2 mV / 1 mV	10 Hz	0.025 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
	20 Hz	0.024 %	
	50 Hz	0.011 %	
	105 Hz	0.012 %	
	200 Hz	0.010 %	
	2 kHz	0.010 %	
	10 kHz	0.010 %	
	20 kHz	0.011 %	
	50 kHz	0.010 %	
	100 kHz	0.011 %	
	200 kHz	0.011 %	
	500 kHz	0.013 %	
	700 kHz	0.018 %	
	1 MHz	0.022 %	
	1.2 MHz	0.022 %	
	2 MHz	0.026 %	
	3 MHz	0.036 %	
	4 MHz	0.039 %	
	6 MHz	0.045 %	
	8 MHz	0.051 %	
	9 MHz	0.052 %	
	10 MHz	0.053 %	
	12 MHz	0.068 %	
	15 MHz	0.073 %	
	17 MHz	0.079 %	
	20 MHz	0.090 %	
	23 MHz	0.068 %	
	26 MHz	0.073 %	
	28 MHz	0.079 %	
	30 MHz	0.090 %	
	35 MHz	0.11 %	
	40 MHz	0.13 %	
	45 MHz	0.14 %	
	50 MHz	0.15 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF AC-DC Difference 2 mV	10 Hz	560 $\mu\text{V/V}$	Fluke 792A
	20 Hz	350 $\mu\text{V/V}$	
	40 Hz	450 $\mu\text{V/V}$	
	100 Hz	390 $\mu\text{V/V}$	
	1 kHz	340 $\mu\text{V/V}$	
	10 kHz	320 $\mu\text{V/V}$	
	20 kHz	320 $\mu\text{V/V}$	
	50 kHz	350 $\mu\text{V/V}$	
	100 kHz	440 $\mu\text{V/V}$	
	300 kHz	510 $\mu\text{V/V}$	
	500 kHz	610 $\mu\text{V/V}$	
	800 kHz	750 $\mu\text{V/V}$	
	1 MHz	760 $\mu\text{V/V}$	
6 mV	10 Hz	230 $\mu\text{V/V}$	
	20 Hz	230 $\mu\text{V/V}$	
	40 Hz	230 $\mu\text{V/V}$	
	100 Hz	190 $\mu\text{V/V}$	
	1 kHz	180 $\mu\text{V/V}$	
	10 kHz	170 $\mu\text{V/V}$	
	20 kHz	200 $\mu\text{V/V}$	
	50 kHz	220 $\mu\text{V/V}$	
	100 kHz	300 $\mu\text{V/V}$	
	300 kHz	410 $\mu\text{V/V}$	
	500 kHz	490 $\mu\text{V/V}$	
	800 kHz	580 $\mu\text{V/V}$	
	1 MHz	630 $\mu\text{V/V}$	
10 mV	10 Hz	110 $\mu\text{V/V}$	
	20 Hz	110 $\mu\text{V/V}$	
	40 Hz	89 $\mu\text{V/V}$	
	100 Hz	140 $\mu\text{V/V}$	
	1 kHz	88 $\mu\text{V/V}$	
	10 kHz	110 $\mu\text{V/V}$	
	20 kHz	83 $\mu\text{V/V}$	
	50 kHz	100 $\mu\text{V/V}$	
	100 kHz	160 $\mu\text{V/V}$	
	300 kHz	220 $\mu\text{V/V}$	
	500 kHz	300 $\mu\text{V/V}$	
	800 kHz	330 $\mu\text{V/V}$	
	1 MHz	420 $\mu\text{V/V}$	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF AC-DC Difference 20 mV	10 Hz	84 μ V/V	Fluke 792A
	20 Hz	68 μ V/V	
	40 Hz	64 μ V/V	
	100 Hz	110 μ V/V	
	1 kHz	67 μ V/V	
	10 kHz	81 μ V/V	
	20 kHz	62 μ V/V	
	50 kHz	110 μ V/V	
	100 kHz	160 μ V/V	
	300 kHz	220 μ V/V	
	500 kHz	310 μ V/V	
	800 kHz	380 μ V/V	
	1 MHz	390 μ V/V	
60 mV	10 Hz	100 μ V/V	
	20 Hz	45 μ V/V	
	40 Hz	35 μ V/V	
	100 Hz	33 μ V/V	
	1 kHz	32 μ V/V	
	10 kHz	37 μ V/V	
	20 kHz	35 μ V/V	
	50 kHz	40 μ V/V	
	100 kHz	77 μ V/V	
	300 kHz	150 μ V/V	
	500 kHz	220 μ V/V	
	800 kHz	290 μ V/V	
	1 MHz	300 μ V/V	
100 mV	10 Hz	46 μ V/V	
	20 Hz	29 μ V/V	
	40 Hz	21 μ V/V	
	100 Hz	15 μ V/V	
	1 kHz	14 μ V/V	
	10 kHz	26 μ V/V	
	20 kHz	29 μ V/V	
	50 kHz	30 μ V/V	
	100 kHz	45 μ V/V	
	300 kHz	90 μ V/V	
	500 kHz	130 μ V/V	
	800 kHz	190 μ V/V	
	1 MHz	200 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF AC-DC Difference 200 mV	10 Hz	35 µV/V	Fluke 792A
	20 Hz	21 µV/V	
	40 Hz	29 µV/V	
	100 Hz	16 µV/V	
	1 kHz	12 µV/V	
	10 kHz	20 µV/V	
	20 kHz	17 µV/V	
	50 kHz	28 µV/V	
	100 kHz	48 µV/V	
	300 kHz	76 µV/V	
	500 kHz	110 µV/V	
	800 kHz	160 µV/V	
	1 MHz	190 µV/V	
600 mV	10 Hz	28 µV/V	
	20 Hz	24 µV/V	
	40 Hz	7.6 µV/V	
	100 Hz	8.7 µV/V	
	1 kHz	9.2 µV/V	
	10 kHz	7.8 µV/V	
	20 kHz	9.7 µV/V	
	50 kHz	8.6 µV/V	
	100 kHz	30 µV/V	
	300 kHz	26 µV/V	
	500 kHz	47 µV/V	
	800 kHz	60 µV/V	
	1 MHz	81 µV/V	
1 V	10 Hz	29 µV/V	
	20 Hz	18 µV/V	
	40 Hz	6.5 µV/V	
	100 Hz	6.7 µV/V	
	1 kHz	7.0 µV/V	
	10 kHz	6.0 µV/V	
	20 kHz	6.0 µV/V	
	50 kHz	8.2 µV/V	
	100 kHz	14 µV/V	
	300 kHz	22 µV/V	
	500 kHz	35 µV/V	
	800 kHz	36 µV/V	
	1 MHz	48 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF AC-DC Difference 2 V	10 Hz	25 µV/V	Fluke 792A
	20 Hz	15 µV/V	
	40 Hz	6.6 µV/V	
	100 Hz	6.4 µV/V	
	1 kHz	6.5 µV/V	
	10 kHz	6.2 µV/V	
	20 kHz	6.8 µV/V	
	50 kHz	7.9 µV/V	
	100 kHz	14 µV/V	
	300 kHz	33 µV/V	
	500 kHz	33 µV/V	
	800 kHz	32 µV/V	
	1 MHz	45 µV/V	
6 V	10 Hz	32 µV/V	
	20 Hz	16 µV/V	
	40 Hz	5.6 µV/V	
	100 Hz	6.1 µV/V	
	1 kHz	5.8 µV/V	
	10 kHz	6.3 µV/V	
	20 kHz	5.8 µV/V	
	50 kHz	6.5 µV/V	
	100 kHz	9.4 µV/V	
	300 kHz	20 µV/V	
	500 kHz	27 µV/V	
	800 kHz	33 µV/V	
	1 MHz	42 µV/V	
10 V	10 Hz	26 µV/V	
	20 Hz	15 µV/V	
	40 Hz	5.5 µV/V	
	100 Hz	6.3 µV/V	
	1 kHz	5.9 µV/V	
	10 kHz	5.5 µV/V	
	20 kHz	5.6 µV/V	
	50 kHz	7.3 µV/V	
	100 kHz	9.6 µV/V	
	300 kHz	20 µV/V	
	500 kHz	35 µV/V	
	800 kHz	56 µV/V	
	1 MHz	81 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF AC-DC Difference 20 V	10 Hz	37 µV/V	Fluke 792A
	20 Hz	17 µV/V	
	40 Hz	8 µV/V	
	100 Hz	7.9 µV/V	
	1 kHz	7.7 µV/V	
	10 kHz	7.9 µV/V	
	20 kHz	7.8 µV/V	
	50 kHz	8.9 µV/V	
	100 kHz	12 µV/V	
	300 kHz	22 µV/V	
	500 kHz	28 µV/V	
	800 kHz	37 µV/V	
	1 MHz	55 µV/V	
60 V	10 Hz	36 µV/V	
	20 Hz	17 µV/V	
	40 Hz	7.1 µV/V	
	100 Hz	6.9 µV/V	
	1 kHz	7.3 µV/V	
	10 kHz	7.0 µV/V	
	20 kHz	7.7 µV/V	
	50 kHz	15 µV/V	
	100 kHz	11 µV/V	
	300 kHz	33 µV/V	
100 V	10 Hz	27 µV/V	
	20 Hz	15 µV/V	
	40 Hz	7.2 µV/V	
	100 Hz	6.9 µV/V	
	1 kHz	7.0 µV/V	
	10 kHz	7.1 µV/V	
	20 kHz	7.6 µV/V	
	50 kHz	12 µV/V	
	100 kHz	18 µV/V	
200 V	10 Hz	44 µV/V	
	20 Hz	17 µV/V	
	40 Hz	10 µV/V	
	100 Hz	10 µV/V	
	1 kHz	9.7 µV/V	
	10 kHz	9.8 µV/V	
	20 kHz	10.3 µV/V	
	50 kHz	12 µV/V	
	100 kHz	19 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
LF AC-DC Difference 600 V	10 Hz	54 $\mu\text{V/V}$	Fluke 792A
	20 Hz	29 $\mu\text{V/V}$	
	40 Hz	14 $\mu\text{V/V}$	
	100 Hz	15 $\mu\text{V/V}$	
	1 kHz	13 $\mu\text{V/V}$	
	10 kHz	18 $\mu\text{V/V}$	
	20 kHz	20 $\mu\text{V/V}$	
	50 kHz	32 $\mu\text{V/V}$	
	100 kHz	72 $\mu\text{V/V}$	
1 000 V	10 Hz	54 $\mu\text{V/V}$	Fluke 792A
	20 Hz	22 $\mu\text{V/V}$	
	40 Hz	13 $\mu\text{V/V}$	
	100 Hz	12 $\mu\text{V/V}$	
	1 kHz	13 $\mu\text{V/V}$	
	10 kHz	16 $\mu\text{V/V}$	
	20 kHz	22 $\mu\text{V/V}$	
	50 kHz	47 $\mu\text{V/V}$	
	100 kHz	67 $\mu\text{V/V}$	
AC Current 100 μA	10 Hz	75 $\mu\text{V/V}$	Fluke A40 Shunts with 792A
	20 Hz	70 $\mu\text{V/V}$	
	40 Hz	61 $\mu\text{V/V}$	
	400 Hz	59 $\mu\text{V/V}$	
	1 kHz	56 $\mu\text{V/V}$	
	5 kHz	73 $\mu\text{V/V}$	
	10 kHz	83 $\mu\text{V/V}$	
	20 kHz	120 $\mu\text{V/V}$	
	30 kHz	160 $\mu\text{V/V}$	
200 μA	10 Hz	95 $\mu\text{V/V}$	Fluke A40 Shunts with 792A
	20 Hz	56 $\mu\text{V/V}$	
	40 Hz	59 $\mu\text{V/V}$	
	400 Hz	45 $\mu\text{V/V}$	
	1 kHz	43 $\mu\text{V/V}$	
	5 kHz	69 $\mu\text{V/V}$	
	10 kHz	81 $\mu\text{V/V}$	
	20 kHz	120 $\mu\text{V/V}$	
	30 kHz	190 $\mu\text{V/V}$	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current 300 µA	10 Hz	71 µV/V	Fluke A40 Shunts with 792A
	20 Hz	70 µV/V	
	40 Hz	49 µV/V	
	400 Hz	47 µV/V	
	1 kHz	47 µV/V	
	5 kHz	47 µV/V	
	10 kHz	49 µV/V	
	20 kHz	68 µV/V	
	30 kHz	120 µV/V	
1 mA	10 Hz	56 µV/V	
	20 Hz	47 µV/V	
	40 Hz	41 µV/V	
	400 Hz	34 µV/V	
	1 kHz	30 µV/V	
	5 kHz	34 µV/V	
	10 kHz	37 µV/V	
	20 kHz	43 µV/V	
	30 kHz	36 µV/V	
2 mA	10 Hz	54 µV/V	
	20 Hz	42 µV/V	
	40 Hz	46 µV/V	
	400 Hz	38 µV/V	
	1 kHz	38 µV/V	
	5 kHz	39 µV/V	
	10 kHz	41 µV/V	
	20 kHz	41 µV/V	
	30 kHz	48 µV/V	
3 mA	10 Hz	51 µV/V	
	20 Hz	40 µV/V	
	40 Hz	35 µV/V	
	400 Hz	33 µV/V	
	1 kHz	33 µV/V	
	5 kHz	32 µV/V	
	10 kHz	32 µV/V	
	20 kHz	38 µV/V	
	30 kHz	44 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current 10 mA	10 Hz	100 μ V/V	Fluke A40 Shunts with 792A
	20 Hz	53 μ V/V	
	40 Hz	38 μ V/V	
	400 Hz	37 μ V/V	
	1 kHz	32 μ V/V	
	5 kHz	31 μ V/V	
	10 kHz	32 μ V/V	
	20 kHz	42 μ V/V	
	30 kHz	63 μ V/V	
20 mA	10 Hz	140 μ V/V	
	20 Hz	84 μ V/V	
	40 Hz	78 μ V/V	
	400 Hz	77 μ V/V	
	1 kHz	76 μ V/V	
	5 kHz	76 μ V/V	
	10 kHz	76 μ V/V	
	20 kHz	78 μ V/V	
	30 kHz	93 μ V/V	
30 mA	10 Hz	150 μ V/V	
	20 Hz	92 μ V/V	
	40 Hz	72 μ V/V	
	400 Hz	66 μ V/V	
	1 kHz	66 μ V/V	
	5 kHz	67 μ V/V	
	10 kHz	73 μ V/V	
	20 kHz	85 μ V/V	
	30 kHz	110 μ V/V	
100 mA	10 Hz	140 μ V/V	
	20 Hz	64 μ V/V	
	40 Hz	53 μ V/V	
	400 Hz	51 μ V/V	
	1 kHz	48 μ V/V	
	5 kHz	48 μ V/V	
	10 kHz	49 μ V/V	
	20 kHz	61 μ V/V	
	30 kHz	78 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current 200 mA	10 Hz	150 μ V/V	Fluke A40 Shunts with 792A
	20 Hz	58 μ V/V	
	40 Hz	39 μ V/V	
	400 Hz	37 μ V/V	
	1 kHz	40 μ V/V	
	5 kHz	34 μ V/V	
	10 kHz	33 μ V/V	
	20 kHz	49 μ V/V	
	30 kHz	68 μ V/V	
300 mA	10 Hz	120 μ V/V	
	20 Hz	56 μ V/V	
	40 Hz	43 μ V/V	
	400 Hz	33 μ V/V	
	1 kHz	32 μ V/V	
	5 kHz	31 μ V/V	
	10 kHz	36 μ V/V	
	20 kHz	43 μ V/V	
	30 kHz	72 μ V/V	
500 mA	10 Hz	260 μ V/V	
	20 Hz	51 μ V/V	
	40 Hz	75 μ V/V	
	400 Hz	50 μ V/V	
	1 kHz	45 μ V/V	
	5 kHz	37 μ V/V	
	10 kHz	29 μ V/V	
	20 kHz	47 μ V/V	
	30 kHz	79 μ V/V	
1A	10 Hz	98 μ V/V	
	20 Hz	50 μ V/V	
	40 Hz	38 μ V/V	
	400 Hz	39 μ V/V	
	1 kHz	35 μ V/V	
	5 kHz	39 μ V/V	
	10 kHz	48 μ V/V	
	20 kHz	80 μ V/V	
	30 kHz	120 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current 2A	10 Hz	110 μ V/V	Fluke A40 Shunts with 792A
	20 Hz	56 μ V/V	
	40 Hz	42 μ V/V	
	400 Hz	37 μ V/V	
	1 kHz	35 μ V/V	
	5 kHz	42 μ V/V	
	10 kHz	43 μ V/V	
	20 kHz	55 μ V/V	
	30 kHz	110 μ V/V	
3 A	10 Hz	133 μ V/V	
	20 Hz	66 μ V/V	
	40 Hz	57 μ V/V	
	400 Hz	56 μ V/V	
	1 kHz	55 μ V/V	
	5 kHz	61 μ V/V	
	10 kHz	63 μ V/V	
	20 kHz	83 μ V/V	
	30 kHz	140 μ V/V	
5 A	10 Hz	130 μ V/V	
	20 Hz	67 μ V/V	
	40 Hz	56 μ V/V	
	400 Hz	61 μ V/V	
	1 kHz	53 μ V/V	
	5 kHz	58 μ V/V	
	10 kHz	69 μ V/V	
	20 kHz	88 μ V/V	
	30 kHz	180 μ V/V	
10A	10 Hz	150 μ V/V	
	20 Hz	84 μ V/V	
	40 Hz	65 μ V/V	
	400 Hz	64 μ V/V	
	1 kHz	62 μ V/V	
	5 kHz	62 μ V/V	
	10 kHz	62 μ V/V	
	20 kHz	100 μ V/V	
	30 kHz	150 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Current 20A	10 Hz 20 Hz 40 Hz 400 Hz 1 kHz 5 kHz 10 kHz 20 kHz 30 kHz	150 μ V/V 120 μ V/V 81 μ V/V 81 μ V/V 77 μ V/V 77 μ V/V 77 μ V/V 130 μ V/V 180 μ V/V	Fluke A40 Shunts with 792A
	10 Hz 20 Hz 40 Hz 400 Hz 1 kHz 5 kHz	160 μ V/V 160 μ V/V 96 μ V/V 86 μ V/V 86 μ V/V 120 μ V/V	
Impedance Measure ³ 0.1 Ω	1 kHz 10 kHz 100 kHz 1 MHz	1.8 % 1.6 % 1 % 1.5 %	Agilent E4980A LCR
1 Ω	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	0.67 % 0.43 % 0.33 % 0.32 % 0.31 % 0.38 % 0.92 %	
10 Ω	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	0.29 % 0.2 % 0.17 % 0.19 % 0.19 % 0.27 % 0.67 %	
100 Ω	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	0.16 % 0.092 % 0.092 % 0.12 % 0.12 % 0.2 % 0.53 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Impedance Measure ³ 1 k Ω	20 Hz	0.15 %	Agilent E4980A LCR
	100 Hz	0.092 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.092 %	
	1 MHz	0.14 %	
	2 MHz	0.3 %	
10 k Ω	20 Hz	0.15 %	
	100 Hz	0.092 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.1 %	
	1 MHz	0.29	
	2 MHz	0.87	
100 k Ω	20 Hz	0.17 %	
	100 Hz	0.1 %	
	1 kHz	0.1 %	
	10 kHz	0.17 %	
	100 kHz	0.28 %	
	1 MHz	0.38 %	
	2 MHz	1.3 %	
AC Voltage – Measure 2 mV	10 Hz	560 μ V/V	Fluke 792A
	20 Hz	350 μ V/V	
	40 Hz	450 μ V/V	
	100 Hz	390 μ V/V	
	1 kHz	340 μ V/V	
	10 kHz	320 μ V/V	
	20 kHz	320 μ V/V	
	50 kHz	350 μ V/V	
	100 kHz	440 μ V/V	
	300 kHz	510 μ V/V	
	500 kHz	610 μ V/V	
	800 kHz	750 μ V/V	
	1 MHz	760 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure 6 mV	10 Hz	230 μ V/V	Fluke 792A
	20 Hz	230 μ V/V	
	40 Hz	230 μ V/V	
	100 Hz	190 μ V/V	
	1 kHz	180 μ V/V	
	10 kHz	170 μ V/V	
	20 kHz	200 μ V/V	
	50 kHz	220 μ V/V	
	100 kHz	300 μ V/V	
	300 kHz	410 μ V/V	
	500 kHz	490 μ V/V	
	800 kHz	580 μ V/V	
	1 MHz	630 μ V/V	
10 mV	10 Hz	110 μ V/V	
	20 Hz	110 μ V/V	
	40 Hz	89 μ V/V	
	100 Hz	140 μ V/V	
	1 kHz	88 μ V/V	
	10 kHz	110 μ V/V	
	20 kHz	83 μ V/V	
	50 kHz	100 μ V/V	
	100 kHz	160 μ V/V	
	300 kHz	220 μ V/V	
	500 kHz	300 μ V/V	
	800 kHz	330 μ V/V	
	1 MHz	420 μ V/V	
20 mV	10 Hz	84 μ V/V	
	20 Hz	68 μ V/V	
	40 Hz	64 μ V/V	
	100 Hz	110 μ V/V	
	1 kHz	67 μ V/V	
	10 kHz	81 μ V/V	
	20 kHz	62 μ V/V	
	50 kHz	110 μ V/V	
	100 kHz	160 μ V/V	
	300 kHz	220 μ V/V	
	500 kHz	310 μ V/V	
	800 kHz	380 μ V/V	
	1 MHz	390 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure 60 mV	10 Hz	100 μ V/V	Fluke 792A
	20 Hz	45 μ V/V	
	40 Hz	35 μ V/V	
	100 Hz	33 μ V/V	
	1 kHz	32 μ V/V	
	10 kHz	37 μ V/V	
	20 kHz	35 μ V/V	
	50 kHz	40 μ V/V	
	100 kHz	77 μ V/V	
	300 kHz	150 μ V/V	
	500 kHz	220 μ V/V	
	800 kHz	290 μ V/V	
	1 MHz	300 μ V/V	
100 mV	10 Hz	46 μ V/V	
	20 Hz	29 μ V/V	
	40 Hz	21 μ V/V	
	100 Hz	15 μ V/V	
	1 kHz	14 μ V/V	
	10 kHz	26 μ V/V	
	20 kHz	29 μ V/V	
	50 kHz	30 μ V/V	
	100 kHz	45 μ V/V	
	300 kHz	90 μ V/V	
	500 kHz	130 μ V/V	
	800 kHz	190 μ V/V	
	1 MHz	200 μ V/V	
200 mV	10 Hz	35 μ V/V	
	20 Hz	21 μ V/V	
	40 Hz	29 μ V/V	
	100 Hz	16 μ V/V	
	1 kHz	12 μ V/V	
	10 kHz	20 μ V/V	
	20 kHz	17 μ V/V	
	50 kHz	28 μ V/V	
	100 kHz	48 μ V/V	
	300 kHz	76 μ V/V	
	500 kHz	110 μ V/V	
	800 kHz	160 μ V/V	
	1 MHz	190 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure	10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 800 kHz 1 MHz	28 μ V/V 24 μ V/V 7.6 μ V/V 8.7 μ V/V 9.2 μ V/V 7.8 μ V/V 9.7 μ V/V 8.6 μ V/V 30 μ V/V 26 μ V/V 47 μ V/V 60 μ V/V 81 μ V/V	Fluke 792A
600 mV			
1 V	10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 800 kHz 1 MHz	29 μ V/V 18 μ V/V 6.5 μ V/V 6.7 μ V/V 7 μ V/V 6 μ V/V 6 μ V/V 8.2 μ V/V 14 μ V/V 22 μ V/V 35 μ V/V 36 μ V/V 48 μ V/V	
2 V	10 Hz 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 800 kHz 1 MHz	25 μ V/V 15 μ V/V 6.6 μ V/V 6.4 μ V/V 6.5 μ V/V 6.2 μ V/V 6.8 μ V/V 7.9 μ V/V 14 μ V/V 33 μ V/V 33 μ V/V 32 μ V/V 45 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure 6 V	10 Hz	32 μ V/V	Fluke 792A
	20 Hz	16 μ V/V	
	40 Hz	5.6 μ V/V	
	100 Hz	6.1 μ V/V	
	1 kHz	5.8 μ V/V	
	10 kHz	6.3 μ V/V	
	20 kHz	5.8 μ V/V	
	50 kHz	6.5 μ V/V	
	100 kHz	9.4 μ V/V	
	300 kHz	20 μ V/V	
	500 kHz	27 μ V/V	
	800 kHz	33 μ V/V	
	1 MHz	42 μ V/V	
10 V	10 Hz	26 μ V/V	
	20 Hz	15 μ V/V	
	40 Hz	5.5 μ V/V	
	100 Hz	6.3 μ V/V	
	1 kHz	5.9 μ V/V	
	10 kHz	5.5 μ V/V	
	20 kHz	5.6 μ V/V	
	50 kHz	7.3 μ V/V	
	100 kHz	9.6 μ V/V	
	300 kHz	20 μ V/V	
	500 kHz	35 μ V/V	
	800 kHz	56 μ V/V	
	1 MHz	81 μ V/V	
20 V	10 Hz	37 μ V/V	
	20 Hz	17 μ V/V	
	40 Hz	8 μ V/V	
	100 Hz	7.9 μ V/V	
	1 kHz	7.7 μ V/V	
	10 kHz	7.9 μ V/V	
	20 kHz	7.8 μ V/V	
	50 kHz	8.9 μ V/V	
	100 kHz	12 μ V/V	
	300 kHz	22 μ V/V	
	500 kHz	28 μ V/V	
	800 kHz	37 μ V/V	
	1 MHz	55 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure 60 V	10 Hz	36 μ V/V	Fluke 792A
	20 Hz	17 μ V/V	
	40 Hz	7.1 μ V/V	
	100 Hz	6.9 μ V/V	
	1 kHz	7.3 μ V/V	
	10 kHz	7.0 μ V/V	
	20 kHz	7.7 μ V/V	
	50 kHz	15 μ V/V	
	100 kHz	11 μ V/V	
	300 kHz	33 μ V/V	
100 V	10 Hz	27 μ V/V	
	20 Hz	15 μ V/V	
	40 Hz	7.2 μ V/V	
	100 Hz	6.9 μ V/V	
	1 kHz	7.0 μ V/V	
	10 kHz	7.1 μ V/V	
	20 kHz	7.6 μ V/V	
	50 kHz	12 μ V/V	
	100 kHz	18 μ V/V	
200 V	10 Hz	44 μ V/V	
	20 Hz	17 μ V/V	
	40 Hz	10 μ V/V	
	100 Hz	10 μ V/V	
	1 kHz	9.7 μ V/V	
	10 kHz	9.8 μ V/V	
	20 kHz	10 μ V/V	
	50 kHz	12 μ V/V	
600 V	100 kHz	19 μ V/V	
	10 Hz	54 μ V/V	
	20 Hz	29 μ V/V	
	40 Hz	14 μ V/V	
	100 Hz	15 μ V/V	
	1 kHz	13 μ V/V	
	10 kHz	18 μ V/V	
	20 kHz	20 μ V/V	
	50 kHz	32 μ V/V	
	100 kHz	72 μ V/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
AC Voltage – Measure 1 000 V	10 Hz	54 µV/V	Fluke 792A
	20 Hz	22 µV/V	
	40 Hz	13 µV/V	
	100 Hz	12 µV/V	
	1 kHz	13 µV/V	
	10 kHz	16 µV/V	
	20 kHz	22 µV/V	
	50 kHz	47 µV/V	
Inductance Measure ³ 1 µH	100 kHz	67 µV/V	Agilent E4980A LCR
	10 kHz	1.6 %	
	100 kHz	0.36 %	
	1 MHz	0.27 %	
	2 MHz	0.66 %	
10 µH	10 kHz	0.37 %	
	100 kHz	0.2 %	
	1 MHz	0.2 %	
	2 MHz	0.3 %	
100 µH	1 kHz	0.4 %	
	10 kHz	0.2 %	
	100 kHz	0.12 %	
	1 MHz	0.14 %	
	2 MHz	0.72 %	
1 mH	100 Hz	0.55 %	
	1 kHz	0.18 %	
	10 kHz	0.12 %	
	100 kHz	0.092 %	
	1 MHz	0.23 %	
	2 MHz	0.88 %	
10 mH	20 Hz	0.85 %	
	100 Hz	0.22 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.1 %	
	1 MHz	0.35 %	
	2 MHz	1.3 %	
100 mH	20 Hz	0.28 %	
	100 Hz	0.1 %	
	1 kHz	0.092 %	
	10 kHz	0.092 %	
	100 kHz	0.21 %	
	1 MHz	0.88 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Inductance Measure ³	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz	0.16 % 0.092 % 0.092 % 0.1 % 0.31 %	Agilent E4980A LCR
1 H			
10 H	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz	0.15 % 0.092 % 0.1 % 0.21 % 0.69 %	
100 H	20 Hz 100 Hz 1 kHz 10 kHz	0.15 % 0.10 % 0.15 % 0.62 %	
Oscilloscopes ¹			
Amplitude DC ¹ into 50 Ω Load into 1 M Ω Load	(-5.0 to 5.0) V (-200 to 200) V	0.023% + 19 μ V 0.023% + 19 μ V	Fluke 9500B
Amplitude Square Wave ¹ into 50 Ω Load Rate: 10 Hz to 10 kHz Rate: 10 Hz to 100 kHz	40 μ V _(pk-pk) to 1.0 mV _(pk-pk) 1.0 mV _(pk-pk) to 5.0 V _(pk-pk) 1.0 mV _(pk-pk) to 5.0 V _(pk-pk)	0.78% + 7.8 μ V 0.078% + 7.8 μ V 0.16% + 7.8 μ V	Fluke 9500B, 9530 Fluke 9500B, 9560
into 1 M Ω Load Rate: 10 Hz to 10 kHz Rate: 10 Hz to 100 kHz	40 μ V _(pk-pk) to 1.0 mV _(pk-pk) 1.0 mV _(pk-pk) to 200 V _(pk-pk)	0.78% + 7.8 μ V 0.078% + 7.8 μ V	Fluke 9500B, 9530
Timing - Generate ¹ 100 mV _(pk-pk) to 1.0 V _(pk-pk) Square Wave	9.0091 ns to 83 μ s 83 μ s to 55 s	0.19 μ s/s 2.3 μ s/s	Fluke 9500B
Sine Wave	450.5 ps to 9.009 ns 180.19 ps to 9.009 ns	0.19 μ s/s 0.19 μ s/s	Fluke 9500B/3200 Fluke 9500B/3200, 9560
Pulse	900.91 ns to 83 μ s 83 μ s to 55 s	0.19 μ s/s 2.3 μ s/s	Fluke 9500B

