CERTIFICATE OF ACCREDITATION

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Hereby attests that

Transcat - Houston
16115 Park Row
Houston, TX 77084

Fulfills the requirements of

ISO/IEC 17025:2017

and national standards

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

In the field of

CALIBRATION

This certificate is valid only when accompanied by a current scope of accreditation document.
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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, ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3 (R2013)

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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		
	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 5720A w/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 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 µA to 330 µA 10 kHz to 30 kHz	1.2 % + 0.31 µA	Fluke 5520A
	0.33 mA to 3.3 mA 10 kHz to 30 kHz	0.78 % + 0.47 µA	
	3.3 mA to 33 mA 10 kHz to 30 kHz	0.31 % + 3.1 µA	
	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 20 Hz to 45 Hz 45 Hz to 5 kHz	 0.46 % + 35 nA 0.18 % + 35 nA 0.072 % + 35 nA	Agilent 3458A opt 2
	0.1 mA to 1 mA 10 Hz to 20 Hz 20 Hz to 45 Hz 45 Hz to 100 Hz 100 Hz to 5 kHz	 0.46 % + 0.23 µA 0.17 % + 0.23 µA 0.071 % + 0.23 µA 0.038 % + 0.23 µA	
	1 mA to 10 mA 10 Hz to 20 Hz 20 Hz to 45 Hz 45 Hz to 100 Hz 100 Hz to 5 kHz	 0.48 % + 2.3 µA 0.17 % + 2.3 µA 0.071 % + 2.3 µA 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 μΩ	0.63 nΩ	Standard Resistors with Current Source and DMM
	100 μΩ to 1 mΩ	6.1 μΩ/Ω	
	1 mΩ to 10 mΩ	7.2 μΩ/Ω	
	10 mΩ to 100 mΩ	2.5 μΩ/Ω	
	0.1 Ω to 1 Ω	4.4 μΩ/Ω	
	1 Ω to 10 Ω	0.41 μΩ/Ω	Standard Resistors with MI 6242B Bridge
	10 Ω to 100 Ω	0.67 μΩ/Ω	
	100 Ω to 1 kΩ	0.82 μΩ/Ω	
	1 kΩ to 10 kΩ	2.4 μΩ/Ω	
	10 kΩ to 100 kΩ	0.29 μΩ/Ω	
	100 kΩ to 1 MΩ	1.4 μΩ/Ω	
	1 MΩ to 10 MΩ	16 μΩ/Ω	
	10 MΩ to 100 MΩ	19 μΩ/Ω	
DC Resistance – Measure	100 MΩ to 1 GΩ	32 μΩ/Ω	Standard Resistors with 8508 (Double Substitution)
	1 GΩ to 20 GΩ	140 μΩ/Ω	
DC Resistance – Measuring Equipment	10 MΩ	19 μΩ/Ω	Standard Resistor
	100 MΩ	30 μΩ/Ω	
	1 GΩ	53 μΩ/Ω	
Resistance Ratio	1 Ω to 1 kΩ	0.16 μΩ/Ω	MI 6242B Bridge
DC Resistance – Measuring Equipment and Measure [1]	0 mΩ to 10 Ω	18 μΩ/Ω + 58 μΩ	HP3458A with Decade Resistor
	10 Ω to 100 Ω	15 μΩ/Ω + 580 μΩ	
	100 Ω to 1 kΩ	12 μΩ/Ω + 580 μΩ	
	1 kΩ to 10 kΩ	12 μΩ/Ω + 5.8 mΩ	

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 kΩ to 100 kΩ	12 μΩ/Ω + 58 mΩ	HP3458A with Decade Resistor
	100 kΩ to 1 MΩ	20 μΩ/Ω + 2.3 Ω	
	1 MΩ to 10 MΩ	62 μΩ/Ω + 120 Ω	
	10 MΩ to 100 MΩ	590 μΩ/Ω + 1.2 kΩ	
	100 MΩ to 1 GΩ	0.82 % + 12 kΩ	
DC Resistance – Measuring Equipment and Measure [1]	1 GΩ to 10 GΩ	0.073 % + 10 kΩ	Keithley 6430 Source / Meter with Voltage Source
	10 GΩ to 100 GΩ	0.074 % + 0.10 MΩ	
	100 GΩ to 1 TΩ	0.075 % + 1.0 MΩ	
	1 TΩ to 10 TΩ	0.19 % + 10 MΩ	
	10 TΩ to 100 TΩ	0.59 % + 0.10 GΩ	
DC Resistance – Measuring Equipment and Measure [1]	10 MΩ to 100 MΩ	0.08 %	IET HRRS-B-7-100k-5kV
	100 MΩ to 1 GΩ	0.25 %	
	1 GΩ to 10 GΩ	0.41 %	
	10 GΩ to 100 GΩ	0.84 %	
	100 GΩ to 1 TΩ	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 μA	0.054 % + 0.000 3 μA	
	1 μA to 10 μA	0.050 % + 0.002 μA	

