



# CERTIFICATE OF ACCREDITATION

## ANSI National Accreditation Board

11617 Coldwater Road, Fort Wayne, IN 46845 USA

This is to certify that

### **The Standards Institution of Israel Electricity and Electronics Laboratory Calibration Center**

**42 Chaim Levanon Street  
Tel Aviv, 69977 Israel**

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

## **ISO/IEC 17025:2017**

while demonstrating technical competence in the field of

## **CALIBRATION**

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

AC-2699

Certificate Number

  
ANAB Approval

Certificate Valid Through: 05/14/2020  
Version No. 001 Issued: 08/21/2019



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

**The Standards Institution of Israel  
Electricity and Electronics Laboratory  
Calibration Center**

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### CALIBRATION

Valid to: **May 14, 2020**

Certificate Number: **AC-2699**

#### Electrical Quantities – DC/Low Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage, Measuring Instruments <sup>1,2</sup>	0 mV	904 nV	Short measurement
	(0.1 to 190] $\mu$ V	$\sqrt{\left(8.1 \frac{\mu V}{V} \cdot OR\right)^2 + (904 \text{ nV})^2} + 0.93 \text{ nV}$	Calibrator Datron 4708
	(0.19 to 1.9] mV	$\sqrt{\left(8.1 \frac{\mu V}{V} \cdot OR\right)^2 + (904 \text{ nV})^2} + 9.76 \text{ nV}$	
	(1.9 to 19] mV	$\sqrt{\left(8.1 \frac{\mu V}{V} \cdot OR\right)^2 + (905 \text{ nV})^2} + 92.3 \text{ nV}$	
	(19 to 190] mV	$\sqrt{\left(8.1 \frac{\mu V}{V} \cdot OR\right)^2 + (1.03 \mu V)^2} + 4.33 \text{ nV}$	
	(0.19 to 1.9] V	$\sqrt{\left(5.8 \frac{\mu V}{V} \cdot OR\right)^2 + (2.91 \mu V)^2} + 994 \text{ nV}$	
	(1.9 to 19] V	$\sqrt{\left(3.5 \frac{\mu V}{V} \cdot OR\right)^2 + (21.3 \mu V)^2} + 2.57 \mu V$	
DC Voltage, Measuring Instruments <sup>1,2</sup>	(19 to 190] V	$\sqrt{\left(5.8 \frac{\mu V}{V} \cdot OR\right)^2 + (296 \mu V)^2} + 49.5 \mu V$	Calibrator Datron 4708
	(190 to 1 000] V	$\sqrt{\left(8.1 \frac{\mu V}{V} \cdot OR\right)^2 + (2.92 \text{ mV})^2} + 271 \mu V$	
DC Voltage, Measuring Instruments <sup>1,2</sup>	(1 000 to 2 000] V	$\sqrt{\left(463 \frac{\mu V}{V} \cdot OR\right)^2 + (1.15 \text{ V})^2} + 263 \text{ mV}$	DC High Voltage Calibrator PINTEK HVC-801
DC Voltage, Measuring Instruments <sup>1,2</sup>	(2 000 to 20 000] V	$\sqrt{\left(463 \frac{\mu V}{V} \cdot OR\right)^2 + (11.5 \text{ V})^2} + 2.63 \text{ V}$	Precision High Voltage Meter VITREK 4700A

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
DC Voltage, Measuring Instruments <sup>1,2</sup>	(20 to 40] kV	24 V/kV	High Voltage Probe: FLUKE 80K-40
DC Voltage, Sources <sup>1,2</sup>	0 mV	1.7 $\mu$ V	Calibrator Datron 4708
	(0.1 $\mu$ V to 190] $\mu$ V	$\sqrt{\left(8.1 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (905 \text{ nV})^2} + 1.34 \text{ nV}$	DMM Datron 1281
	(0.19 mV to 1.9] mV	$\sqrt{\left(8.1 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (906 \text{ nV})^2} + 10.0 \text{ nV}$	
	(1.9 mV to 19] mV	$\sqrt{\left(8.1 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.03 \mu\text{V})^2} + 86.7 \text{ nV}$	
	(19 mV to 190] mV	$\sqrt{\left(8.1 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.03 \mu\text{V})^2} + 433 \text{ nV}$	
	(0.19 V to 1.9] V	$\sqrt{\left(5.8 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (2.91 \mu\text{V})^2} + 994 \text{ nV}$	
DC Voltage, Sources <sup>1,2</sup>	(1.9 V to 19] V	$\sqrt{\left(3.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (21.3 \mu\text{V})^2} + 2.57 \mu\text{V}$	Precision High Voltage Meter VITREK 4700A
	(19 to 190] V	$\sqrt{\left(5.8 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (296 \mu\text{V})^2} + 49.5 \mu\text{V}$	
	(190 to 1 000] V	$\sqrt{\left(8.1 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (2.92 \text{ mV})^2} + 271 \mu\text{V}$	
DC Voltage, Sources <sup>1,2</sup>	(1 000 to 2 000] V	$\sqrt{\left(463 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.15 \text{ V})^2} + 263 \text{ mV}$	High Voltage Probe: FLUKE 80K-40
	(2 000 to 20 000] V	$\sqrt{\left(463 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (11.5 \text{ V})^2} + 2.63 \text{ V}$	
DC Voltage, Sources <sup>1,2</sup>	(20 to 30] kV	24 V/kV	High Voltage Probe: FLUKE 80K-40
	(2 000 to 20 000] V	$\sqrt{\left(463 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (11.5 \text{ V})^2} + 2.63 \text{ V}$	
DC Current, Measuring Instruments <sup>1,2</sup>	0 pA	810 fA	Open measurement
DC Current, Measuring Instruments <sup>1,2</sup>	(0 to 2] pA	$\sqrt{(0.49 \% \cdot \text{OR})^2 + (810 \text{ fA})^2} + 1.58 \text{ fA}$	Calibrator KEITHLEY 263
	(2 to 20] pA	$\sqrt{(0.43 \% \cdot \text{OR})^2 + (810 \text{ fA})^2} + 12.4 \text{ fA}$	
	(20 to 200] pA	$\sqrt{(0.29 \% \cdot \text{OR})^2 + (8.02 \text{ pA})^2} + 9.81 \text{ fA}$	

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Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current, Measuring Instruments <sup>1,2</sup>	(0.2 to 2] nA (2 to 20] nA (20 to 200] nA (0.2 to 2] $\mu$ A	$\sqrt{\left(752 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (20 \text{ pA})^2} + 65.1 \text{ fA}$ $\sqrt{\left(752 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (200 \text{ pA})^2} + 554 \text{ fA}$ $\sqrt{\left(405 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (2.0 \text{ nA})^2} + 5.12 \text{ pA}$ $\sqrt{\left(289 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (117 \text{ pA})^2} + 104 \text{ pA}$	Calibrator KEITHLEY 263
DC Current, Measuring Instruments <sup>1,2</sup>	(2 to 19] $\mu$ A (19 to 190] $\mu$ A (0.19 to 1.9] mA (1.9 to 19] mA (19 to 190] mA (0.19 to 1.9] A	$\sqrt{\left(116 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (3.06 \text{ nA})^2} + 1.12 \text{ nA}$ $\sqrt{\left(116 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (3.06 \text{ nA})^2} + 2.09 \text{ nA}$ $\sqrt{\left(46.3 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (167 \text{ nA})^2} + 45.5 \text{ nA}$ $\sqrt{\left(46.3 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (1.96 \mu\text{A})^2} + 412 \text{ nA}$ $\sqrt{\left(46.3 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (1.96 \mu\text{A})^2} + 1.02 \mu\text{A}$ $\sqrt{\left(116 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (36 \mu\text{A})^2} + 20.8 \mu\text{A}$	Calibrator DATRON 4708
DC Current, Measuring Instruments <sup>1,2</sup>	(1.9 to 3] A (3 to 10] A (10 to 20] A (20 to 32] A (32 to 105] A (105 to 160] A (160 to 525] A (525 to 1 000] A	$\sqrt{\left(440 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (783 \mu\text{A})^2} + 39.4 \mu\text{A}$ $\sqrt{\left(579 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (3.56 \text{ mA})^2} + 474 \mu\text{A}$ $\sqrt{\left(637 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (8.74 \text{ mA})^2} + 3.82 \text{ mA}$ $\sqrt{(0.30 \% \cdot \text{OR})^2 + (7.94 \text{ mA})^2} + 57.3 \text{ mA}$ $\sqrt{(0.30 \% \cdot \text{OR})^2 + (27 \text{ mA})^2} + 194 \text{ mA}$ $\sqrt{(0.30 \% \cdot \text{OR})^2 + (39.9 \text{ mA})^2} + 350 \text{ mA}$ $\sqrt{(0.30 \% \cdot \text{OR})^2 + (134 \text{ mA})^2} + 1.18 \text{ A}$ $\sqrt{(0.30 \% \cdot \text{OR})^2 + (350 \text{ mA})^2} + 2.33 \text{ A}$	Calibrator FLUKE 5520A
DC Current, Sources <sup>1,2</sup>	0 nA	2 nA	Open measurement

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current, Sources <sup>1,2</sup>	(0 to 120] nA	$\sqrt{\left(34.7 \frac{\mu A}{A} \cdot OR\right)^2 + (2.01 \text{ nA})^2}$ — 4.44 pA	DMM HP 3458A
DC Current, Sources <sup>1,2</sup>	(0.12 to 1.2] $\mu A$ (1.2 to 12] $\mu A$ (12 to 120] $\mu A$ (0.12 to 1.2] mA (1.2 to 12] mA (12 to 120] mA	$\sqrt{\left(23.1 \frac{\mu A}{A} \cdot OR\right)^2 + (411 \text{ pA})^2} + 80.5 \text{ fA}$ $\sqrt{\left(23.1 \frac{\mu A}{A} \cdot OR\right)^2 + (4.11 \text{ nA})^2} - 406 \text{ fA}$ $\sqrt{\left(23.1 \frac{\mu A}{A} \cdot OR\right)^2 + (14.0 \text{ nA})^2} + 33.4 \text{ pA}$ $\sqrt{\left(23.1 \frac{\mu A}{A} \cdot OR\right)^2 + (591 \text{ nA})^2} + 460 \text{ pA}$ $\sqrt{\left(23.1 \frac{\mu A}{A} \cdot OR\right)^2 + (591 \text{ nA})^2} + 658 \text{ pA}$ $\sqrt{\left(40.5 \frac{\mu A}{A} \cdot OR\right)^2 + (6.01 \mu A)^2} + 4.38 \text{ nA}$	DMM HP 3458A
DC Current, Sources <sup>1,2</sup>	(0.12 to 1.05] A (1.05 to 20] A	$\sqrt{\left(127 \frac{\mu A}{A} \cdot OR\right)^2 + (141 \mu A)^2} + 8.1 \mu A$ 230 $\mu A/A$	Shunt: FLUKE A40A-20A
DC Current, Sources <sup>1,2</sup>	(20 to 1 000] A	8 mA/A	Calibrator, FLUKE 5520A +DC Clamp meter used as Transfer Standard
AC Voltage, Measuring Instruments <sup>1,2</sup>	[0.1 to 1.9] mV [10 to 31] Hz (31 to 330] Hz (0.33 to 10] kHz (10 to 33] kHz (33 to 100] kHz (100 to 330] kHz (033 to 1] MHz	$\sqrt{\left(139 \frac{\mu V}{V} \cdot OR\right)^2 + (6.26 \mu V)^2} + 244 \text{ nV}$ $\sqrt{\left(81 \frac{\mu V}{V} \cdot OR\right)^2 + (6.26 \mu V)^2} + 137 \text{ nV}$ $\sqrt{\left(69.4 \frac{\mu V}{V} \cdot OR\right)^2 + (6.26 \mu V)^2} + 124 \text{ nV}$ $\sqrt{\left(81 \frac{\mu V}{V} \cdot OR\right)^2 + (6.30 \mu V)^2} + 143 \text{ nV}$ $\sqrt{\left(347 \frac{\mu V}{V} \cdot OR\right)^2 + (6.39 \mu V)^2} + 578 \text{ nV}$ $\sqrt{(0.12 \% \cdot OR)^2 + (12.0 \mu V)^2} + 1.95 \mu V$ $\sqrt{(0.23 \% \cdot OR)^2 + (24.3 \mu V)^2} + 3.96 \mu V$	IEC 60051-9; IEC 60044 Calibrator Datron 4709