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Oscilloscopes ¹ Triangle Wave	900.91 ns to 83 μ s 83 μ s to 55 s	0.19 μ s/s 2.3 μ s/s	Fluke 9500B
Rise Time – Generate ^{1,8} 50 Ω Load 5.0 mV _(pk-pk) to 3.0 V _(pk-pk) Rate: 10 Hz to 2 MHz	500 ps (nominal) 150 ps (nominal)	290 ps 34 ps	Fluke 9500B/ 9530
25 mV _(pk-pk) to 2.0 V _(pk-pk) Rate: 10 Hz to 1 MHz	70 ps (nominal)	21 ps	Fluke 9500B/ 9560
425 mV _(pk-pk) to 575 mV _(pk-pk) Rate: 10 Hz to 1 MHz	25 ps (nominal)	5.7 ps	Fluke 9500B/ 9550
200 mV _(pk-pk)	16 ps (nominal)	2.1 ps	Tektronix 067-1330-00
Leveled Sine Wave Generate ¹ 50 Ω Load Reference Frequency 5.0 mV _(pk-pk) to 5.0 V _(pk-pk)	50 kHz to 10 MHz	1.2 %	Fluke 9500B/ 9530
Bandwidth/Flatness Measure ¹ (wrt Reference Frequency)			
Into VSWR (1.2:1) 5.0 mV _(pk-pk) to 5.0 V _(pk-pk)	0.10 Hz to 300 MHz 300 MHz to 550 MHz	1.6 % 1.9 %	9500B/3200, 9530
5.0 mV _(pk-pk) to 3.0 V _(pk-pk)	550 MHz to 1.1 GHz 1.1 GHz to 2.5 GHz	2.7 % 3.1 %	
5.0 mV _(pk-pk) to 2.0 V _(pk-pk)	2.5 GHz to 3.2 GHz	3.1 %	
Into VSWR (1.2:1) 5.0 mV _(pk-pk) to 5.0 V _(pk-pk)	0.10 Hz to 300 MHz 300 MHz to 550 MHz	1.6 % 1.9 %	9500B/1100, 9560
5.0 mV _(pk-pk) to 3.0 V _(pk-pk)	550 MHz to 1.1 GHz 1.1 GHz to 2.5 GHz	2.3 % 2.3 %	
5.0 mV _(pk-pk) to 2.0 V _(pk-pk)	2.5 GHz to 3.0 GHz	2.3 %	
25 mV _(pk-pk) to 2.0 V _(pk-pk)	3.0 GHz to 6.0 GHz	3.1 %	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Oscilloscopes ¹	10 Ω to 40 Ω 40 Ω to 90 Ω 90 Ω to 150 Ω 50 k Ω to 800 k Ω 800 k Ω to 1.2 M Ω 1.2 M Ω to 12 M Ω	0.39 % 0.083 % 0.39 % 0.39 % 0.083 % 0.39 %	Fluke 9500B
Input Impedance Measure ¹			
Input Capacitance Measure ¹	1.0 pF to 35 pF 35 pF to 95 pF	1.6 % + 0.19 pF 2.3 % + 0.19 pF	Fluke 9500B
Electrical Simulation of Thermocouples – Measure and Measuring Equipment ¹			
Type J	-210 °C to -180 °C -180 °C to -120 °C -120 °C to -50 °C -50 °C to 1200 °C	0.13 °C 0.11 °C 0.09 °C 0.08 °C	Ectron 1140A
Type K	-270 °C to -255 °C -255 °C to -195 °C -195 °C to -115 °C -115 °C to -55 °C -55 °C to 1 000 °C 1 000 °C to 1 372 °C -270 °C to -250 °C -250 °C to -240 °C	2.3 °C 0.73 °C 0.14 °C 0.1 °C 0.08 °C 0.09 °C 1.8 °C 0.52 °C	
Type T	-240 °C to -210 °C -210 °C to -150 °C -150 °C to -40 °C -40 °C to 100 °C 100 °C to 400 °C	0.32 °C 0.19 °C 0.13 °C 0.09 °C 0.08 °C	
Type E	-270 °C to -245 °C -245 °C to -195 °C -195 °C to -155 °C -155 °C to -90 °C -90 °C to 0 °C 0 °C to 15 °C 15 °C to 890 °C 890 °C to 1 000 °C	2.1 °C 0.22 °C 0.11 °C 0.099 °C 0.08 °C 0.08 °C 0.07 °C 0.08 °C	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Type R	-50 °C to -30 °C -30 °C to 45 °C 45 °C to 160 °C 160 °C to 380 °C 380 °C to 775 °C 775 °C to 1 768.1 °C	0.68 °C 0.58 °C 0.42 °C 0.31 °C 0.28 °C 0.23 °C	Ectron 1140A
Type S	-50 °C to -30 °C -30 °C to 45 °C 45 °C to 105 °C 105 °C to 310 °C 310 °C to 615 °C 615 °C to 1 768.1 °C	0.65 °C 0.59 °C 0.42 °C 0.35 °C 0.31 °C 0.27 °C	
Type N	-270 °C to -260 °C -260 °C to -200 °C -200 °C to -140 °C -140 °C to -70 °C -70 °C to 25 °C 25 °C to 160 °C 160 °C to 1 300 °C	0.42 °C 0.24 °C 0.25 °C 0.21 °C 0.13 °C 0.11 °C 0.11 °C	
Type B	250 °C to 350 °C 350 °C to 450 °C 450 °C to 580 °C 580 °C to 750 °C 750 °C to 1 000 °C 1 000 °C to 1 820 °C	1 °C 0.77 °C 0.61 °C 0.47 °C 0.39 °C 0.31 °C	
Type C	0 °C to 250 °C 250 °C to 1 000 °C 1 000 °C to 1 500 °C 1 500 °C to 1 800 °C 1 800 °C to 2 000 °C 2 000 °C to 2 250 °C 2 250 °C to 2 315 °C	0.21 °C 0.17 °C 0.19 °C 0.22 °C 0.24 °C 0.30 °C 0.33 °C	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Power Measuring Equipment ¹ DC Power 0.33 mA to 330 mA 0.33 A to 3 A 3 A to 20.5 A	11 µW to 1.1 mW 1.1 mW to 110 mW 0.11W to 110 W 110 W to 330 W 11 W to 110 mW 0.11 W to 990 W 1 W to 3 kW 0.099 W to 0.99 W 0.99 W to 6.8 kW 6.8 W to 20.5 kW	0.024 % 0.027 % 0.024 % 0.018 % 0.044 % 0.053 % 0.009 6 % 0.088 % 0.07 % 0.04 %	Fluke 5520A
AC Power ^{1,4} (PF=1) (10 to 65) Hz (3.3 to 9.0) mA (9.0 to 33) mA (33 to 90) mA (90 to 330) mA (0.33 to 0.9) A (0.9 to 2.2) A (2.2 to 4.5) A (4.5 to 20.5) A	0.11 mW to 3.0 mW 3.0 mW to 9.0 W 0.3 mW to 10 mW 10 mW to 33W 1 mW to 30 mW 30 mW to 90 W 3 mW to 100 mW 100 mW to 300 W 11 mW to 300 mW 300 mW to 900 W 30 mW to 720 mW 720 mW to 2 kW 80 mW to 1.4 W 1.4 W to 4.5 kW 150 mW to 6.7 W 6.7 W to 20 kW	0.13% 0.077% 0.089 % 0.077% 0.071 % 0.057 % 0.089 % 0.078 % 0.071 % 0.081 % 0.089 % 0.079 % 0.088 % 0.18 % 0.17 % 0.17 %	
(16 to 850) Hz (0.5 to 20) A	23 W to 13 kW	0.024 %	Fluke 6105A