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) ≤ I < 100nA	1.5 pA	Standard Shunts with Current Source
	100 nA ≤ I < 1µA	21 µA/A	
	1 µA ≤ I < 10 µA	7.2 µA/A	
	10 µA ≤ I < 100 µA	6.5 µA/A	
	100 µA ≤ I < 1 mA	2.8 µA/A	
	1 mA ≤ I < 10 mA	5.1 µA/A	
	10 mA ≤ I < 100 mA	2.0 µA/A	
	100 mA ≤ I < 1 A	2.4 µA/A	
	1 A ≤ I < 10 A	4.8 µA/A	
	10 A ≤ I < 20 A	4.0 µA/A	
	20 A ≤ I ≤ 30 A	10 µA/A	
	30 A < I ≤ 100 A	36 µA/A	
DC Current – Measuring Equipment and Measure [1]	0 µA to 100 µA	26 µA/A + 0.92 nA	HP3458A 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	130 µA/A + 12 µA	
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) 100 mV 1 V 10 V 19 V 100 V 1 000 V	59 nV 0.80 µV/V 0.29 µV/V 0.2 µV/V 0.46 µV/V 0.28 µV/V 0.54 µV/V	Ratio Metric with Zener
	1 mV ≤ V < 10mV 10 mV	100 µV/V 13 µV/V	Fluke 8508
DC Voltage – Fixed Points Measuring Equipment and Measure	10 mV < V < 100 mV 100 mV < V ≤ 1 kV	8.6 µV/V 7.4 µV/V + 0.059 µV	Fluke 8508 Ratio Metric with Zener
DC Voltage – Measuring Equipment and Measure [1]	0 V to 100 mV 100 mV to 10 V 10 V to 100 V 100 V to 500 V 500 V to 800 V 800 V to 1 100 V	8.3 µV/V + 0.58 µV 5.3 µV/V + 0.58 µV 7.6 µV/V + 35 µV 14 µV/V + 120 µV 18 µV/V + 120 µV 21 µV/V + 120 µV	HP3458A opt 2 with 5720A
DC Voltage- Measure [1]	1 kV to 10 kV	0.049 % + 0.62 V	Vitrek 4700
	10 kV to 20 kV 20 kV to 35 kV	0.08 % + 0.35 V 0.14 % + 1 V	4700A w/HVP-35
	15 kV to 30 kV 30 kV to 45 kV 45 kV to 70 kV	0.065 % + 1 V 0.09 % + 3 V 0.17 % + 1 V	4700A w/HVL-70

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 µV	
	40 Hz to 1 kHz	0.03 % + 1.2 µV	
	1 kHz to 20 kHz	0.04 % + 1.2 µV	
	20 kHz to 50 kHz	0.15 % + 1.2 µV	
	50 kHz to 100 kHz	0.59 % + 1.2 µV	
	100 kHz to 300 kHz	4.6 % + 2.3 µV	
	300 kHz to 1 MHz	1.5 % + 5.8 µV	
	1 MHz to 4 MHz	8.1% + 8.1 µV	
	10 mV to 100 mV		
	1 Hz to 40 Hz	0.013 % + 4.6 µV	
	40 Hz to 1 kHz	0.009 7 % + 2.3 µV	
	1 kHz to 20 kHz	0.017 % + 2.3 µV	
	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	
	1 MHz to 2 MHz	1.8 % + 12 µV	
	2 MHz to 4 MHz	4.7 % + 81 µV	
	4 MHz to 8 MHz	4.7 % + 92 µV	
	8 MHz to 10 MHz	17 % + 120 µV	
	100 mV to 1 V		
	1 Hz to 40 Hz	0.008 8 % + 46 µV	
	40 Hz to 1 kHz	0.0083 % + 23 µV	