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Voltage, Measuring Instruments <sup>1,2</sup>	(1.9 to 19] mV	$\sqrt{\left(139 \frac{\mu V}{V} \cdot OR\right)^2 + (7.18 \mu V)^2} + 1.91 \mu V$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
	[10 to 31] Hz	$\sqrt{\left(81 \frac{\mu V}{V} \cdot OR\right)^2 + (7.09 \mu V)^2} + 1.22 \mu V$	
	(31 to 330] Hz	$\sqrt{\left(69.4 \frac{\mu V}{V} \cdot OR\right)^2 + (7.18 \mu V)^2} + 1.05 \mu V$	
	(0.33 to 10] kHz	$\sqrt{\left(81 \frac{\mu V}{V} \cdot OR\right)^2 + (7.63 \mu V)^2} + 1.15 \mu V$	
	(10 to 33] kHz	$\sqrt{\left(347 \frac{\mu V}{V} \cdot OR\right)^2 + (8.70 \mu V)^2} + 3.27 \mu V$	
	(33 to 100] kHz	$\sqrt{(0.12 \% \cdot OR)^2 + (14.9 \mu V)^2} + 8.99 \mu V$	
	(100 to 330] kHz	$\sqrt{(0.23 \% \cdot OR)^2 + (36.2 \mu V)^2} + 22.1 \mu V$	
AC Voltage, Measuring Instruments <sup>1,2</sup>	(0.33 to 1] MHz	$\sqrt{(0.23 \% \cdot OR)^2 + (36.2 \mu V)^2} + 22.1 \mu V$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
	[19 to 190] mV	$\sqrt{\left(139 \frac{\mu V}{V} \cdot OR\right)^2 + (17.3 \mu V)^2} + 7.58 \mu V$	
	[10 to 31] Hz	$\sqrt{\left(81 \frac{\mu V}{V} \cdot OR\right)^2 + (15.1 \mu V)^2} + 6.33 \mu V$	
	(31 to 330] Hz	$\sqrt{\left(69.4 \frac{\mu V}{V} \cdot OR\right)^2 + (16.1 \mu V)^2} + 5.71 \mu V$	
	(0.33 to 10] kHz	$\sqrt{\left(81 \frac{\mu V}{V} \cdot OR\right)^2 + (23.5 \mu V)^2} + 5.10 \mu V$	
	(10 to 33] kHz	$\sqrt{\left(347 \frac{\mu V}{V} \cdot OR\right)^2 + (39.3 \mu V)^2} + 8.32 \mu V$	
	(33 to 100] kHz	$\sqrt{(0.12 \% \cdot OR)^2 + (65.1 \mu V)^2} + 20.7 \mu V$	
AC Voltage, Measuring Instruments <sup>1,2</sup>	(100 to 330] kHz	$\sqrt{(0.23 \% \cdot OR)^2 + (167 \mu V)^2} + 111 \mu V$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
	(0.33 to 1] MHz	$\sqrt{(0.23 \% \cdot OR)^2 + (167 \mu V)^2} + 111 \mu V$	
	(190 mV to 1.90 V]	$\sqrt{\left(104 \frac{\mu V}{V} \cdot OR\right)^2 + (50.4 \mu V)^2} + 29.7 \mu V$	
	[10 to 31] Hz	$\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (34.1 \mu V)^2} + 19.3 \mu V$	
	(31 to 330] Hz	$\sqrt{\left(46.3 \frac{\mu V}{V} \cdot OR\right)^2 + (28.3 \mu V)^2} + 9.92 \mu V$	
	(0.33 to 33] kHz	$\sqrt{\left(92.6 \frac{\mu V}{V} \cdot OR\right)^2 + (52.0 \mu V)^2} + 20.0 \mu V$	
	(33 to 100] kHz	$\sqrt{\left(289 \frac{\mu V}{V} \cdot OR\right)^2 + (162 \mu V)^2} + 97.4 \mu V$	
AC Voltage, Measuring Instruments <sup>1,2</sup>	(100 to 330] kHz	$\sqrt{(0.17 \% \cdot OR)^2 + (738 \mu V)^2} + 405 \mu V$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
	(0.33 to 1] MHz	$\sqrt{(0.17 \% \cdot OR)^2 + (738 \mu V)^2} + 405 \mu V$	

**Electrical Quantities – DC/Low Frequency**

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AC Voltage, Measuring Instruments <sup>1,2</sup>	(1.9 to 19] V [10 to 31] Hz (31 to 330] Hz (0.33 to 10] kHz (10 to 33] kHz (33 to 100] kHz (33 to 100] kHz (100 to 330] kHz (0.33 to 1] MHz	$\sqrt{\left(104 \frac{\mu V}{V} \cdot OR\right)^2 + (504 \mu V)^2} + 297 \mu V$ $\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (341 \mu V)^2} + 193 \mu V$ $\sqrt{\left(46.3 \frac{\mu V}{V} \cdot OR\right)^2 + (283 \mu V)^2} + 992 \mu V$ $\sqrt{\left(46.3 \frac{\mu V}{V} \cdot OR\right)^2 + (301 \mu V)^2} + 988 \mu V$ $\sqrt{\left(92.6 \frac{\mu V}{V} \cdot OR\right)^2 + (457 \mu V)^2} + 202 \mu V$ $\sqrt{\left(92.6 \frac{\mu V}{V} \cdot OR\right)^2 + (457 \mu V)^2} + 202 \mu V$ $\sqrt{\left(289 \frac{\mu V}{V} \cdot OR\right)^2 + (1.55 mV)^2} + 976 \mu V$ $\sqrt{(0.17 \% \cdot OR)^2 + (7.14 mV)^2} + 4.05 mV$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
AC Voltage, Measuring Instruments <sup>1,2</sup>	(19 to 190] V [10 to 31] Hz (31 to 330] Hz (0.33 to 10] kHz (10 to 33] kHz (33 to 100] kHz (100 to 200] kHz	$\sqrt{\left(116 \frac{\mu V}{V} \cdot OR\right)^2 + (5.35 mV)^2} + 3.01 mV$ $\sqrt{\left(69.4 \frac{\mu V}{V} \cdot OR\right)^2 + (3.57 mV)^2} + 1.99 mV$ $\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (3.01 mV)^2} + 1.0 mV$ $\sqrt{\left(69.4 \frac{\mu V}{V} \cdot OR\right)^2 + (3.81 mV)^2} + 1.98 mV$ $\sqrt{\left(139 \frac{\mu V}{V} \cdot OR\right)^2 + (7.84 mV)^2} + 3.00 mV$ $\sqrt{\left(463 \frac{\mu V}{V} \cdot OR\right)^2 + (26.8 mV)^2} + 9.97 mV$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
AC Voltage, Measuring Instruments <sup>1,2</sup>	(190 to 1 000] V [50 to 330] Hz (0.33 to 10] kHz (10 to 33] kHz (33 to 100] kHz	$\sqrt{\left(162 \frac{\mu V}{V} \cdot OR\right)^2 + (41.7 mV)^2} + 10.9 mV$ $\sqrt{\left(116 \frac{\mu V}{V} \cdot OR\right)^2 + (45.6 mV)^2} + 10.4 mV$ $\sqrt{\left(162 \frac{\mu V}{V} \cdot OR\right)^2 + (76.1 mV)^2} + 10.2 mV$ $\sqrt{(0.12 \% \cdot OR)^2 + (350 mV)^2} + 21.8 mV$	IEC 60051-9; IEC 60044 Calibrator Datron 4709
AC Voltage, Measuring Instruments <sup>1,2</sup>	(1 to 1.5) kV [40 to 60] Hz	$\sqrt{\left(810 \frac{\mu V}{V} \cdot OR\right)^2 + (2.1 V)^2} + 7.54 V$	Potential Transformer TETTEX 7823, Precision High Voltage Meter