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Phase – Measure Equipment ¹	0° to 180° 10 Hz to 65 Hz 65 Hz to 500 Hz 500 Hz to 1 kHz 1 kHz to 5 kHz 5 kHz to 10 kHz 10 kHz to 20 kHz	0.11° 0.20° 0.40° 1.9° 3.9° 7.8°	Fluke 5520A
Phase – Measure Equipment 5 V	0° to 360° 1 Hz ≤ f ≤ 5 kHz 5 kHz < f ≤ 50 kHz 50 kHz < f ≤ 200 kHz	0.006 6° 0.013° 0.052°	Clark-Hess 5002 Bridge Set (equal amplitude)
50 mV ≤ V ≤ 100 V 100 V < V < 120 V	0° to 360° 1 Hz ≤ f ≤ 1 kHz 1 kHz ≤ f ≤ 5 kHz 5 kHz < f ≤ 50 kHz 50 kHz < f ≤ 200 kHz 0° to 360° 1 Hz ≤ f ≤ 1 kHz 1 kHz ≤ f ≤ 5 kHz 5 kHz < f ≤ 50 kHz 50 kHz < f ≤ 200 kHz	0.006 6° 0.013° 0.019° 0.05° 0.012° 0.024° 0.036° 0.094°	Clark-Hess 5500-2 Phase Standard (Ratio Independent) (Ratio Independent)
Phase – Measure	0° to 360° 1 Hz ≤ f ≤ 10 kHz 10 kHz ≤ f ≤ 50 kHz 50 kHz < f ≤ 100 kHz 100 kHz < f ≤ 200 kHz	0.002 3° 0.002 7° 0.01° 0.012°	Phase Verification Bridge Set (1:1)