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 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 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		
	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		Vitrek 4700A
	60 Hz	0.17 % + 0.16 V	
	10 kV to 20 kV		4700A w/HVP-35
	60 Hz	0.17 % + 0.6V	
	20 kV to 35 kV		
	60 Hz	0.23 % + 3.5 V	
	12.5 kV to 25 kV		4700A w/HVL-70
	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 10 Hz to 20 Hz 20 Hz to 40 Hz	 0.16 % + 4 µV 0.1 % + 4 µV	Fluke 5720A
	40 Hz to 20 kHz 20 kHz to 50 kHz 50 kHz to 100 kHz 100 kHz to 300 kHz 300 kHz to 500 kHz 500 kHz to 1 MHz	0.078 % + 4 µV 0.13 % + 4 µV 0.17 % + 5 µV 0.33 % + 10 µV 0.47 % + 20 µV 0.58 % + 20 µV	
	2.2 mV to 22 mV 10 Hz to 20 Hz 20 Hz to 40 Hz 40 Hz to 20 kHz 20 kHz to 50 kHz 50 kHz to 100 kHz 100 kHz to 300 kHz 300 kHz to 500 kHz 500 kHz to 1 MHz	 0.042 % + 4 µV 0.03 % + 4 µV 0.014 % + 4 µV 0.03 % + 4 µV 0.058 % + 5 µV 0.12 % + 10 µV 0.16 % + 20 µV 0.27 % + 20 µV	
	22 mV to 220 mV 10 Hz to 20 Hz 20 Hz to 40 Hz 40 Hz to 20 kHz 20 kHz to 50 kHz	 0.028 % + 12 µV 0.011 % + 7 µV 0.008 5 % + 7 µV 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 100 kHz 1 MHz 2 MHz	 1.6 % 0.36 % 0.27 % 0.66 %	
	10 µH 10 kHz 100 kHz 1 MHz 2 MHz	 0.37 % 0.2 % 0.2 % 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 100 Hz 1 kHz 10 kHz	 0.15 % 0.1 % 0.15 % 0.62 %	
DC Voltage – Measuring Equipment	1 mV 10 mV 100 mV 1 V 10 V 100 V	2.6 % 0.68 % 0.052 % 0.0064 % 0.027 % 0.026 %	Fluke 9500B with Fluke 9530 head
Flatness Relative to 1 kHz 7 V / 3.2 V	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz	0.009 % 0.008% 0.006 % 0.007 % 0.006 % 0.006 % 0.006 % 0.008 % 0.007 % 0.007 % 0.007 % 0.009 % 0.013 % 0.016 % 0.016 % 0.021 % 0.024 % 0.028% 0.031 % 0.034 % 0.034 % 0.034 % 0.042 %	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 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.046 % 0.052 % 0.062 % 0.087 % 0.10 % 0.11 % 0.12 % 0.15 % 0.17 % 0.20 % 0.25 %	
Flatness Relative to 1 kHz 2.2 V / 2 V	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz	0.012 % 0.012 % 0.007 % 0.008 % 0.006 % 0.007 % 0.007 % 0.008 % 0.007% 0.007 % 0.007 % 0.009 % 0.014 % 0.017 % 0.017 % 0.021 % 0.026 % 0.029 % 0.033 % 0.037 % 0.036 % 0.036 % 0.045 % 0.049 % 0.054 % 0.065 % 0.045 % 0.049 %	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 2.2 V / 2 V	28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.054 % 0.065 % 0.089 % 0.10 % 0.12 % 0.12 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
Flatness Relative to 1 kHz 2.2 V / 1 V	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.014 % 0.013 % 0.008 % 0.009 % 0.007 % 0.007 % 0.007 % 0.008 % 0.007 % 0.007 % 0.007 % 0.009 % 0.014 % 0.017 % 0.017 % 0.022 % 0.027 % 0.031 % 0.035 % 0.039 % 0.040 % 0.040 % 0.049 % 0.052 % 0.056 % 0.066 % 0.049 % 0.052 % 0.056 % 0.066 % 0.090 % 0.11 % 0.12 % 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 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.017 % 0.016 % 0.009 % 0.010 % 0.008 % 0.007 % 0.007 % 0.009 % 0.008 % 0.008 % 0.008 % 0.010 % 0.015 % 0.018 % 0.018 % 0.023 % 0.028 % 0.032 % 0.037 % 0.041 % 0.042 % 0.042 % 0.052 % 0.055 % 0.059 % 0.069 % 0.052 % 0.055 % 0.059 % 0.069 % 0.093 % 0.11 % 0.12 % 0.13 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