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AC Voltage, Measuring Instruments <sup>1,2</sup>	(1.5 to 10] kV [40 to 60] Hz	$\sqrt{(0.23\% \cdot \text{OR})^2 + (23.0 \text{ V})^2} + 10.6 \text{ V}$	VITREK VITREK 4600A 4600A
AC Voltage, Sources <sup>1,2</sup>	[1 to 3] mV [10 to 100] Hz (100 Hz to 30 kHz) (30 to 200] kHz (200 to 500] kHz (500 to 1 000] kHz	$\sqrt{(0.15\% \cdot \text{OR})^2 + (1.06 \mu\text{V})^2} + 38.5 \text{ nV}$ $\sqrt{(0.13\% \cdot \text{OR})^2 + (1.06 \mu\text{V})^2} + 37.1 \text{ nV}$ $\sqrt{(0.19\% \cdot \text{OR})^2 + (1.11 \mu\text{V})^2} - 8.6 \text{ nV}$ $\sqrt{(0.36\% \cdot \text{OR})^2 + (1.11 \mu\text{V})^2} + 45.4 \text{ nV}$ $\sqrt{(0.75\% \cdot \text{OR})^2 + (1.31 \mu\text{V})^2} + 50.0 \text{ nV}$	AV Measurement, Standard, Datron 4920
AC Voltage, Sources <sup>1,2</sup>	(3 to 10] mV [10 to 100] Hz (100 Hz to 30 kHz) (30 to 200] kHz (200 to 500] kHz (500 kHz to 1 MHz]	$\sqrt{\left(509 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.12 \mu\text{V})^2} - 10.9 \text{ nV}$ $\sqrt{\left(312 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.12 \mu\text{V})^2} - 16.5 \text{ nV}$ $\sqrt{\left(729 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.56 \mu\text{V})^2} - 641 \text{ pV}$ $\sqrt{\left(2.1 \frac{\text{mV}}{\text{V}} \cdot \text{OR}\right)^2 + (1.56 \mu\text{V})^2} + 49.8 \text{ nV}$ $\sqrt{\left(5.2 \frac{\text{mV}}{\text{V}} \cdot \text{OR}\right)^2 + (3.00 \mu\text{V})^2} + 50.4 \text{ nV}$	AV Measurement, Standard, Datron 4920
AC Voltage, Sources <sup>1,2</sup>	(10 to 30] mV [10 to 100] Hz (100 Hz to 30 kHz) (30 to 200] kHz (200 to 500] kHz (500 to 1 000] kHz	$\sqrt{\left(405 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.16 \mu\text{V})^2} + 45.1 \text{ nV}$ $\sqrt{\left(243 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.16 \mu\text{V})^2} + 41.1 \text{ nV}$ $\sqrt{\left(521 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.52 \mu\text{V})^2} + 50.7 \text{ nV}$ $\sqrt{\left(1.6 \frac{\text{mV}}{\text{V}} \cdot \text{OR}\right)^2 + (2.94 \mu\text{V})^2} + 51.4 \text{ nV}$ $\sqrt{\left(3.9 \frac{\text{mV}}{\text{V}} \cdot \text{OR}\right)^2 + (8.54 \mu\text{V})^2} + 50.5 \text{ nV}$	AV Measurement, Standard, Datron 4920



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Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage, Sources <sup>1,2</sup>	(30 to 100] mV		Standard, Datron 4920
	[10 to 100] Hz	$\sqrt{\left(301 \frac{\mu V}{V} \cdot OR\right)^2 + (1.89 \mu V)^2} + 52.2 \text{ nV}$	
	(100 Hz to 30 kHz]	$\sqrt{\left(150 \frac{\mu V}{V} \cdot OR\right)^2 + (1.89 \mu V)^2} + 46.2 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(289 \frac{\mu V}{V} \cdot OR\right)^2 + (3.94 \mu V)^2} + 4.51 \text{ nV}$	
	(200 to 500] kHz	$\sqrt{\left(868 \frac{\mu V}{V} \cdot OR\right)^2 + (9.28 \mu V)^2} + 53.6 \text{ nV}$	
	(500 to 1 000] kHz	$\sqrt{\left(2.3 \frac{mV}{V} \cdot OR\right)^2 + (24.1 \mu V)^2} + 45.2 \text{ nV}$	
AC Voltage, Sources <sup>1,2</sup>	(100 to 300] mV		Standard, Datron 4920
	[1 to 2] Hz	$\sqrt{\left(428 \frac{\mu V}{V} \cdot OR\right)^2 + (30.1 \mu V)^2} + 2.94 \text{ nV}$	
	(2 to 10] Hz	$\sqrt{\left(197 \frac{\mu V}{V} \cdot OR\right)^2 + (10.5 \mu V)^2} - 8.65 \text{ nV}$	
	(10 to 40] Hz	$\sqrt{\left(40.5 \frac{\mu V}{V} \cdot OR\right)^2 + (6.62 \mu V)^2} + 404 \text{ pV}$	
	(40 Hz to 30 kHz]	$\sqrt{\left(40.5 \frac{\mu V}{V} \cdot OR\right)^2 + (11.1 \mu V)^2} + 19.6 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(98.4 \frac{\mu V}{V} \cdot OR\right)^2 + (35.8 \mu V)^2} - 17.1 \text{ nV}$	
	(200 to 500] kHz	$\sqrt{\left(405 \frac{\mu V}{V} \cdot OR\right)^2 + (35.8 \mu V)^2} - 8.85 \text{ nV}$	
	(500 to 1 000] kHz	$\sqrt{\left(1.1 \frac{mV}{V} \cdot OR\right)^2 + (84.8 \mu V)^2} + 4.59 \text{ nV}$	

### Electrical Quantities – DC/Low Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage, Sources <sup>1,2</sup>	(0.3 to 1] V		Standard, Datron 4920
	[1 to 2] Hz	$\sqrt{\left(428 \frac{\mu V}{V} \cdot OR\right)^2 + (50.1 \mu V)^2} + 86.3 \text{ nV}$	
	(2 to 10] Hz	$\sqrt{\left(197 \frac{\mu V}{V} \cdot OR\right)^2 + (27.1 \mu V)^2} + 3.80 \text{ nV}$	
	(10 to 40] Hz	$\sqrt{\left(40.5 \frac{\mu V}{V} \cdot OR\right)^2 + (16.1 \mu V)^2} - 3.61 \text{ nV}$	
	(40 Hz to 30 kHz]	$\sqrt{\left(40.5 \frac{\mu V}{V} \cdot OR\right)^2 + (18.1 \mu V)^2} - 4.48 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(98.4 \frac{\mu V}{V} \cdot OR\right)^2 + (41.1 \mu V)^2} - 17.4 \text{ nV}$	
	(200 to 500] kHz	$\sqrt{\left(405 \frac{\mu V}{V} \cdot OR\right)^2 + (118 \mu V)^2} + 64.4 \text{ nV}$	
	(500 to 1 000] kHz	$\sqrt{(0.11 \% \cdot OR)^2 + (283 \mu V)^2} - 67.4 \text{ nV}$	
AC Voltage, Sources <sup>1,2</sup>	(1 to 3] V		Standard, Datron 4920
	[1 to 2] Hz	$\sqrt{\left(428 \frac{\mu V}{V} \cdot OR\right)^2 + (160 \mu V)^2} + 196 \text{ nV}$	
	(2 to 10] Hz	$\sqrt{\left(197 \frac{\mu V}{V} \cdot OR\right)^2 + (81.2 \mu V)^2} - 81.7 \text{ nV}$	
	(10 to 40] Hz	$\sqrt{\left(40.5 \frac{\mu V}{V} \cdot OR\right)^2 + (42.1 \mu V)^2} + 27.5 \text{ nV}$	
	(40 Hz to 30 kHz]	$\sqrt{\left(40.5 \frac{\mu V}{V} \cdot OR\right)^2 + (48.1 \mu V)^2} + 32.1 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(98.4 \frac{\mu V}{V} \cdot OR\right)^2 + (114 \mu V)^2} + 35.6 \text{ nV}$	
	(200 to 500] kHz	$\sqrt{\left(405 \frac{\mu V}{V} \cdot OR\right)^2 + (277 \mu V)^2} - 121 \text{ nV}$	
	(500 to 1 000] kHz	$\sqrt{\left(1.1 \frac{\text{mV}}{V} \cdot OR\right)^2 + (722 \mu V)^2} - 15.3 \text{ nV}$	

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage, Measuring Instruments <sup>1,2</sup>	(3 to 10] V		Standard, Datron 4920
	[1 to 2] Hz	$\sqrt{\left(428 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (53.1 \mu\text{V})^2} + 835 \text{ nV}$	
	(2 to 10] Hz	$\sqrt{\left(197 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (271 \mu\text{V})^2} + 38.0 \text{ nV}$	
	(10 to 40] Hz	$\sqrt{\left(40.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (141 \mu\text{V})^2} - 22.6 \text{ nV}$	
	(40 Hz to 30 kHz]	$\sqrt{\left(40.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (161 \mu\text{V})^2} - 36.1 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(98.4 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (381 \mu\text{V})^2} - 199 \text{ nV}$	
	(200 to 500] kHz	$\sqrt{\left(405 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (922 \mu\text{V})^2} - 95.7 \text{ nV}$	
	(500 to 1 000] kHz	$\sqrt{\left(1.1 \frac{\text{mV}}{\text{V}} \cdot \text{OR}\right)^2 + (2.83 \text{ mV})^2} - 674 \text{ nV}$	
AC Voltage, Measuring Instruments <sup>1,2</sup>	(10 to 30] V		Standard, Datron 4920
	[1 to 2] Hz	$\sqrt{\left(428 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.60 \text{ mV})^2} + 1.96 \mu\text{V}$	
	(2 to 10] Hz	$\sqrt{\left(197 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (812 \mu\text{V})^2} - 817 \text{ nV}$	
	(10 to 40] Hz	$\sqrt{\left(40.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (812 \mu\text{V})^2} + 184 \text{ nV}$	
	(40 Hz to 30 kHz]	$\sqrt{\left(40.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (481 \mu\text{V})^2} + 321 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(98.4 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.14 \text{ mV})^2} + 356 \text{ nV}$	
	(200 to 500] kHz	$\sqrt{\left(405 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (2.77 \text{ mV})^2} - 1.21 \mu\text{V}$	
	(500 to 1 000] kHz	$\sqrt{\left(1.1 \frac{\text{mV}}{\text{V}} \cdot \text{OR}\right)^2 + (7.22 \text{ mV})^2} - 153 \text{ nV}$	
AC Voltage, Measuring Instruments <sup>1,2</sup>	(30 to 100] V		Standard, Datron 4920
	[1 to 2] Hz	$\sqrt{\left(428 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (5.81 \text{ mV})^2} + 8.90 \mu\text{V}$	
	(2 to 10] Hz	$\sqrt{\left(197 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (2.91 \text{ mV})^2} - 4.58 \mu\text{V}$	
	(10 to 40] Hz	$\sqrt{\left(40.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (2.91 \text{ mV})^2} - 189 \text{ nV}$	
	(40 Hz to 30 kHz]	$\sqrt{\left(40.5 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (1.61 \text{ mV})^2} - 361 \text{ nV}$	
	(30 to 200] kHz	$\sqrt{\left(98.4 \frac{\mu\text{V}}{\text{V}} \cdot \text{OR}\right)^2 + (5.01 \text{ mV})^2} - 765 \text{ nV}$	