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Dips and Interrupts Measure	0% to 100% Ratio, 0° to 360°	1.3 %	Agilent Infinity Oscilloscope
Electrical Fast Transients Measure	0.25 kV to 4 kV	2.6 %	Agilent Infinity Oscilloscope and Haefely HV Attenuators
Electrostatic Discharge Measure	0.1 to 15 kV	2.5 %	Tektronix TDS7404 Oscilloscope, KeyTech CTC-3 Target, Barth HV Attenuators
Harmonic Flicker Measure 100 V to 230V	50 Hz to 400 Hz	3.6 %	Tektronix TDS1012B Oscilloscope, Keysight DMM, CNS HFC-II Load, Ohms Lab CS100 Shunt
Surge Measure (Open)	0.25 to 4 kV	1.3 %	Agilent Infinity Oscilloscope, Tektronix 6015A HV Probe
Surge Measure (Short)	0.25 to 4 kV	1.4 %	Agilent Infinity Oscilloscope, Tegam RF Current Probe
Impulse – Source 60 dBuV Nominal	(Band A) 10 kHz to 150 kHz (Band B) 150 kHz to 30 MHz (Band C & D) 30 MHz to 1 GHz	13 % 13 % 20 %	Schwarzbeck IGLK 2914
Modulation Measure AM FM PM	50 Hz to 50 kHz 50 Hz to 100 kHz 150 kHz to 1300 MHz	1.3 % 1.6 % 4.3 %	Keysight 8902A Receiver
RF Power Measure (Noise Figure) +0 dB to -40 dB	10 MHz to 26.5 GHz	0.40 dB	Keysight PSA (E4440A) w/ Opt 219 Personality Module and 346C Noise Source