Flatness Relative to 1 kHz 0.7 V / 0.32 V	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz	0.014 % 0.014 % 0.008 % 0.008 % 0.007 % 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 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz 10 Hz 20 Hz 50 Hz	0.007 % 0.009 % 0.008 % 0.008 % 0.008 % 0.010 % 0.015 % 0.017 % 0.018 % 0.022 % 0.028 % 0.031 % 0.034 % 0.038 % 0.038 % 0.038 % 0.049 % 0.053 % 0.060 % 0.071 % 0.049 % 0.053 % 0.060% 0.071 % 0.094 % 0.11 % 0.12 % 0.13 % 0.018 % 0.017 % 0.010 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
Flatness Relative to 1 kHz 0.22 V / 0.1 V	105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz	0.010 % 0.008 % 0.008 % 0.008 % 0.009 % 0.009 % 0.009 % 0.009 % 0.010 % 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 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.019 % 0.019 % 0.023 % 0.030 % 0.034 % 0.038 % 0.043 % 0.043 % 0.044 % 0.055 % 0.059 % 0.064 % 0.075 % 0.055 % 0.059 % 0.064 % 0.075 % 0.098 % 0.12 % 0.13 % 0.14 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
Flatness Relative to 1 kHz 0.07 V / 32 mV	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz	0.019 % 0.018 % 0.009 % 0.010 % 0.008 % 0.009 % 0.009 % 0.010 % 0.009 % 0.009 % 0.01 % 0.011 % 0.016 % 0.020 % 0.020 % 0.024 % 0.031 % 0.034 % 0.039 % 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 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.044 % 0.045 % 0.057 % 0.063 % 0.070 % 0.080 % 0.057 % 0.063 % 0.070 % 0.080 % 0.10 % 0.12 % 0.13 % 0.14 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
Flatness Relative to 1 kHz 22 mV / 10 mV	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz	0.022 % 0.021 % 0.011 % 0.011 % 0.009 % 0.009 % 0.009 % 0.010 % 0.010 % 0.010 % 0.010 % 0.012 % 0.017 % 0.021 % 0.021 % 0.025 % 0.033 % 0.037 % 0.043 % 0.048 % 0.049 % 0.050 % 0.063 % 0.068 % 0.073 % 0.084 % 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 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.068 % 0.073% 0.084 % 0.11 % 0.12 % 0.14 % 0.15 %	Fluke 5790B, EL1100 3 V Thermal converter, 4 dB attenuator, 10 dB attenuator, (3) 20 dB attenuators, with source (5730A)
Flatness Relative to 1 kHz 7 mV / 3.2 mV	10 Hz 20 Hz 50 Hz 105 Hz 200 Hz 2 kHz 10 kHz 20 kHz 50 kHz 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz 1.2 MHz 2 MHz 3 MHz 4 MHz 6 MHz 8 MHz 9 MHz 10 MHz 12 MHz 15 MHz 17 MHz 20 MHz 23 MHz 26 MHz 28 MHz 30 MHz 35 MHz 40 MHz 45 MHz 50 MHz	0.022 % 0.022 % 0.010 % 0.011 % 0.009 % 0.010 % 0.010 % 0.011 % 0.010 % 0.010 % 0.010 % 0.012 % 0.018 % 0.021 % 0.021 % 0.025 % 0.034 % 0.036 % 0.042 % 0.047 % 0.048 % 0.049 % 0.063 % 0.069 % 0.076 % 0.087 % 0.063 % 0.069 % 0.076 % 0.087 % 0.11 % 0.13 % 0.14 % 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 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 800 kHz 1 MHz	560 µV/V 350 µV/V 450 µV/V 390 µV/V 340 µV/V 320 µV/V 320 µV/V 350 µV/V 440 µV/V 510 µV/V 610 µV/V 750 µV/V 760 µV/V	Fluke 792A
6 mV	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	230 µV/V 230 µV/V 230 µV/V 190 µV/V 180 µV/V 170 µV/V 200 µV/V 220 µV/V 300 µV/V 410 µV/V 490 µV/V 580 µV/V 630 µV/V	
10 mV	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	110 µV/V 110 µV/V 89 µV/V 140 µV/V 88 µV/V 110 µV/V 83 µV/V 100 µV/V 160 µV/V 220 µV/V 300 µV/V 330 µV/V 420 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) [2]	Reference Standard, Method and/or Equipment
LF AC-DC Difference	10 Hz	84 µV/V	Fluke 792A
	20 Hz	68 µV/V	
	40 Hz	64 µV/V	
	100 Hz	110 µV/V	
	1 kHz	67 µV/V	
	10 kHz	81 µV/V	
20 mV	20 kHz	62 µV/V	
	50 kHz	110 µV/V	
	100 kHz	160 µV/V	
	300 kHz	220 µV/V	
	500 kHz	310 µV/V	
	800 kHz	380 µV/V	