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage, Measuring Instruments <sup>1,2</sup>	(100 to 300] V [1 to 2] Hz (2 to 10] Hz (10 to 40] Hz (40 Hz to 20 kHz] (20 to 100] kHz	$\sqrt{\left(475 \frac{\mu V}{V} \cdot OR\right)^2 + (69.2 \text{ mV})^2} - 9.38 \mu V$ $\sqrt{\left(243 \frac{\mu V}{V} \cdot OR\right)^2 + (10.0 \text{ mV})^2} - 6.20 \mu V$ $\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (6.92 \text{ mV})^2} - 9.72 \mu V$ $\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (7.22 \text{ mV})^2} - 9.46 \mu V$ $\sqrt{\left(151 \frac{\mu V}{V} \cdot OR\right)^2 + (39.7 \text{ mV})^2} - 14.0 \mu V$	Standard, Datron 4920
AC Voltage, Measuring Instruments <sup>1,2</sup>	(300 to 1 000] V [1 to 2] Hz (2 to 10] Hz (10 to 40] Hz (40 Hz to 20 kHz] (20 to 100] kHz	$\sqrt{\left(475 \frac{\mu V}{V} \cdot OR\right)^2 + (301 \text{ mV})^2} - 136 \mu V$ $\sqrt{\left(243 \frac{\mu V}{V} \cdot OR\right)^2 + (27.1 \text{ mV})^2} - 326 \text{ nV}$ $\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (27.1 \text{ mV})^2} - 35.6 \mu V$ $\sqrt{\left(57.9 \frac{\mu V}{V} \cdot OR\right)^2 + (52.1 \text{ mV})^2} - 2.22 \mu V$ $\sqrt{\left(151 \frac{\mu V}{V} \cdot OR\right)^2 + (132 \text{ mV})^2} + 175 \mu V$	Standard, Datron 4920
AC Voltage, Measuring Instruments <sup>1,2</sup>	(1 000 to 1 500] V [50 to 60] Hz (1.5 to 15] kV [50 to 60] Hz	$\sqrt{\left(810 \frac{\mu V}{V} \cdot OR\right)^2 + (2.10 \text{ V})^2} + 754 \text{ mV}$ $\sqrt{\left(2.3 \frac{\text{mV}}{V} \cdot OR\right)^2 + (23 \text{ V})^2} + 12.6 \text{ V}$	Precision High Voltage Meter VITREK 4700A
AC Voltage, Measuring Instruments <sup>1,2</sup>	(15 to 28] kV [50 to 60] Hz	58 V/kV	High Voltage Probe FLUKE 80K-40
AC Current, Measuring Instruments <sup>1,2</sup>	(0 to 190] $\mu A$ (0.01 to 1] kHz (1 to 5] kHz (5 to 10] kHz (10 to 30] kHz	$\sqrt{\left(174 \frac{\mu A}{A} \cdot OR\right)^2 + (17 \text{ nA})^2} + 8.7 \text{ nA}$ $\sqrt{\left(347 \frac{\mu A}{A} \cdot OR\right)^2 + (22 \text{ nA})^2} + 13 \text{ nA}$ $\sqrt{\left(2.1 \frac{\text{mA}}{A} \cdot OR\right)^2 + (248 \text{ nA})^2} + 90 \text{ nA}$ $\sqrt{\left(2.9 \frac{\text{mA}}{A} \cdot OR\right)^2 + (3.5 \mu A)^2} + 509 \text{ nA}$	IEC 60051-9; IEC 60044 Calibrator DATRON 4708

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Current, Measuring Instruments <sup>1,2</sup>	(0.19 to 1.9] mA  (0.01 to 1] kHz  (1 to 5] kHz  (5 to 10] kHz  (10 to 30] kHz	$\sqrt{\left(116 \frac{\mu A}{A} \cdot OR\right)^2 + (1.6 \mu A)^2} + 141 \text{ nA}$  $\sqrt{\left(232 \frac{\mu A}{A} \cdot OR\right)^2 + (1.7 \mu A)^2} + 248 \text{ nA}$  $\sqrt{\left(1.2 \frac{mA}{A} \cdot OR\right)^2 + (913 \text{ nA})^2} + 573 \text{ nA}$  $\sqrt{\left(2.9 \frac{mA}{A} \cdot OR\right)^2 + (3.5 \mu A)^2} + 2.5 \text{ mA}$	IEC 60051-9; IEC 60044 Calibrator DATRON 4708
AC Current, Measuring Instruments <sup>1,2</sup>	(1.9 to 19] mA  (0.01 to 1] kHz  (1 to 5] kHz  (5 to 10] kHz  (10 to 30] kHz	$\sqrt{\left(116 \frac{\mu A}{A} \cdot OR\right)^2 + (16 \mu A)^2} + 1.4 \mu A$  $\sqrt{\left(232 \frac{\mu A}{A} \cdot OR\right)^2 + (17 \mu A)^2} + 2.5 \mu A$  $\sqrt{\left(1.2 \frac{mA}{A} \cdot OR\right)^2 + (9.5 \mu A)^2} + 6.0 \text{ mA}$  $\sqrt{\left(2.9 \frac{mA}{A} \cdot OR\right)^2 + (27 \mu A)^2} + 20 \text{ mA}$	IEC 60051-9; IEC 60044 Calibrator DATRON 4708
AC Current, Measuring Instruments <sup>1,2</sup>	(19 to 190] mA (0.01 Hz to 1 kHz]  (1 to 5] kHz  (5 to 10] kHz  (10 to 30] kHz	$\sqrt{\left(116 \frac{\mu A}{A} \cdot OR\right)^2 + (16 \mu A)^2} + 7.7 \mu A$  $\sqrt{\left(232 \frac{\mu A}{A} \cdot OR\right)^2 + (17 \mu A)^2} + 9.3 \mu A$  $\sqrt{\left(1.2 \frac{mA}{A} \cdot OR\right)^2 + (81 \mu A)^2} + 47 \mu A$  $\sqrt{\left(2.9 \frac{mA}{A} \cdot OR\right)^2 + (126 \mu A)^2} + 100 \mu A$	IEC 60051-9; IEC 60044 Calibrator DATRON 4708
AC Current, Measuring Instruments <sup>1,2</sup>	(0.19 mA to 1.9 A] (0.01 Hz to 1 kHz]  (1 to 5] kHz  (5 to 10] kHz	$\sqrt{\left(347 \frac{\mu A}{A} \cdot OR\right)^2 + (203 \mu A)^2} + 98 \mu A$  $\sqrt{\left(521 \frac{\mu A}{A} \cdot OR\right)^2 + (271 \mu A)^2} + 139 \mu A$  $\sqrt{\left(694 \frac{\mu A}{A} \cdot OR\right)^2 + (4.4 \text{ mA})^2} + 787 \mu A$	IEC 60051-9; IEC 60044 Calibrator DATRON 4708
AC Current, Measuring Instruments <sup>1,2</sup>	(1.9 to 3.2] A (0.01 to 3] kHz (3 to 10] kHz	$\sqrt{(0.12 \% \cdot OR)^2 + (3.3 \text{ mA})^2} + 402 \mu A$  $\sqrt{\left(694 \frac{\mu A}{A} \cdot OR\right)^2 + (4.4 \text{ mA})^2} + 1.2 \text{ mA}$	Calibrator FLUKE 5520A
AC Current, Measuring Instruments <sup>1,2</sup>	(3.2 to 10.5] A (0.01 to 3] kHz (3 to 10] kHz	$\sqrt{(0.23 \% \cdot OR)^2 + (9.3 \text{ mA})^2} + 3.1 \text{ mA}$  $\sqrt{(0.58 \% \cdot OR)^2 + (15 \text{ mA})^2} + 10 \text{ mA}$	Calibrator FLUKE 5520A
AC Current, Measuring Instruments <sup>1,2</sup>	(10.5 to 20] A (0.01 to 3] kHz (3 to 10] kHz	$\sqrt{(0.23 \% \cdot OR)^2 + (18 \text{ mA})^2} + 7.0 \text{ mA}$  $\sqrt{(0.58 \% \cdot OR)^2 + (31 \text{ mA})^2} + 23 \text{ mA}$	Calibrator FLUKE 5520A

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Current, Measuring Instruments <sup>1,2</sup>	(20 to 32] A (10 to 100] Hz (100 to 440] Hz	$\sqrt{(0.23\% \cdot \text{OR})^2 + (7.3 \text{ mA})^2} + 69 \text{ mA}$ $\sqrt{(0.90\% \cdot \text{OR})^2 + (32 \text{ mA})^2} + 51 \text{ mA}$	Calibrator FLUKE 5520A
AC Current, Measuring Instruments <sup>1,2</sup>	(32 to 200] A (10 to 100] Hz (100 to 440] Hz	$\sqrt{(0.24\% \cdot \text{OR})^2 + (107 \text{ mA})^2} + 531 \text{ mA}$ $\sqrt{(0.78\% \cdot \text{OR})^2 + (290 \text{ mA})^2} + 446 \text{ mA}$	Calibrator FLUKE 5520A
AC Current, Measuring Instruments <sup>1,2</sup>	(200 to 1 000] A (10 to 100] Hz	$\sqrt{(0.24\% \cdot \text{OR})^2 + (52 \text{ mA})^2} + 2.5 \text{ A}$	Calibrator FLUKE 5520A
AC Current, Sources <sup>1,2</sup>	(0 to 120] $\mu\text{A}$ (10 to 20] Hz (20 to 45] Hz (45 to 1 000] Hz	$\sqrt{(0.46\% \cdot \text{OR})^2 + (31 \text{ nA})^2} + 44 \text{ pA}$ $\sqrt{(0.17\% \cdot \text{OR})^2 + (42 \text{ nA})^2} + 26 \text{ nA}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (42 \text{ nA})^2} + 22 \text{ nA}$	DMM HP 3458A
AC Current, Sources <sup>1,2</sup>	(120 $\mu\text{A}$ to 1.2 mA] (10 to 20] Hz (20 to 45] Hz (45 to 100] Hz (100 Hz to 5 kHz] (5 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.46\% \cdot \text{OR})^2 + (381 \text{ nA})^2} + 271 \text{ nA}$ $\sqrt{(0.17\% \cdot \text{OR})^2 + (381 \text{ nA})^2} + 258 \text{ nA}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (381 \text{ nA})^2} + 225 \text{ nA}$ $\sqrt{\left(347 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (371 \text{ nA})^2} + 13 \text{ pA}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (521 \text{ nA})^2} + 196 \text{ pA}$ $\sqrt{(0.46\% \cdot \text{OR})^2 + (1.3 \mu\text{A})^2} + 642 \text{ pA}$ $\sqrt{(0.64\% \cdot \text{OR})^2 + (5.4 \mu\text{A})^2} + 1.5 \text{ nA}$	DMM HP 3458A
AC Current, Sources <sup>1,2</sup>	(1.2 to 12] mA (10 to 20] Hz (20 to 45] Hz (45 to 100] Hz (100 Hz to 5 kHz] (5 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.46\% \cdot \text{OR})^2 + (3.8 \mu\text{A})^2} + 2.7 \mu\text{A}$ $\sqrt{(0.17\% \cdot \text{OR})^2 + (3.8 \mu\text{A})^2} + 2.6 \mu\text{A}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (3.8 \mu\text{A})^2} + 2.3 \mu\text{A}$ $\sqrt{\left(347 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (3.7 \mu\text{A})^2} + 126 \text{ pA}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (5.2 \mu\text{A})^2} + 2.0 \text{ nA}$ $\sqrt{(0.46\% \cdot \text{OR})^2 + (14 \mu\text{A})^2} + 5.1 \mu\text{A}$ $\sqrt{(0.64\% \cdot \text{OR})^2 + (58 \mu\text{A})^2} + 15 \mu\text{A}$	DMM HP 3458A