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
RF Power – Transfer Measure +10 dBm to -20 dbm	9 kHz to 18 GHz 10 MHz to 26.5 GHz 26.5 GHz to 50 GHz	1.3 % 2.6 % 4.8 %	Tegam 2510A Power Standard, Tegam 1803A Power Meter
RF Power ¹ 9 kHz to 18 GHz	+20 dBm to -60 dBm	2.6 %	Agilent E9304A H18 Power Sensor, E4419B Power Meter
26.5 GHz to 40 GHz	+20 dBm to -70 dBm	3.8 %	Agilent 8487A Power Sensor, E4419B Power Meter
40 GHz to 50 GHz	+20 dBm to -70 dBm	5.1 %	
30 MHz to 26.5 GHz	+30 dBm to +10 dBm +10 dBm to -30 dBm	5.7 % 3.3 %	Agilent E4440, E4419B Power Meter, N5532A Power Sensor
RF Power Tuned RF 30 MHz to 26.5 GHz	0 dBm to -58 dBm -58 dBm to -78 dBm -78 dBm to -114 dBm	3.5 % 4.0 % 4.8 %	Agilent E4440, E4419B Power Meter, N5532A Power Sensor
Relative RF Power Tuned RF 30 MHz to 26.5 GHz	0 dBm to -58 dBm -58 dBm to -78 dBm -78 dBm to -114 dBm	1.1 % 2.3 % 3.4 %	Agilent E4440, E4419B Power Meter, N5532A Power Sensor
Sine Flatness (RF)	9 kHz to 6 GHz	0.073 dB	Agilent E4418B w/ E9304A
Attenuation - Source	0 dB to 50 dB 30 MHz	1.6 %	Agilent 11812A Verification Kit
SSB Phase Noise Measure RMS (Noise/Jitter) +20 dBm to -50 dBm	1 MHz to 3 GHz 3 GHz to 6.6 GHz 6.6 GHz to 13.2 GHz 13.2 GHz to 22 GHz 22 GHz to 26.5 GHz	0.62 dBm 0.92 dBm 1.3 dBm 1.2 dBm 1.6 dBm	Keysight PSA (E4440A) w/ Opt 226 Personality Module