	1 MHz	390 µV/V	
	10 Hz	100 µV/V	
	20 Hz	45 µV/V	
	40 Hz	35 µV/V	
	100 Hz	33 µV/V	
	1 kHz	32 µV/V	
	10 kHz	37 µV/V	
60 mV	20 kHz	35 µV/V	
	50 kHz	40 µV/V	
	100 kHz	77 µV/V	
	300 kHz	150 µV/V	
	500 kHz	220 µV/V	
	800 kHz	290 µV/V	
	1 MHz	300 µV/V	
	10 Hz	46 µV/V	
	20 Hz	29 µV/V	
	40 Hz	21 µV/V	
	100 Hz	15 µV/V	
	1 kHz	14 µV/V	
	10 kHz	26 µV/V	
100 mV	20 kHz	29 µV/V	
	50 kHz	30 µV/V	
	100 kHz	45 µV/V	
	300 kHz	90 µV/V	
	500 kHz	130 µV/V	
	800 kHz	190 µV/V	
	1 MHz	200 µV/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 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 800 kHz 1 MHz	35 µV/V 21 µV/V 29 µV/V 16 µV/V 12 µV/V 20 µV/V 17 µV/V 28 µV/V 48 µV/V 76 µV/V 110 µV/V 160 µV/V 190 µV/V	Fluke 792A
600 mV	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 µV/V 24 µV/V 7.6 µV/V 8.7 µV/V 9.2 µV/V 7.8 µV/V 9.7 µV/V 8.6 µV/V 30 µV/V 26 µV/V 47 µV/V 60 µV/V 81 µV/V	
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 µV/V 18 µV/V 6.5 µV/V 6.7 µV/V 7.0 µV/V 6.0 µV/V 6.0 µV/V 8.2 µV/V 14 µV/V 22 µV/V 35 µV/V 36 µV/V 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	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	6.5µV/V	
	10 kHz	6.2 µV/V	
2 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	
	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	
6 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 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	
10 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	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 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	10 Hz	54 µV/V	Fluke 792A
	20 Hz	29 µV/V	
	40 Hz	14 µV/V	
	100 Hz	15 µV/V	
600 V	1 kHz	13 µV/V	
	10 kHz	18 µV/V	
	20 kHz	20 µV/V	
	50 kHz	32 µV/V	
	100 kH	72 µV/V	
	10 Hz	54 µV/V	
	20 Hz	22 µV/V	
	40 Hz	13 µV/V	
	100 Hz	12 µV/V	
1 000 V	1 kHz	13 µV/V	
	10 kHz	16 µV/V	
	20 kHz	22 µV/V	
	50 kHz	47 µV/V	
	100 kHz	67 µV/V	
AC Current	10 Hz	75 µV/V	Fluke A40 Shunts with 792A
	20 Hz	70 µV/V	
	40 Hz	61 µV/V	
	400 Hz	59 µV/V	
100 µA	1 kHz	56 µV/V	
	5 kHz	73 µV/V	
	10 kHz	83 µV/V	
	20 kHz	120 µV/V	
	30 kHz	160 µV/V	
	10 Hz	95 µV/V	
	20 Hz	56 µV/V	
	40 Hz	59 µV/V	
	400 Hz	45 µV/V	
200 µA	1 kHz	43 µV/V	
	5 kHz	69 µV/V	
	10 kHz	81 µV/V	
	20 kHz	120 µV/V	
	30 kHz	190 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) [2]	Reference Standard, Method and/or Equipment
AC Current	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	
300 µA	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	
	10 Hz	56 µV/V	
	20 Hz	47 µV/V	
	40 Hz	41 µV/V	
	400 Hz	34 µV/V	
1 mA	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	
	10 Hz	54 µV/V	
	20 Hz	42 µV/V	
	40 Hz	46 µV/V	
	400 Hz	38 µV/V	
2 mA	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	
	10 Hz	51 µV/V	
	20 Hz	40 µV/V	
	40 Hz	35 µV/V	
	400 Hz	33 µV/V	
3 mA	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 Hz	100 µV/V	Fluke A40 Shunts with 792A
	20 Hz	53 µV/V	
	40 Hz	38 µV/V	
	400 Hz	37 µV/V	
10 mA	1 kHz	32 µV/V	
	5 kHz	31 µV/V	
	10 kHz	32 µV/V	
	20 kHz	42 µV/V	
	30 kHz	63 µV/V	
	10 Hz	140 µV/V	
	20 Hz	84 µV/V	
	40 Hz	78 µV/V	
	400 Hz	77 µV/V	
20 mA	1 kHz	76 µV/V	
	5 kHz	76 µV/V	
	10 kHz	76 µV/V	
	20 kHz	78 µV/V	
	30 kHz	93 µV/V	
	10 Hz	150 µV/V	
	20 Hz	92 µV/V	
	40 Hz	72 µV/V	
	400 Hz	66 µV/V	
30 mA	1 kHz	66 µV/V	
	5 kHz	67 µV/V	
	10 kHz	73 µV/V	
	20 kHz	85 µV/V	
	30 kHz	110 µV/V	
	10 Hz	140 µV/V	
	20 Hz	64 µV/V	
	40 Hz	53 µV/V	
	400 Hz	51 µV/V	
100 mA	1 kHz	48 µV/V	
	5 kHz	48 µV/V	
	10 kHz	49 µV/V	
	20 kHz	61 µV/V	
	30 kHz	78 µV/V	