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current, Sources <sup>1,2</sup>	(12 to 120] mA (10 to 20] Hz (20 to 45] Hz (45 to 100] Hz (100 Hz to 5 kHz] (5 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.46\% \cdot \text{OR})^2 + (38 \mu\text{A})^2} + 27 \mu\text{A}$ $\sqrt{(0.17\% \cdot \text{OR})^2 + (38 \mu\text{A})^2} + 26 \mu\text{A}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (38 \mu\text{A})^2} + 23 \mu\text{A}$ $\sqrt{\left(347 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (37 \mu\text{A})^2} + 1.3 \text{ nA}$ $\sqrt{\left(694 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (52 \mu\text{A})^2} + 20 \text{ nA}$ $\sqrt{(0.46\% \cdot \text{OR})^2 + (142 \mu\text{A})^2} + 51 \mu\text{A}$ $\sqrt{(0.64\% \cdot \text{OR})^2 + (541 \mu\text{A})^2} + 152 \text{ nA}$	DMM HP 3458A
AC Current, Sources <sup>1,2</sup>	(120 mA to 1.05 A] (10 to 20] Hz (20 to 45] Hz (45 to 100] Hz (100 Hz to 5 kHz] (5 to 20] kHz (20 to 50] kHz	$\sqrt{(0.46\% \cdot \text{OR})^2 + (548 \mu\text{A})^2} + 236 \mu\text{A}$ $\sqrt{(0.19\% \cdot \text{OR})^2 + (548 \mu\text{A})^2} + 222 \mu\text{A}$ $\sqrt{\left(926 \frac{\mu\text{A}}{\text{A}} \cdot \text{OR}\right)^2 + (491 \mu\text{A})^2} + 119 \text{ nA}$ $\sqrt{(0.12\% \cdot \text{OR})^2 + (752 \mu\text{A})^2} + 194 \mu\text{A}$ $\sqrt{(0.35\% \cdot \text{OR})^2 + (1.0 \text{ mA})^2} + 228 \mu\text{A}$ $\sqrt{(1.16\% \cdot \text{OR})^2 + (3.5 \text{ mA})^2} + 459 \mu\text{A}$	DMM HP 3458A
AC Current, Sources <sup>1,2</sup>	(1.05 to 20] A (10 to 1 000] Hz (1 000 Hz to 5 kHz]	690 $\mu\text{A/A}$ 870 $\mu\text{A/A}$	Shunt FLUKE A40A-20A
AC Current, Sources <sup>1,2</sup>	(20 to 100] A (10 to 100] Hz (100 to 400] Hz	8.4 mA/A OR 15 mA/A OR	Calibrator FLUKE 5520A, AC Clamp meter used as transfer standard
AC Current, Sources <sup>1,2</sup>	(100 to 1 000] A (10 to 50] Hz (50 to 100] Hz	8.0 mA/A OR 7.9 mA/A OR	Calibrator FLUKE 5520A, AC Clamp meter used as transfer standard
DC Resistance Measuring Instruments <sup>1</sup>	0 m $\Omega$ 100 $\mu\Omega$ 1 m $\Omega$ 10 m $\Omega$	4.6 $\mu\Omega$ 38 $\mu\Omega/\Omega$ 34 $\mu\Omega/\Omega$ 56 $\mu\Omega/\Omega$	IEC 60051-9 IEC 60477 IEC 60564 Short measurement



**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance Measuring Instruments <sup>1</sup>	100 mΩ 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ	824 μΩ/Ω 9.3 μΩ/Ω 15 μΩ/Ω 9.3 μΩ/Ω 37 μΩ/Ω 12 μΩ/Ω 24 μΩ/Ω 11 μΩ/Ω 18 μΩ/Ω 11 μΩ/Ω	Standard Resistors: Tettex 3200, Tettex 3201 Tettex 3202, Tettex 3203 Tettex 3274, Tettex 3275 Calibrator Datron 4708 Calibrator Fluke 5700A Calibrator Keithley 263
DC Resistance Measuring Instruments <sup>1</sup>	19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ 1 GΩ	17 μΩ/Ω 14 μΩ/Ω 20 μΩ/Ω 32 μΩ/Ω 30 μΩ/Ω 63 μΩ/Ω 67 μΩ/Ω 214 μΩ/Ω 5.1 mΩ/Ω	Standard Resistors: Tettex 3200, Tettex 3201 Tettex 3202, Tettex 3203 Tettex 3274, Tettex 3275 Calibrator Datron 4708 Calibrator Fluke 5700A Calibrator Keithley 263
DC Resistance Measuring Instruments <sup>1,2</sup>	(1 to 20] mΩ (20 to 200] mΩ (200 mΩ to 2 Ω] (2 to 19] Ω (19 to 190] Ω 90) Ω to 1.9 kΩ] (1.9 to 19] kΩ (19 to 190] kΩ (190 k Ω to 1.9 MΩ] (1.9 to 19] MΩ (19 to 190] MΩ	$\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (10.8 \mu\Omega)^2} + 830 \text{ n}\Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (108 \mu\Omega)^2} + 8.3 \mu\Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (1.08 \text{ m}\Omega)^2} + 83 \mu\Omega$ $\sqrt{\left(17.4 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (302 \mu\Omega)^2} + 15.2 \mu\Omega$ $\sqrt{\left(12.7 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (1.2 \text{ m}\Omega)^2} + 65.8 \mu\Omega$ $\sqrt{\left(10.4 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (11 \text{ m}\Omega)^2} + 619 \mu\Omega$ $\sqrt{\left(10.4 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (110 \text{ m}\Omega)^2} + 6.19 \text{ m}\Omega$ $\sqrt{\left(10.4 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (1.4 \Omega)^2} + 58.6 \text{ m}\Omega$ $\sqrt{\left(16.2 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (32.1 \Omega)^2} + 1.07 \Omega$ $\sqrt{\left(34.7 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (638 \Omega)^2} + 61.2 \Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot OR\right)^2 + (23.3 \text{ k}\Omega)^2} + 8.78 \text{ k}\Omega$	Resistance decades, micro-ohmmeter Tettex 2226 or DMM Datron 1281 used as transfer standards

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
DC Resistance Measuring Instruments <sup>1,2</sup>	(190 MΩ to 1.9 GΩ] (1.9 to 10] GΩ	$\sqrt{(0.35\% \text{ OR})^2 + (1.01 \text{ M}\Omega)^2} + 916 \text{ k}\Omega$ 12 mΩ/Ω	Resistance decades, micro-ohmmeter Tettex 2226 or DMM Datron 1281 used as transfer standards
DC Resistance Measuring Instruments <sup>1,2</sup>	(10 to 90] GΩ	58 mΩ/Ω	Resistance decades, micro-ohmmeter Tettex 2226 or DMM Datron 1281 used as transfer standards
DC Resistance, Resistors <sup>1,2</sup>	0 mΩ (100 μΩ to 2 mΩ] (2 to 20] mΩ (20 to 200] mΩ (200 mΩ to 2 Ω] (2 to 19] Ω (19 to 190] Ω (190 Ω to 1.9 kΩ] (1.9 to 19] kΩ (19 to 190] kΩ (190 kΩ to 1.9 MΩ] (1.9 to 19] MΩ (19 to 190] MΩ (190 MΩ to 1.9 GΩ]	290 nΩ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (1.08 \mu\Omega)^2} + 83 \text{ n}\Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (10.8 \mu\Omega)^2} + 830 \text{ n}\Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (108 \mu\Omega)^2} + 8.3 \mu\Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (1.08 \text{ m}\Omega)^2} + 83 \mu\Omega$ $\sqrt{\left(17.4 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (302 \mu\Omega)^2} + 15.2 \mu\Omega$ $\sqrt{\left(12.7 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (1.2 \text{ m}\Omega)^2} + 65.8 \mu\Omega$ $\sqrt{\left(10.4 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (11 \text{ m}\Omega)^2} + 619 \mu\Omega$ $\sqrt{\left(10.4 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (110 \text{ m}\Omega)^2} + 6.19 \text{ m}\Omega$ $\sqrt{\left(10.4 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (1.4 \Omega)^2} + 58.6 \text{ m}\Omega$ $\sqrt{\left(16.2 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (32.1 \Omega)^2} + 1.07 \Omega$ $\sqrt{\left(34.7 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (638 \Omega)^2} + 61.2 \Omega$ $\sqrt{\left(347 \frac{\mu\Omega}{\Omega} \cdot \text{OR}\right)^2 + (23.3 \text{ k}\Omega)^2} + 8.78 \text{ k}\Omega$ $\sqrt{(0.35\% \cdot \text{OR})^2 + (1.01 \text{ M}\Omega)^2} + 916 \text{ k}\Omega$	Micro-ohmmeter Tettex 2226 DMM Datron 1281 OR – Of Reading
AC Resistance. Measuring Instruments <sup>1,2</sup>	[1 to 6.25] Ω [12 to 30] Hz [30 to 100] Hz	$\sqrt{(0.59\% \cdot \text{OR})^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.30\% \cdot \text{OR})^2 + (1.42 \text{ m}\Omega)^2}$	Resistance decades GENRAD 1433-F; 1433-H Digibridge GENRAD 1689M used as transfer standard

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Resistance. Measuring Instruments <sup>1,2</sup>	[1 to 6.25) $\Omega$ [100 to 250) Hz [250 to 1 000) Hz	$\sqrt{(0.23 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.16 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$	Resistance decades GENRAD 1433-F; 1433-H Digibridge GENRAD 1689M used as transfer standard
AC Resistance. Measuring Instruments <sup>1,2</sup>	[1 to 6.25) $\Omega$ 1 kHz (1 to 3] kHz (3 to 6] kHz (6 to 10] kHz (10 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.08 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.16 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.23 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.30 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.45 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(1.21 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(2.39 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$	
AC Resistance. Measuring Instruments <sup>1,2</sup>	[6.25 to 100) $\Omega$ [12 to 30) Hz [30 to 100) Hz [100 to 250) Hz [250 to 1 000) Hz 1 kHz (1 to 3] kHz (3 to 6] kHz (6 to 10] kHz (10 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.10 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.06 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.05 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.03 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.02 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.03 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.05 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.06 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.08 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.20 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.37 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$	Resistance decades GENRAD 1433-F; 1433-H Digibridge GENRAD 1689M used as transfer standard