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement $(+/-)^2$	Reference Standard, Method and/or Equipment
Spectral Analysis Measure (Amplitude) (w/o pre-amp) +30 dBm to -127 dBm	3 Hz to 3 GHz (3.0 to 6.6) GHz (6.6 to 13.2) GHz (13.2 to 22) GHz (22 to 26.5) GHz (26.5 to 40) GHz (33 to 50) GHz	0.90 dBm 1.1 dBm 1.4 dBm 1.4 dBm 1.7 dBm 3.6 dBm 3.6 dBm	Keysight: PSA (E4440A) w/11970A Mixer w/11970Q Mixer
Attenuation Measure or Tuned RF Relative Power 2.5 MHz to 26.5 GHz	0 dB to -10 dB -10 dB to -20 dB -20 dB to -30 dB -30 dB to -40 dB -40 dB to -50 dB -50 dB to -60 dB -60 dB to -70 dB -70 dB to -80 dB -80 dB to -90 dB -90 dB to -100 dB -100 dB to -110 dB -110 dB to -120 dB	0.026 dB 0.038 dB 0.048 dB 0.056 dB 0.060 dB 0.069 dB 0.077 dB 0.082 dB 0.090 dB 0.099 dB 0.10 dB 0.12 dB	Agilent 8902 w/11793A Sensor
RF Impedance Measure 5 Hz to 3 GHz	1 Ω to 2 k Ω	3.0 %	Keysight E5061B VNA
RF Current Measure (Insertion Loss) +10 dB to -90dB	10 kHz to 400 MHz	2.9 dB	Keysight E5061B VNA, FCC BCICF-1 Cal Fixture
RF Current Measure (Transfer Z) +10 dB to -90 dB	10 kHz to 400 MHz	2.2 dB	Keysight E5061B VNA, FCC BCICF-1 Cal Fixture
Transmission Longitudinal Conversion Loss +10 dB to -90 dB	10 kHz to 100 MHz	5.6 %	Schaffner BCS-1000 Bridge, Agilent E5061B VNA