Electrical – DC/Low Frequency

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

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) [2]	Reference Standard, Method and/or Equipment
AC Current	10 Hz	110 µV/V	Fluke A40 Shunts with 792A
	20 Hz	56 µV/V	
	40 Hz	42 µV/V	
	400 Hz	37 µV/V	
2A	1 kHz	35 µV/V	
	5 kHz	42 µV/V	
	10 kHz	43 µV/V	
	20 kHz	55 µV/V	
	30 kHz	110 µV/V	
	10 Hz	133 µV/V	
	20 Hz	66 µV/V	
	40 Hz	57 µV/V	
	400 Hz	56 µV/V	
3 A	1 kHz	55 µV/V	
	5 kHz	61 µV/V	
	10 kHz	63 µV/V	
	20 kHz	83 µV/V	
	30 kHz	140 µV/V	
	10 Hz	130 µV/V	
	20 Hz	67 µV/V	
	40 Hz	56 µV/V	
	400 Hz	61 µV/V	
5 A	1 kHz	53 µV/V	
	5 kHz	58 µV/V	
	10 kHz	69 µV/V	
	20 kHz	88 µV/V	
	30 kHz	180 µV/V	
	10 Hz	150 µV/V	
	20 Hz	84 µV/V	
	40 Hz	65 µV/V	
	400 Hz	64 µV/V	
10A	1 kHz	62 µV/V	
	5 kHz	62 µV/V	
	10 kHz	62 µV/V	
	20 kHz	100 µV/V	
	30 kHz	150 µV/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 µV/V 120 µV/V 81 µV/V 81 µV/V 77 µV/V 77 µV/V 77 µV/V 130 µV/V 180 µV/V	Fluke A40 Shunts with 792A
100A	10 Hz 20 Hz 40 Hz 400 Hz 1 kHz 5 kHz	160 µV/V 160 µV/V 96 µV/V 86 µV/V 86 µV/V 120 µV/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]	20 Hz	0.15 %	Agilent E4980A LCR
	100 Hz	0.092 %	
	1 kHz	0.092 %	
1 kΩ	10 kHz	0.092 %	
	100 kHz	0.092 %	
	1 MHz	0.14 %	
	2 MHz	0.3 %	
	20 Hz	0.15 %	
	100 Hz	0.092 %	
	1 kHz	0.092 %	
10 kΩ	10 kHz	0.092 %	
	100 kHz	0.1 %	
	1 MHz	0.29	
	2 MHz	0.87	
	20 Hz	0.17 %	
	100 Hz	0.1 %	
	1 kHz	0.1 %	
100 kΩ	10 kHz	0.17 %	
	100 kHz	0.28 %	
	1 MHz	0.38 %	
	2 MHz	1.3 %	
AC Voltage – Measure	10 Hz	560 µV/V	Fluke 792A
	20 Hz	350 µV/V	
	40 Hz	450 µV/V	
	100 Hz	390 µV/V	
	1 kHz	340 µV/V	
	10 kHz	320 µV/V	
2 mV	20 kHz	320 µV/V	
	50 kHz	350 µV/V	
	100 kHz	440 µV/V	
	300 kHz	510 µV/V	
	500 kHz	610 µV/V	
	800 kHz	750 µV/V	
	1 MHz	760 µV/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 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 800 kHz 1 MHz	230 µV/V 230 µV/V 230 µV/V 190 µV/V 180 µV/V 170 µV/V 200 µV/V 220 µV/V 300 µV/V 410 µV/V 490 µV/V 580 µV/V 630 µV/V	Fluke 792A
10 mV	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	110 µV/V 110 µV/V 89 µV/V 140 µV/V 88 µV/V 110 µV/V 83 µV/V 100 µV/V 160 µV/V 220 µV/V 300 µV/V 330 µV/V 420 µV/V	
20 mV	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	84 µV/V 68 µV/V 64 µV/V 110 µV/V 67 µV/V 81 µV/V 62 µV/V 110 µV/V 160 µV/V 220 µV/V 310 µV/V 380 µV/V 390 µV/V	

Electrical – DC/Low Frequency

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

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) [2]	Reference Standard, Method and/or Equipment
AC Voltage – Measure 600 mV	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 µV/V 24 µV/V 7.6 µV/V 8.7 µV/V 9.2 µV/V 7.8 µV/V 9.7 µV/V 8.6 µV/V 30 µV/V 26 µV/V 47 µV/V 60 µV/V 81 µV/V	Fluke 792A
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 µV/V 18 µV/V 6.5 µV/V 6.7 µV/V 7 µV/V 6 µV/V 6 µV/V 8.2 µV/V 14 µV/V 22 µV/V 35 µV/V 36 µV/V 48 µV/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 µV/V 15 µV/V 6.6 µV/V 6.4 µV/V 6.5µV/V 6.2 µV/V 6.8 µV/V 7.9 µV/V 14 µV/V 33 µV/V 33 µV/V 32 µV/V 45 µV/V	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) [2]	Reference Standard, Method and/or Equipment
AC Voltage – Measure	10 Hz	32 µV/V	Fluke 792A
	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	
6 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	
20 V	10 Hz	37 µV/V	
	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	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) [2]	Reference Standard, Method and/or Equipment
AC Voltage – Measure	10 Hz	36 µV/V	Fluke 792A
	20 Hz	17 µV/V	
	40 Hz	7.1 µV/V	
	100 Hz	6.9 µV/V	
60 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	
	10 Hz	27 µV/V	
	20 Hz	15 µV/V	
	40 Hz	7.2 µV/V	
	100 Hz	6.9 µV/V	
100 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	
	10 Hz	44 µV/V	
	20 Hz	17 µV/V	
	40 Hz	10 µV/V	
	100 Hz	10 µV/V	
200 V	1 kHz	9.7 µV/V	
	10 kHz	9.8 µV/V	
	20 kHz	10 µV/V	
	50 kHz	12 µV/V	
	100 kHz	19 µV/V	
	10 Hz	54 µV/V	
	20 Hz	29 µV/V	
	40 Hz	14 µV/V	
	100 Hz	15 µV/V	
600 V	1 kHz	13 µV/V	
	10 kHz	18 µV/V	
	20 kHz	20 µV/V	
	50 kHz	32 µV/V	
	100 kHz	72 µV/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 20 Hz 40 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	54 µV/V 22 µV/V 13 µV/V 12 µV/V 13 µV/V 16 µV/V 22 µV/V 47 µV/V 67 µV/V	Fluke 792A
Inductance Measure [3] 1 µH	10 kHz 100 kHz 1 MHz 2 MHz	1.6 % 0.36 % 0.27 % 0.66 %	Agilent E4980A LCR
10 µH	10 kHz 100 kHz 1 MHz 2 MHz	0.37 % 0.2 % 0.2 % 0.3 %	
100 µH	1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	0.4 % 0.2 % 0.12 % 0.14 % 0.72 %	
1 mH	100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	0.55 % 0.18 % 0.12 % 0.092 % 0.23 % 0.88 %	
10 mH	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 2 MHz	0.85 % 0.22 % 0.092 % 0.092 % 0.1 % 0.35 % 1.3 %	
100 mH	20 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz	0.28 % 0.1 % 0.092 % 0.092 % 0.21 % 0.88 %	