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Resistance. Measuring Instruments <sup>1,2</sup>	[100 Ω to 1.6 k Ω]		Resistance decades GENRAD 1433-F; 1433-H Digibridge GENRAD 1689M used as transfer standard
	[12 to 30) Hz	$\sqrt{(0.10 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	[30 to 100) Hz	$\sqrt{(0.06 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	[100 to 250) Hz	$\sqrt{(0.05 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	]250 to 1 000) Hz	$\sqrt{(0.03 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	1 kHz	$\sqrt{(0.02 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	(1 to 3] kHz	$\sqrt{(0.03 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	(3 to 6] kHz	$\sqrt{(0.05 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	(6 to 10] kHz	$\sqrt{(0.06 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	(10 to 20] kHz	$\sqrt{(0.10 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	(20 to 50] kHz	$\sqrt{(0.20 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
	(50 to 100] kHz	$\sqrt{(0.37 \% \cdot OR)^2 + (1.02 \Omega)^2}$	
AC Resistance. Measuring Instruments <sup>1,2</sup>	(1.6 to 25.6] kΩ		Resistance decades GENRAD 1433-F; 1433-H Digibridge GENRAD 1689M used as transfer standard
	[12 to 30) Hz	$\sqrt{(0.10 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	[30 to 100) Hz	$\sqrt{(0.06 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	[100 to 250) Hz	$\sqrt{(0.05 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	]250 to 1 000) Hz	$\sqrt{(0.03 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	1 kHz	$\sqrt{(0.02 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(1 to 3] kHz	$\sqrt{(0.03 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(3 to 6] kHz	$\sqrt{(0.05 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(6 to 10] kHz	$\sqrt{(0.06 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(10 to 20] kHz	$\sqrt{(0.08 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(20 to 50] kHz	$\sqrt{(0.20 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(50 to 100] kHz	$\sqrt{(0.37 \% \cdot OR)^2 + (11.7 \Omega)^2}$	

### Electrical Quantities – DC/Low Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance. Measuring Instruments <sup>1,2</sup>	(25.6 to 410] kΩ [12 to 30) Hz [30 to 100) Hz [100 to 250) Hz [250 to 1 000) Hz 1 kHz (1 to 3] kHz (3 to 6] kHz (6 to 10] kHz (10 to 20] kHz	$\sqrt{(0.10\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.06\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.05\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.03\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.02\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.05\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.09\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.20\% \cdot OR)^2 + (102 \Omega)^2}$ $\sqrt{(0.60\% \cdot OR)^2 + (102 \Omega)^2}$	Resistance decades GENRAD 1433-F; 1433-H Digibridge GENRAD 1689M used as transfer standard
AC Resistance, Resistors <sup>1,2</sup>	(1 to 6.25] Ω [12 to 30) Hz [30 to 100) Hz [100 to 250) Hz [250 to 1 000) Hz 1 kHz (1 to 3] kHz (3 to 6] kHz (6 to 10] kHz (10 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.59\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.30\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.23\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.16\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.08\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.16\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.23\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.30\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.45\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(1.21\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(2.39\% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$	Digibridge Genrad 1689M Resistors that have a serial inductance not exceeding 10 μH. The uncertainties will be increased for resistors with higher inductance.

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance, Resistors <sup>1,2</sup>	(6.25 to 100] $\Omega$ [12 to 30) Hz [30 to 100) Hz [100 to 250) Hz [250 to 1 000) Hz 1 kHz (1 to 3] kHz (3 to 6] kHz (6 to 10] kHz (10 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.10 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.06 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.05 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.03 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.02 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.03 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.05 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.06 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.08 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.20 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$ $\sqrt{(0.37 \% \cdot OR)^2 + (1.42 \text{ m}\Omega)^2}$	Digibridge Genrad 1689M Resistors that have a serial inductance not exceeding 10 $\mu\text{H}$ . The uncertainties will be increased for resistors with higher inductance.
AC Resistance, Resistors <sup>1,2</sup>	(100 $\Omega$ to 1.6 k $\Omega$ ) [12 to 30) Hz [30 to 100) Hz [100 to 250) Hz [250 to 1 000) Hz 1 kHz (1 to 3] kHz (3 to 6] kHz (6 to 10] kHz (10 to 20] kHz (20 to 50] kHz (50 to 100] kHz	$\sqrt{(0.10 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.06 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.05 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.03 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.02 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.03 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.05 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.06 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.10 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.20 \% \cdot OR)^2 + (1.02 \Omega)^2}$ $\sqrt{(0.37 \% \cdot OR)^2 + (1.02 \Omega)^2}$	Digibridge Genrad 1689M Resistors that have a serial inductance not exceeding 10 $\mu\text{H}$ . The uncertainties will be increased for resistors with higher inductance

### Electrical Quantities – DC/Low Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance, Resistors <sup>1,2</sup>	(1.6 $\Omega$ to 25.6 k $\Omega$ )		Digibridge Genrad 1689M Resistors that have a serial inductance not exceeding 10 $\mu$ H.  The uncertainties will be increased for resistors with higher inductance
	[12 to 30) Hz	$\sqrt{(0.10 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	[30 to 100) Hz	$\sqrt{(0.06 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	[100 to 250) Hz	$\sqrt{(0.05 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	[250 to 1000) Hz	$\sqrt{(0.03 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	1 kHz	$\sqrt{(0.02 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(1 to 3] kHz	$\sqrt{(0.03 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(3 to 6] kHz	$\sqrt{(0.05 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(6 to 10] kHz	$\sqrt{(0.06 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(10 to 20] kHz	$\sqrt{(0.08 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(20 to 50] kHz	$\sqrt{(0.20 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
	(50 to 100] kHz	$\sqrt{(0.37 \% \cdot OR)^2 + (11.7 \Omega)^2}$	
AC Resistance, Resistors <sup>1,2</sup>	(25.6 $\Omega$ to 410 k $\Omega$ )		Digibridge Genrad 1689M Resistors that have a serial inductance not exceeding 10 $\mu$ H.  The uncertainties will be increased for resistors with higher inductance
	[12 to 30) Hz	$\sqrt{(0.10 \% \cdot OR)^2 + (102 \Omega)^2}$	
	[30 to 100) Hz	$\sqrt{(0.06 \% \cdot OR)^2 + (102 \Omega)^2}$	
	[100 to 250) Hz	$\sqrt{(0.05 \% \cdot OR)^2 + (102 \Omega)^2}$	
	[250 to 1 000) Hz	$\sqrt{(0.03 \% \cdot OR)^2 + (102 \Omega)^2}$	
	1 kHz	$\sqrt{(0.02 \% \cdot OR)^2 + (102 \Omega)^2}$	
	(1 to 3] kHz	$\sqrt{(0.05 \% \cdot OR)^2 + (102 \Omega)^2}$	
	(3 to 6] kHz	$\sqrt{(0.09 \% \cdot OR)^2 + (102 \Omega)^2}$	
	(6 to 10] kHz	$\sqrt{(0.20 \% \cdot OR)^2 + (102 \Omega)^2}$	
	(10 to 20] kHz	$\sqrt{(0.60 \% \cdot OR)^2 + (102 \Omega)^2}$	



### Electrical Quantities – DC/Low Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance, Measuring Instruments <sup>1,2</sup>	1 kHz		IEC 60477 IEC 60564 HP 16381A, HP 16382A HP 16383A, HP 16384A St. Capacitors Genrad 1409 Y, Genrad 1409 L, Genrad 1409 T, Capacitance Decades + Digibridge Genrad 1689M used as a transfer standard
	1 pF	0.19 fF	
	10 pF	1.3 fF	
	100 pF	11 fF	
	1000 pF	110 fF	
	10 nF	1.5 pF	
	100 nF	15 pF	
	1 μF	150 pF	
	[1 to 10] pF	$\sqrt{(0.02 \% \cdot OR)^2 + (2.2 \text{ fF})^2}$	
	(10 to 1 000] pF	$\sqrt{(0.02 \% \cdot OR)^2 + (7.4 \text{ fF})^2}$	
	(1 to 1.5] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (240 \text{ fF})^2}$	
	(1.5 to 6.4] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (680 \text{ fF})^2}$	
	(6.4 to 10] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (740 \text{ fF})^2}$	
	(10 to 25] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (3.3 \text{ pF})^2}$	
	(25 to 100] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (11 \text{ pF})^2}$	
Capacitance, Capacitors <sup>1,2</sup>	1 kHz		Digibridge Genrad 1689M The uncertainties measurement of capacitors that have a dissipation factor $\leq 1\%$ of a lossless capacitor
	[1 to 10] pF	$\sqrt{(0.02 \% \cdot OR)^2 + (2.2 \text{ fF})^2}$	
	(10 to 1 000] pF	$\sqrt{(0.02 \% \cdot OR)^2 + (7.4 \text{ fF})^2}$	
	(1 to 1.5] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (240 \text{ fF})^2}$	
	(1.5 to 6.4] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (680 \text{ fF})^2}$	
	(6.4 to 10] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (740 \text{ fF})^2}$	
	(10 to 25] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (3.3 \text{ pF})^2}$	
	(25 to 100] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (11 \text{ pF})^2}$	
	(100 to 200] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (29 \text{ pF})^2}$	
	(200 to 400] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (46 \text{ pF})^2}$	
	(400 to 1 000] nF	$\sqrt{(0.02 \% \cdot OR)^2 + (102 \text{ pF})^2}$	

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance, Measuring Instruments <sup>1,2</sup>	100 µH		IEC 60477 IEC 60 564 St. Inductors Genrad 1482- B, Genrad 1482-E, Genrad 1482-H, Genrad 1482-L, Genrad 1482-P, Genrad 1482-T, +Digibridge Genrad 1689M Used as a transfer standard
	100 Hz, 400 Hz, 1kHz,	1.1 µH	
	1 mH		
	100 Hz, 400 Hz, 1kHz	1.2 µH	
	10 mH		
	100 Hz, 400 Hz, 1kHz	11 µH	
	100 mH		
	100 Hz, 400 Hz, 1kHz	33 µH	
	1 H		
	100 Hz 400 Hz	1.2 mH 1.3 mH	
	10 H		
	100 Hz	13 mH	
Inductance, Measuring Instruments <sup>1,2</sup>	100 Hz		IEC 60477 IEC 60 564 St. Inductors Genrad 1482- B, Genrad 1482-E, Genrad 1482-H, Genrad 1482-L, Genrad 1482-P, Genrad 1482-T, Inductance Decade +Digibridge Genrad 1689M Used as a transfer standard
	[10 µH to 1mH]	$\sqrt{(9.10\% \cdot OR)^2 + (5.1\mu H)^2}$	
	(1 to 9] mH	$\sqrt{(0.07\% \cdot OR)^2 + (5.1\mu H)^2}$	
	(9 to 90] mH	$\sqrt{(0.11\% \cdot OR)^2 + (3.1\mu H)^2}$	
	(90 to 900] mH	$\sqrt{(0.17\% \cdot OR)^2 + (55\mu H)^2}$	
	(0.9 to 9] H	$\sqrt{(0.05\% \cdot OR)^2 + (11\text{ mH})^2}$	
	(9 to 10] H	$\sqrt{(0.06\% \cdot OR)^2 + (24\text{ mH})^2}$	