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
S-Parameter S11-S22 Measure (BNC) (0 to 1) Lin Mag, +10 dB to -90 dB	10 Hz to 100 kHz 100 kHz to 10 MHz	0.030 Lin Mag 0.030 Lin Mag	E5061B w/8550CK Calibration Kit
S-Parameter S11-S22 Measure (7 mm) (0 to 1) Lin Mag +10 dB to -90 dB	300 kHz to 1.3 GHz 1.3 GHz to 3 GHz 3 GHz to 6 GHz	0.0060 Lin Mag 0.0070 Lin Mag 0.013 Lin Mag	8753ES w/85050C Calibration Kit
S-Parameter S11-S22 Measure (N-Type) (0 to 1) Lin Mag +10 dB to -90 dB	10 MHz to 500 MHz 500 MHz to 2 GHz	0.025 Lin Mag 0.017 Lin Mag	N5230A w/N4690C Ecal Calibration Kit
S-Parameter S11-S22 Measure (3.5 mm) (0 to 1) Lin Mag +10 dB to -90 dB	10 MHz to 500 MHz 500 MHz to 2 GHz 2 GHz to 26.5 GHz	0.026 Lin Mag 0.025 Lin Mag 0.076 Lin Mag	N5230A w/ N4692A Ecal Calibration Kit
S-Parameter S11-S22 Measure (2.9 mm) (0 to 1) Lin Mag +10 dB to -90 dB	10 MHz to 500 MHz 500 MHz to 2 GHz 2 GHz to 26.5 GHz	0.026 Lin Mag 0.025 Lin Mag 0.076 Lin Mag	N5230A w/ N4692A Ecal Calibration Kit
S-Parameter S11-S22 Measure (2.4 mm) (0 to 1) Lin Mag +10 dB to -90 dB	50 MHz to 50 GHz	0.22 Lin Mag	N5225A /85056D Calibration Kit
S-Parameter S21-S12 Measure (BNC) +10 dB to -50 dB	10 Hz to 100 kHz 100 kHz to 10 MHz 10 MHz to 500 MHz	0.57 dB 0.37 dB 0.36 dB	E5061B w/8550CK Calibration Kit

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement $(+/-)^2$	Reference Standard, Method and/or Equipment
S-Parameter S21-S12 Measure (7 mm) +10 dB to -50 dB	300 kHz to 1.3 GHz 1.3 GHz to 3 GHz	0.24 dB 0.25 dB	8753ES w/85050C Calibration Kit
S-Parameter S21-S12 Measure (N-Type) +10 dB to -30 dB -30 dB to -50 dB +10 dB to -50 dB	10 MHz to 500 MHz 10 MHz to 500 MHz 500 MHz to 2 GHz 2 GHz to 18 GHz	0.43 dB 2.6 dB 0.17 dB 0.39 dB	N5230A w/N4690C Ecal Calibration Kit
S-Parameter S21-S12 Measure (3.5 mm) +10 dB to -30 dB -30 dB to -50 dB +10 dB to -50 dB	10 MHz to 500 MHz 10 MHz to 500 MHz 500 MHz to 2 GHz 2 GHz to 26.5 GHz	0.50 dB 2.6 dB 0.28 dB 0.79 dB	N5230A w/ N4692A Ecal Calibration Kit
S-Parameter S21-S12 Measure (2.9 mm) +10 dB to -30 dB -30 dB to -50 dB +10 dB to -50 dB	10 MHz to 500 MHz 10 MHz to 500 MHz 500 MHz to 2 GHz 2 GHz to 26.5 GHz 26.5 GHz to 40GHz	0.49 dB 2.7 dB 0.28 dB 0.79 dB 0.82 dB	N5230A w/ N4692A Ecal Calibration Kit
S-Parameter S21-S12 Measure (2.4 mm) +10 dB to -30 dB -30 dB to -50 dB +10 dB to -50 dB	50 MHz to 500 MHz 50 MHz to 500 MHz 500 MHz to 2 GHz 2 GHz to 26.5 GHz 26.5 GHz to 50 GHz	0.24 dB 0.93 dB 0.14 dB 0.56 dB 0.86 dB	N5225A w/85056D Calibration Kit

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ⁶	Reference Standard, Method and/or Equipment
Angles	0° to 60°	8.3 arc seconds	Sine Bar
	90°	2.8 arc seconds	Master Square
Micrometers & Calipers - Outside, Inside, Depth ¹	0.01 in to 0.5 in	13 µin	Comparison to Gage Blocks
	0.5 in to 1 in	14 µin	
	1 in to 4 in	(3.5 + 10L) µin	
	4 in to 15 in	(4.3 + 11L) µin	
	15 in to 40 in	(4.4 + 11L) µin	
Anvil Flatness ¹	0 in to 1 in Diameter	6.1 µin	Optical Flats
Dial Indicators ¹	0 in to 6 in	(1.5 + 21L) µin	Comparison to Gage Blocks
Length Single Axis Outside Dimension	(0 to 1.0) in (1.0 to 7.0) in (7.0 to 21) in	(6.0 + 1 L) µin (4.3 + 3.5 L) µin (1 + 4 L) µin	ULM
Length Single Axis Inside Dimension	(0.040 to 0.125) in (0.125 to 0.250) in (0.0250 to 1.00) in (1.0 to 2.5) in (2.5 to 10) in (10 to 14) in	11 µin 11 µin 11 µin 17 µin (18 + 3 L) µin (38 + 3 L) µin	ULM
Height Gages	0 in to 24 in	(60 + 0.7L) µin	Comparison to Gage Blocks
Thread Wires	2 TPI to 120 TPI (0.008 to 0.5) in	12 µin	ULM

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ⁶	Reference Standard, Method and/or Equipment
Plug Gage Outside Diameter	(0 to 1) in (1 to 7) in	12 μin (9 + 3 L) μin	ULM
Ring Gage Inside Diameter	(0.04 to 0.125) in (0.125 to 0.25) in (0.025 to 1) in (1 to 2.5) in (2.5 to 10) in (10 to 14) in	11 μin 11 μin 11 μin 17 μin (18 + 3 L) μin (38 + 3.0 L) μin	ULM w/Working Reference Rings
Thread Plug Gages Pitch Diameter 60° Thread	(0 to 1) in (1 to 4) in (4 in to 7) in	79 μin 80 μin 83 μin	ULM w/Thread Wires
Major Diameter	(0 to 1.0) in (1.0 to 7.0) in	13 μin (10 + 3.0 L) μin	ULM
Tapered Thread Plug Gage Pitch Diameter	(0 to 3) in	90 μin	ULM
Standoff	(0 to 1) in	31 μin	Gage Blocks and Amplifier
Thread Ring Gages Inner Pitch Diameter	(0 to 1.0) in (1.0 to 4.0) in (4.0 in to 7.0) in	79 μin 80 μin 83 μin	Master Plug Uncertainty

Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Mass – Metric ¹	1 mg 2 mg 5 mg 10 mg 20 mg 50 mg 100 mg 200 mg 500 mg	0.064 mg 0.064 mg 0.097 mg 0.084 mg 0.073 mg 0.064 mg 0.065 mg 0.076 mg 0.078 mg	Echelon III
Mass – Metric ¹	1 g 2 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 4 kg 5 kg 6 kg 7 kg 8 kg 16 kg 32 kg	0.083 mg 0.16 mg 0.13 mg 0.14 mg 0.16 mg 0.11 mg 0.35 mg 0.39 mg 1 mg 1.6 mg 10 mg 12 mg 13 mg 15 mg 16 mg 18 mg 98 mg 210 mg	Echelon III
Torque –Hydraulic ¹ (1 000 to 10 000) psi	(270 to 2 700) N·m (200 to 2 000) lbf·ft (2 700 to 4 000) N·m (2 000 to 20 000) lbf·ft	1.3 % 1.3 %	Torque Calibration System
Torque – Multipliers ¹	(270 to 2 700) N·m (200 to 2 000) lbf·ft (2 700 to 4 000) N·m (2 000 to 20 000) lbf·ft	1.5 % 1.5 %	Torque Calibration System
Torque - Measure ¹	2 lbf·in to 811 lbf·ft	1.2 %	Torque Calibrator

Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Balance and Scale ¹	(0 to 1) g	0.076 mg	ASTM Class 1 and Class 2 Mass Standards
	(1 to 50) g	0.15 mg	
	(50 to 100) g	0.35 mg	
	(100 to 200) g	0.56 mg	
	(200 to 500) g	1.0 mg	
	(500 to 1) kg	1.6 mg	
	(1 to 2) kg	10 mg	
	(2 to 4) kg	12 mg	
	(4 to 5) kg	13 mg	
	(5 to 6) kg	15 mg	
	(6 to 7) kg	16 mg	
	(7 to 8) kg	18 mg	
	(8 to 16) kg	98 mg	
	(16 to 32) kg	0.21 g	
	(32 to 64) kg	0.45 g	
	(64 to 114) kg	0.60 g	
Absolute Pressure Source – Pneumatic	0.2 psi to 1.45 psi	0.001 3 % + 0.29 mpsi	Ruska 2465
	1.45 psi to 50 psi	0.001 5 % + 14 µpsi	DHI FPG 7601
	50 psi to 1 000 psi	0.001 9 %	
Gage Pressure Source – Pneumatic	-14.7 psi to -0.2 psi	0.001 3 % + 8 µpsi	Ruska 2465
	-60 inH ₂ O to +60 inH ₂ O	0.002 8 % + 22 µinH ₂ O	DHI FPG 8601
	0.2 psi to 100 psi	0.001 3 % + 8 µpsi	Ruska 2465
	100 psi to 1 000 psi	0.001 9 %	
Gage Pressure Source – Hydraulic	72.5 psi to 7 250 psi	0.002 % + 2.9 mpsi	DHI PG7000
	200 psi to 20 000 psi	0.003 5 % + 7.3 mpsi	
	20 000 psi to 72 500 psi	0.005 5 % + 15 mpsi	
Determination of Piston Area	0.2 psi to 100 psi	0.001 1 %	Ruska 2465
	100 psi to 1 000 psi	0.001 7 %	
	72.5 psi to 7 250 psi	0.001 7 %	DHI PG7000 (Gas to 6 kpsi)
	200 psi to 20 000 psi	0.002 6 %	
	725 psi to 72 500 psi	0.005 1 %	

Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Pressure Source Pneumatic ¹	-14.7 psi to -0.2 psi	0.001 3% + 8 µpsi	Ruska 2465 gauge mode
	0.2 psi to 100 psi	0.001 3% + 8 µpsi	
	0.2 psi to 100 psi	0.001 1% + 0.29 mpsi	Ruska 2465 absolute mode
	100 psi to 1 000 psi	0.001 9 %	Ruska 2465 gauge or absolute
Hydraulic ¹	50 psi to 15 000 psi	0.011 % + 0.17 psi	Ametek T-150
Absolute Pressure Source - Pneumatic	(0.000 27 to 0.0051) Pa	22 %	Ion Gauge
	(0.000 7 to 0.027) Pa	8.0 %	Ion Gauge
	(0.028 to 2 500) Pa	0.05 % + 0.07 Pa	CDG
Gas Flow	(1 to 10) sccm	0.22 % + 0.0042 sccm	Fluke Molbox with bloc's
	(20 to 200) sccm	0.25 % + 0.0017 sccm	
	(0.2 to 2) slm	0.25 % + 0.00002 slm	
	(2 to 20) slm	0.25 % + 0.00036 slm	
	(20 to 50) slm	0.34 %	
	(50 to 100) slm	0.34 %	

Thermodynamic

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Humidity – Measure ¹ (15 °C to 25 °C)	(10 to 90) %RH	1.3 % RH	Thermo-hygrometer
	(90 to 95) %RH	2.0 % RH	
	(25 °C to 40 °C)	(10 to 50) %RH	Thermo-hygrometer
	(50 to 75) %RH	1.7 % RH	
	(75 to 95) %RH	2.0 % RH	
		2.3 % RH	
Temperature - Measuring Equipment	-20 °C to 100 °C	0.011 °C	SPRT, Super Thermometer Liquid Baths
	100 °C to 150 °C	0.013 °C	
	150 °C to 230 °C	0.016 °C	
	230 °C to 300 °C	0.018 °C	Metrology Wells
	300 °C to 420 °C	0.074 °C	
	420 °C to 660 °C	0.12 °C	

Thermodynamic

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Temperature - Measure ¹	-195 °C to 0 °C 0 °C to 420 °C 420 °C to 660 °C 660 °C to 750 °C 750 °C to 1 000 °C	0.012 °C 0.025 °C 0.036 °C 1.3 °C 1.8 °C	SPRT w/Black Stack Type K Probe and Readout
Infrared Temperature – Measuring Equipment ¹ $\epsilon = (0.1 \text{ to } 1.0)$ $\lambda = (8 \text{ to } 14) \mu\text{m}$	(-15 to 0) °C (0 to 50) °C (50 to 100) °C (100 to 120) °C (120 to 200) °C (200 to 350) °C (350 to 500) °C	0.80 °C 0.65 °C 0.70 °C 0.76 °C 0.95 °C 1.6 °C 2.1 °C	Black Body Source (Flat Plate)
Isothermal Block Verification ¹	Ambient (~ 23 °C)	0.02 °C	Thermocouple Half Junction

Time and Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Frequency – Source and Measure ⁵	10 MHz	3.7×10^{-12} Hz/Hz	Fluke 910R
Harmonic Distortion - Measure	10 Hz to 100 kHz	0.7 dB	Agilent U8903A Audio Analyzer
Frequency Comparison- Measure	+30 dBm to -20 dBm 10 MHz Reference	8.2×10^{-10} Hz	Fluke PM6681R Rubidium Counter
Frequency Drift - Measure	+30 dBm to -20 dBm 10 MHz Reference	8.2×10^{-10} Hz	Fluke PM6681R Rubidium Counter
Frequency Measure (w/o pre-amp) +30 dBm to -127 dBm	3 Hz to 10 MHz 10 MHz to 1 GHz 1 GHz to 10 GHz 10 GHz to 26.5 GHz	2.0×10^{-2} Hz 1.2×10^{-1} Hz 1.2 Hz 3.1 Hz	Keysight PSA E4440A

Time and Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) ²	Reference Standard, Method and/or Equipment
Measure (w/pre-amp)	26.5 GHz to 50 GHz	3.3 Hz	
Time Interval / Duty Cycle – Measure	10 s Interval	8.5×10^{-10} Hz	Fluke PM6681R Rubidium Counter
Risetime – Measure	≤ 500 ps	2.5 ps	Agilent 83484A, 86100C Oscilloscope Mainframe
Total Harmonic Distortion: CW, Modulation	5 Hz to 500 kHz 500 kHz to 1 MHz	1.4 dB 2.3 dB	Krohn-Hite 6900B
Harmonic Distortion	100 kHz to 2.9 GHz 2.9 GHz to 6.5 GHz 6.5 GHz to 13.2 GHz 13.2 GHz to 22 GHz 22 GHz to 26.5 GHz	1.7 dB 1.9 dB 2.6 dB 2.9 dB 3.7 dB	Spectrum Analyzer
Rise time (Generate)	≥ 14 ps	2.4 ps	Pulser
Rise time (Measure)	28 ps to 300 ps 300 ps to 5 ns 5 ns to 100 ns 100 ns	14 % 4.7 % 1.4 % 0.73 %	Sampling System

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. As frequency & amplitude deviate from the listed values, uncertainty may be higher than stated. If needed, contact laboratory for more information regarding uncertainties at frequency and range combinations other than the ones shown.
4. 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.
5. Uncertainty values of derivatives of 10 MHz will differ due to resolution, noise and gating errors.
6. L = Length in inches.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.02
8. The stated uncertainty is the laboratory's ability to source a fast rise pulse that is approximately 500 ps, 150 ps, 70 ps, 25 ps or 16 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 UUT. The known source rise time is mathematically removed from the total observed UUT rise time.



R. Douglas Leonard Jr., VP, PILR SBU