Electrical – DC/Low Frequency

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

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 µs 83 µs to 55 s	0.19 µs/s 2.3 µs/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	0.39 %	Fluke 9500B
	40 Ω to 90 Ω	0.083 %	
Input Impedance Measure[1]	90 Ω to 150 Ω	0.39 %	
	50 kΩ to 800 kΩ	0.39 %	
	800 kΩ to 1.2 MΩ	0.083 %	
	1.2 MΩ to 12 MΩ	0.39 %	
Input Capacitance Measure[1]	1.0 pF to 35 pF	1.6 % + 0.19 pF	Fluke 9500B
	35 pF to 95 pF	2.3 % + 0.19 pF	
Electrical Simulation of Thermocouples – Measure and Measuring Equipment [1]			Ectron 1140A
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 1200 °C	0.08 °C	
Type K	-270 °C to -255 °C	2.3 °C	
	-255 °C to -195 °C	0.73 °C	
	-195 °C to -115 °C	0.14 °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	
	-270 °C to -250 °C	1.8 °C	
	-250 °C to -240 °C	0.52 °C	
Type T	-240 °C to -210 °C	0.32 °C	
	-210 °C to -150 °C	0.19 °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	
Type E	-270 °C to -245 °C	2.1 °C	
	-245 °C to -195 °C	0.22 °C	
	-195 °C to -155 °C	0.11 °C	
	-155 °C to -90 °C	0.099 °C	
	-90 °C to 0 °C	0.08 °C	
	0 °C to 15 °C	0.08 °C	
	15 °C to 890 °C	0.07 °C	
	890 °C to 1 000 °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	0.68 °C	Ectron 1140A
	-30 °C to 45 °C	0.58 °C	
	45 °C to 160 °C	0.42 °C	
	160 °C to 380 °C	0.31 °C	
	380 °C to 775 °C	0.28 °C	
	775 °C to 1 768.1 °C	0.23 °C	
Type S	-50 °C to -30 °C	0.65 °C	
	-30 °C to 45 °C	0.59 °C	
	45 °C to 105 °C	0.42 °C	
	105 °C to 310 °C	0.35 °C	
	310 °C to 615 °C	0.31 °C	
	615 °C to 1 768.1 °C	0.27 °C	
Type N	-270 °C to -260 °C	0.42 °C	
	-260 °C to -200 °C	0.24 °C	
	-200 °C to -140 °C	0.25 °C	
	-140 °C to -70 °C	0.21 °C	
	-70 °C to 25 °C	0.13 °C	
	25 °C to 160 °C	0.11 °C	
	160 °C to 1 300 °C	0.11 °C	
Type B	250 °C to 350 °C	1 °C	
	350 °C to 450 °C	0.77 ºC	
	450 °C to 580 °C	0.61 ºC	
	580 °C to 750 °C	0.47 ºC	
	750 °C to 1 000 °C	0.39 ºC	
	1 000 °C to 1 820 °C	0.31 °C	
Type C	0 °C to 250 °C	0.21 °C	
	250 °C to 1 000 °C	0.17 °C	
	1 000 °C to 1 500 °C	0.19 °C	
	1 500 °C to 1 800 °C	0.22 °C	
	1 800 °C to 2 000 °C	0.24 °C	
	2 000 °C to 2 250 °C	0.30 °C	
	2 250 °C to 2 315 °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	11 µW to 1.1 mW	0.024 %	
	1.1 mW to 110 mW	0.027 %	
	0.11W to 110 W	0.024 %	
	110 W to 330 W	0.018 %	
0.33 A to 3 A	11 W to 110 mW	0.044 %	
	0.11 W to 990 W	0.053 %	
	1 W to 3 kW	0.009 6 %	
3 A to 20.5 A	0.099 W to 0.99 W	0.088 %	
	0.99 W to 6.8 kW	0.07 %	
	6.8 W to 20.5 kW	0.04 %	
AC Power [1,4] (PF=1)			Fluke 5520A
(10 to 65) Hz			
(3.3 to 9.0) mA	0.11 mW to 3.0 mW	0.13%	
	3.0 mW to 9.0 W	0.077%	
(9.0 to 33) mA	0.3 mW to 10 mW	0.089 %	
	10 mW to 33W	0.077%	
(33 to 90) mA	1 mW to 30 mW	0.071 %	
	30 mW to 90 W	0.057 %	
(90 to 330) mA	3 mW to 100 mW	0.089 %	
	100 mW to 300 W	0.078 %	
(0.33 to 0.9) A	11 mW to 300 mW	0.071 %	
	300 mW to 900 W	0.081 %	
(0.9 to 2.2) A	30 mW to 720 mW	0.089 %	
	720 mW to 2 kW	0.079 %	
(2.2 to 4.5) A	80 mW to 1.4 W	0.088 %	
	1.4 W to 4.5 kW	0.18 %	
(4.5 to 20.5) A	150 mW to 6.7 W	0.17 %	
	6.7 W to 20 kW	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 to100 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 kΩ	 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 + 10*L*) µin	
	4 in to 15 in	(4.3 + 11*L*) µin	
	15 in to 40 in	(4.4 + 11*L*) 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 + 21*L*) µin	Comparison to Gage Blocks
Length Single Axis Outside Dimension	(0 to 1.0) in	(6.0 + 1 *L*) µin	ULM
	(1.0 to 7.0) in	(4.3 + 3.5 *L*) µin	
	(7.0 to 21) in	(1 + 4 *L*) µin	
Length Single Axis Inside Dimension	(0.040 to 0.125) in	11 µin	ULM
	(0.125 to 0.250) in	11 µin	
	(0.0250 to 1.00) in	11 µin	
	(1.0 to 2.5) in	17 µin	
	(2.5 to 10) in	(18 + 3 *L*) µin	
	(10 to 14) in	(38 + 3 *L*) µin	
Height Gages	0 in to 24 in	(60 + 0.7*L*) µin	Comparison to Gage Blocks
Thread Wires	2 TPI to 120 TPI		ULM
	(0.008 to 0.5) in	12 µin	