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Inductance, Inductors <sup>1,2</sup>	100 Hz [10 µH to 1 mH] (1 to 9] mH (9 to 90] mH (90 to 900] mH (0.9 to 9] H (9 to 90] H (90 to 900] H	$\sqrt{(9.10\% \cdot \text{OR})^2 + (5.1 \mu\text{H})^2}$ $\sqrt{(0.07\% \cdot \text{OR})^2 + (5.1 \mu\text{H})^2}$ $\sqrt{(0.11\% \cdot \text{OR})^2 + (3.1 \mu\text{H})^2}$ $\sqrt{(0.17\% \cdot \text{OR})^2 + (55 \mu\text{H})^2}$ $\sqrt{(0.05\% \cdot \text{OR})^2 + (11 \text{ mH})^2}$ $\sqrt{(0.06\% \cdot \text{OR})^2 + (24 \text{ mH})^2}$ $\sqrt{(0.49\% \cdot \text{OR})^2 + (21 \text{ mH})^2}$	Digibridge Genrad 1689M The uncertainties apply to the measurement of inductors that have a quality factor $\leq 1\%$ of series impedance of an ideal inductor
AC Power, Measuring Instruments <sup>1,2</sup>	[1 to 1 008] V, (0 to 40] Hz, [0 to 20] A [0.00 to 20 160.00] VA PF = 1 20160.00 W PF = 0.8 8 064.00 W 6 048.00 VAR PF = 0.5 5 040.00 W 8 729.54 VAR PF = 0.2 2 016.00 W 19 752.69 VAR	0.06 % OR 0.08 % OR 0.09 % OR 0.05 % OR 0.13 % OR 0.06 % OR 0.32 % OR 0.04 % OR	Calibrator FLUKE 6100B
AC Power, Measuring Instruments <sup>1,2</sup>	(40 to 65] Hz, [0 to 5] A (0.00 to 5 040.00] VA PF = 1 5 040.00 W	0.04 % OR 0.07 % OR	Calibrator FLUKE 6100B
AC Power, Measuring Instruments <sup>1,2</sup>	(0 to 40] Hz, [0 to 20] A PF = 0.8 4 032.00 W 3 024.00 VAR PF = 0.5 2520.00 W 3 117.69 VAR PF = 0.2 720.00 W / 3 527.27 VAR	0.09 % OR 0.05 % OR 0.13 % OR 0.04 % OR 0.32 % OR 0.04 % OR	Calibrator FLUKE 6100B

**Electrical Quantities – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Power, Measuring Instruments <sup>1,2</sup>	(40 to 65] Hz, (5 to 80] A (5 040.00 to 80 640.0] VA PF = 1 80 640.00 W PF = 0.8 64 512.00 W/ 48 384.00 VAR PF = 0.5 40 320.00 W/ 698.29 VAR	0.05 % OR 0.07 % OR 0.09 % OR 0.05 % OR 0.13 % OR 0.05 % OR	Calibrator FLUKE 6100B
AC Power, Measuring Instruments <sup>1,2</sup>	(65 to 850] Hz, (20 to 80] A (20 160.0 to 80 640.0] VA PF = 1 8 0640.00 W PF = 0.8 64 512.00 W 48 384.00 VAR PF = 0.5 4 0320.00 W 6 9836.29 VAR PF = 0.2 16 128.00 W 79 010.74 VAR	0.06 % OR 0.08 % OR 0.13 % OR 0.18 % OR 0.24 % OR 0.09 % OR 0.65 % OR 0.06 % OR	Calibrator FLUKE 6100B
AC Power, Measuring Instruments <sup>1,2</sup>	(65 to 850] Hz (20 to 800 A (20 160.0 to 80 640.0] VA PF = 1 8 0640.00 W	0.06 % OR 0.08 % OR	Calibrator FLUKE 6100B
AC Power, Generating instruments <sup>1</sup>	(45 to 1 000] Hz [11 to 749] V PF range [(0.1 to 1] [1 to 4) W (4 W to 1.42 kW] (1.42 to 75] kW	2.3 mW/W 1 mW/W 3.5 mW/W	DMM DATRON 1281 DMM DATRON 1271 CLAPMETER FLUKE 801-1000S

**Electrical Quantities – DC/Low Frequency**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power factor (PF) Measurement Instruments <sup>1,2,4</sup>	[1 to 1008] V [16 to 850] Hz [0.01 to 80] A PF = 1 PF = 0.9 PF = 0.8 PF = 0.7 PF = 0.6 PF = 0.5 PF = 0.4 PF = 0.3 PF = 0.2 PF = 0.1	0.005 5 0.006 7 0.007 9 0.008 9 0.009 6 0.01 0.011 0.011 0.011 0.011	Calibrator FLUKE 6100B
Power factor Generating Instruments <sup>1,2,4</sup>	[45 to 75] Hz Up to 500 V Up to 10 A PF range [0.1 to 1]	0.03	IEC 60051-9
AC Energy, Single phase Measuring Instruments <sup>1,2</sup>	[1 to 1 008] V [0.01 to 80] A [16 to 850] Hz Max: 1000 h	0.08 % OR	Calibrator FLUKE 6100B

**Electrical – RF/Microwave**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calibration Factor for Power Sensors <sup>1,2</sup>	[100 to 150] kHz [0.15 to 1] MHz [1 to 10] MHz	1.7 % 1.6 % 1.3 %	Power Meter HP 438 with Power sensor HP 8482A
Calibration Factor for Power Sensors <sup>1,2</sup>	[10 to 499] MHz [499 to 580] MHz [580 to 820] MHz (0.82 to 2.6] GHz (2.6 to 3.3] GHz (3.3 to 4.0] GHz (4.0 to 4.5] GHz (4.5 to 5.0] GHz (5.0 to 6.0] GHz	1.1 % 1.2 % 1.3 % 1.4 % 1.5 % 1.6 % 1.7 % 1.8 % 1.9 %	RF REFERENCE SOURCE FLOUKE 96270A With Power Sensors: R & S Z55-1

**Electrical – RF/Microwave**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Calibration Factor for Power Sensors <sup>1,2</sup>	(6 to 8] GHz (8 to 10] GHz (10 to 12] GHz (12 to 15] GHz (15 to 18] GHz	2.0 % 2.1 % 2.2 % 2.3 % 2.4 %	Power Meter HP 438 with Power sensor HP 8485A
RF Attenuation <sup>1,2</sup>	(0 to 4) dB [300 kHz to 3 GHz] (3 to 6] GHz (6 to 18] GHz (4 to 6) dB [300 kHz to 3 GHz] (3 to 6] GHz (6 to 18] GHz	0.09 dB 0.1 dB 0.27 dB 0.1 dB 0.12 dB 0.27 dB	The uncertainties apply to the measurements of devices fitted with connectors that have input/ output VSWR not exceeding 1.1 The uncertainties will be increased for devices with higher VSWR Network analyzers: HP 8757A, HP 8753C
RF Attenuation <sup>1,2</sup>	(6 to 40) dB [300 kHz to 10 MHz) (40 to 45) dB [300 kHz to 10 MHz) (45 to 50) dB [300 kHz to 10 MHz) (50 to 55) dB [300 kHz to 10 MHz) (55 to 60) dB [300 kHz to 10 MHz) (60 to 65) dB [300 kHz to 10 MHz) (65 to 70) dB [300 kHz to 10 MHz) (70 to 75) dB [300 kHz to 10 MHz) (75 to 80) dB [300 kHz to 10 MHz) (80 to 85) dB [300 kHz to 10 MHz) (85 to 90) dB [300 kHz to 10 MHz)	0.13 dB 0.20 dB 0.41 dB 0.51 dB 0.54 dB 0.56 dB 0.64 dB 0.86 dB 1.4 dB 2.1 dB 3.4 dB	Spectrum analyzer Agilent N9030A

**Electrical – RF/Microwave**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
RF Attenuation <sup>1,2</sup>	(6 to 25) dB [10 MHz to 3.6 GHz] (3.6 to 8.4] GHz (8.4 to 17.1] GHz (17.1 to 18] GHz [25 to 40) dB [10 MHz to 3.6 GHz] (3.6 to 8.4] GHz (8.4 to 17.1] GHz (17.1 to 18] GHz [40 to 80] dB [10 MHz to 3.6 GHz] (3.6 to 8.4] GHz (8.4 to 13.6] GHz (13.6 to 17.1] GHz (17.1 to 18] GHz	0.13 dB 0.14 dB 0.16 dB 0.17 dB 0.1 dB 0.12 dB 0.16 dB 0.17 dB 0.1 dB 0.12 dB 0.13 dB 0.14 dB 0.15 dB	Spectrum analyzer Agilent N9030A
Power Source <sup>1,2</sup>	[-100 to -35) dBm) (100 kHz to 60 MHz] (60 MHz to 16 GHz] (8 to 16] GHz (16 to 26.5] GHz	0.16 dB 0.3 dB 0.41 dB 0.52 dB	RF Reference Source FLUKE 96270A for absolute power offset measurement + Spectrum analyzer Agilent N9030A for power measurement exceeding 1.1 The uncertainties will be increased for devices with higher VSWR
Power Source <sup>1,2</sup>	(-35 to 20) dBm [100 kHz to 26.5 GHz]	0.078 dB	RF Reference Source FLUKE 96270A
Power Source <sup>1,2</sup>	(20 to 44) dBm [10 MHz- 2 GHz] (2 to 6] GHz (6 to 9] GHz (9 to 13] GHz (13 to 16] GHz (16 to 18] GHz	0.23 dB 0.24 dB 0.25 dB 0.27 dB 0.31 dB 0.39 dB	Power Meter HP438A With High Frequency Power sensor HP 8481B