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	12 µin	ULM
	(1 to 7) in	(9 + 3 *L*) µin	
Ring Gage			
Inside Diameter	(0.04 to 0.125) in	11 µin	ULM w/Working Reference Rings
	(0.125 to 0.25) in	11 µin	
	(0.025 to 1) in	11 µin	
	(1 to 2.5) in	17 µin	
	(2.5 to 10) in	(18 + 3 *L*) µin	
	(10 to 14) in	(38 + 3.0 *L*) µin	
Thread Plug Gages			
Pitch Diameter 60° Thread	(0 to 1) in	79 µin	ULM w/Thread Wires
	(1 to 4) in	80 µin	
	(4 in to 7) in	83 µin	
Major Diameter	(0 to 1.0) in	13 µin	ULM
	(1.0 to 7.0) in	(10 + 3.0 *L*) µin	
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	79 µin	Master Plug Uncertainty
	(1.0 to 4.0) in	80 µin	
	(4.0 in to 7.0) in	83 µin	

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 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	0.064 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 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
Mass – Metric [1]			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_2O to +60 inH_2O	0.002 8 % + 22 µinH_2O	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 (20 to 200) sccm (0.2 to 2) slm (2 to 20) slm (20 to 50) slm (50 to 100) slm	0.22 % + 0.0042 sccm 0.25 % + 0.0017 sccm 0.25 % + 0.00002 slm 0.25 % + 0.00036 slm 0.34 % 0.34 %	Fluke Molbox with bloc's

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	1.7 % RH	Thermo-hygrometer
	(50 to 75) %RH	2.0 % RH	
	(75 to 95) %RH	2.3 % RH	
Temperature - Measuring Equipment	-20 ºC to 100 ºC	0.011 ºC	SPRT, Super Thermometer
	100 ºC to 150 ºC	0.013 °C	Liquid Baths
	150 °C to 230 °C	0.016 °C	
	230 °C to 300 °C	0.018 °C	
	300 °C to 420 °C	0.074 °C	Metrology Wells
	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 ºC to 0 ºC 0 ºC to 420 °C 420 °C to 660 °C 660 °C to 750° C 750 °C to 1 000 °C	0.012 ºC 0.025 ºC 0.036 ºC 1.3 °C 1.8 °C	SPRT w/Black Stack Type K Probe and Readout
Infrared Temperature – Measuring Equipment [1] Ɛ = (0.1 to 1.0) λ = (8 to 14) µm	(-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 ºC)	0.02 ºC	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

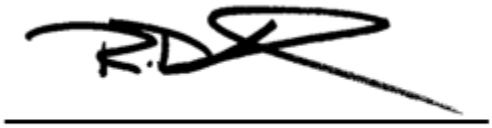
Time and Frequency

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	<= 500ps	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.



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