**Electrical – RF/Microwave**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Power, Measuring Instruments <sup>1,2</sup>	[-130 to -110) dBm [10 to 240) MHz [240 MHz to 3 GHz]	0.92 dB 2 dB	RF Reference Source FLUKE 96270A
Power, Measuring Instruments <sup>1,2</sup>	[-110 to -35) dBm [100 to 300) kHz [300 kHz to 4] GHz (4 to 26.5] GHz	0.054 dB 0.049 dB 0.1 dB	Power Meter HP438A + High Frequency Power sensors HP 8482A, 8485A with automatic dynamic attenuator and generator error correction
Power, Measuring Instruments <sup>1,2</sup>	[-35 to 20) dBm [100 kHz to 14 GHz] (14 to 26.5] GHz	0.02 dB 0.026 dB	RF Reference Source FLUKE 96270A Power sensor R & S
Power, Measuring Instruments <sup>1,2</sup>	20 dBm [100 kHz to 18 GHz] (20 to 44) dBm (10 MHz to 6 GHz) (2 to 6] GHz (6 to 9] GHz (9 to 13] GHz (13 to 16] GHz (16 to 18] GHz	0.026 dB 0.23 dB 0.24 dB 0.25 dB 0.27 dB 0.3 dB 0.38 dB	Power sensor HP 8481B, HP 8482A, HP 8485A
Relative Power Sources <sup>1,2</sup>	[-80 to -35] dB [100 kHz to 3.6 GHz) (3.6 to 8.4) GHz (8.4 to 13.6) GHz (13.6 to 26.5] GHz	0.15 dB 0.27 dB 0.35 dB 0.41 dB	Spectrum Analyzer Agilent N9030A
Relative Power Sources <sup>1,2</sup>	[-35 to 20) dB [100 kHz to 26.5 GHz]	0.08 dB	RF Reference Source FLUKE 96270A Power sensor R & S
	(20 to 44) dB [10 MHz to 18 GHz] (6 to 9] GHz (9 to 13] GHz (13 to 16] GHz (16 to 26.5] GHz	0.08 dB 0.09 dB 0.01 dB 0.11 dB 0.12 dB	High Frequency Power sensor HP 8481B

**Electrical – RF/Microwave**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Relative Power Measuring Instruments <sup>1,2</sup>	[-110 to -35) dBm (100 kHz to 10 MHz) [10 MHz to 4 GHz] (4 to 18] GHz (18 to 26.5] GHz	0.054 dB 0.044 dB 0.098 dB 0.1 dB	Power Meter HP438A + High Frequency Power sensors HP 8482A, 8485A with automatic dynamic attenuator and generator error correction
Relative Power Measuring Instruments <sup>1,2</sup>	(-35 to 20) dB [100 kHz to 26.5 GHz]	0.014 dB	RF Reference Source FLUKE 96270A Power sensor R & S
Relative Power Measuring Instruments <sup>1,2</sup>	(20 to 44) dB [10 MHz to 18 GHz]	0.08 dB	High Frequency Power sensor HP 8481B
Amplitude Modulation, Sources <sup>1,2</sup>	carrier: [0.15 to 10) MHz: modulation rate: [20 to 50) Hz modulation depth: [10 to 90) % carrier: [0.15 to 10) MHz: modulation rate: [50 Hz to 10 kHz] modulation depth: [10 to 90) % carrier: [10 MHz to 1.3 GHz] modulation rate: [20 to 50) Hz modulation depth: [10 to 90) % carrier: [10 MHz to 1.3 GHz] modulation rate: [50 Hz to 50 kHz] modulation depth [10 to 90) %	3.6 % OR  2.4 % OR  3.6 % OR  13 % OR	Modulation Analyzer HP 8901 B

**Electrical – RF/Microwave**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Amplitude Modulation, Sources <sup>1,2</sup>	carrier: [10 MHz to 1.3 GHz] modulation rate: (50 to 100) kHz modulation depth [10 to 90) %	3.6 % OR	Modulation Analyzer HP 8901 B
Frequency Modulation, Sources <sup>1,2</sup>	carrier: [0.25 to 10] MHz modulation rate: [20 Hz to 10 kHz] frequency deviation: [0.1 to 4) kHz carrier: [0.25 to 10] MHz modulation rate: [20 Hz to 10 kHz] frequency deviation: [4 to 40] kHz carrier: [10 MHz to 1.3 GHz] modulation rate: [20 to 50) Hz frequency deviation: [0.1 to 4) kHz carrier: [10 MHz to 1.3 GHz] modulation rate: [20 to 50) Hz frequency deviation: [4 to 40) kHz carrier: [10 MHz to 1.3 GHz] modulation rate: [20 to 50) Hz frequency deviation: [40 to 40) kHz	$\sqrt{(2.3\% \text{ OR})^2 + (3 \text{ Hz})^2}$ $\sqrt{(2.3\% \text{ OR})^2 + (31 \text{ Hz})^2}$ $\sqrt{(5.8\% \text{ OR})^2 + (3 \text{ Hz})^2}$ $\sqrt{(5.8\% \text{ OR})^2 + (31 \text{ Hz})^2}$ $\sqrt{(5.8\% \text{ OR})^2 + (218 \text{ Hz})^2}$	Spectrum Analyzer Agilent N9030A

**Electrical – RF/Microwave**

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation, Sources <sup>1,2</sup>	carrier: [10 MHz to 1.3 GHz] modulation rate: [50 to 10] kHz frequency deviation: [0.01 to 4] kHz	$\sqrt{(1.2\% \text{ OR})^2 + (3 \text{ Hz})^2}$	Spectrum Analyzer Agilent N9030A
	carrier: [10 MHz to 1.3 GHz] modulation rate: { 50 Hz to 100 kHz} frequency deviation: [4 to 40] kHz	$\sqrt{(1.2\% \text{ OR})^2 + (31 \text{ Hz})^2}$	
	carrier: [10 MHz to 1.3 GHz] modulation rate: [50 Hz to 100 kHz] frequency deviation: [40 to 400] kHz	$\sqrt{(1.2\% \text{ OR})^2 + (218 \text{ Hz})^2}$	
	carrier: [10 MHz to 1.3 GHz] modulation rate: (00 Hz to 200 kHz) frequency deviation: [4 kHz to 40 kHz]	$\sqrt{(5.8\% \text{ OR})^2 + (31 \text{ Hz})^2}$	
Distortion, Sources	carrier: [10 MHz to 1.3 GHz] modulation rate: (00 Hz to 200 kHz) frequency deviation: (40 to 400] kHz	$\sqrt{(5.8\% \text{ OR})^2 + (218 \text{ Hz})^2}$	HP 8903
	[0.001 to 100] %: [20 Hz to 20 kHz] (20 to 100] kHz	$\sqrt{(13.9\% \text{ OR})^2 + (0.00058 \%)^2}$ $\sqrt{(29.0\% \text{ OR})^2 + (0.00058 \%)^2}$	

**Electrical – RF/Microwave**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Voltage reflection coefficient (VRC) <sup>1,2,4</sup>	[300 kHz to 3 GHz]		The results may also be expressed in terms of VSWR or Return Loss (dB) with uncertainties stated in the appropriated units. Network Analyzer HP 8753C The uncertainties are for one-port or tow - port device with greater than 25 dB transmission loss.
	(0 to 0.01)	0.008	
	(0.01 to 0.1)	0.009	
	(0.1 to 0.2)	0.01	
	(0.2 to 0.3)	0.012	
	(0.3 to 0.4)	0.014	
	(0.4 to 0.5)	0.016	
	(0.5 to 0.6)	0.019	
	(0.6 to 0.7)	0.023	
	(0.7 to 0.8)	0.026	
	(0.4 to 0.5)	0.016	
	(0.5 to 0.6)	0.019	
	(0.6 to 0.7)	0.023	
	(0.7 to 0.8)	0.026	
	(0.8 to 0.9)	0.03	
	(0.9 to 1.0)	0.034	
Voltage reflection coefficient (VRC) <sup>1,2,4</sup>	(3 to 6] GHz		The results may also be expressed in terms of VSWR or Return Loss (dB) with uncertainties stated in the appropriated units. Network Analyzer HP 8753C The uncertainties are for one-port or tow - port device with greater than 25 dB transmission loss.
	(0 to 0.01)	0.012	
	(0.01 to 0.1)	0.013	
	(0.1 to 0.2)	0.015	
	(0.2 to 0.3)	0.018	
	(0.3 to 0.4)	0.022	
	(0.4 to 0.5)	0.025	
	(0.5 to 0.6)	0.03	
	(0.6 to 0.7)	0.035	
	(0.7 to 0.8)	0.04	
	(0.8 to 0.9)	0.046	
	(0.9 to 1.0)	0.052	
Voltage reflection coefficient (VRC) <sup>1,2,4</sup>	(6 to 12] GHz		Network Analyzer HP 8757A
	(0.00 to 1.00]	0.034	
	(12 to 18] GHz		
	(0.01 to 1.00] GHz	0.042	

**Length – Dimensional metrology**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Length, Dimensions of Traffic Camera's Loop Field <sup>2,3</sup>	[1 to 5] m	(1 + L/2) mm	Reference Measuring Tape

### Length – Dimensional metrology

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Traffic Speed, Gatso Loop Detector Traffic Cameras <sup>1,2</sup>	[20 to 250] km/h	1 km/h	Calibration of Gatso loop detector traffic speed cameras by means of 4 lanes simulator. The scope of accreditation comprises conducting camera self-tests and speed limit accuracy tests. The results of these tests may be included in the calibration certificates.
Distance- Calibration of City Train Tachograph <sup>2</sup>	(875 to 885) m	2 m	Reference Measuring Tape CP 25.240
Speed -Calibration of City Train Tachograph <sup>2</sup>	(10 to 70) km/h	0.45 km/h	GPS Standard Instrument The scope of accreditation comprises tests hereafter. The results may be included in the certificates. Tachograph, Functional tests according regulator's specification Functional tests will cover items (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), (l), (m). Chapter 5 paragraph 20(5) of Railroad Regulations.
Perpendicularity, Height Gauge <sup>1</sup>	(-1 to 1) mm (gauge height up to 600 mm)	5 $\mu$ m	JIS B7517; BS 1643 Gauge blocks, Angle Plate WYLER
Perpendicularity, Squares <sup>1</sup>	[0 to 300] mm (300 to 600) mm	3 $\mu$ m 5 $\mu$ m	JIS B 7526; DIN 875 Height up to 600 mm Grade "00" Standard Angle plate WYLER, Gauge blocks.
Angle, Sine Bars <sup>1</sup>	[0 to 45] °	22 $\mu$ rad	DIN 2273; JIS B 7523 BS 3064 Base length up to 200 mm Grade "1" Gauge blocks, Angle gauges
Angle, Bevel protractors <sup>1</sup>	(-90 to 90) °	0.6 mrad	BS 1685; GGG-P-676b Angle gauges TSUGAMI Scale interval 5'

**Length – Dimensional metrology**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Angle, Levels <sup>1</sup>	Up to $\pm 3^\circ$ $\pm (3 \text{ to } \pm 10)^\circ$ $\pm (10 \text{ to } \pm 20)^\circ$ $\pm (20 \text{ to } \pm 30)^\circ$	0.5 " 1 " 2 " 3 "	JIS B 7510; DIN 877; BS 958; BS 3509 Small angles generator, 1 $\mu\text{m/m}$ sensitivity
Form, Flatness, Surface Plates, Granite <sup>1,2,3</sup>	ISO 8512-2, BS 817, DIN 876 Grades	$(2 + 0.5 \times L) \mu\text{m}$	Surface Plate 250 x 250 mm minimum size up to 4 m in diagonal Grade "0" Electronic level WYLER
Gauge Blocks <sup>1,3</sup>	[0.5 to 100] mm	$(0.1 + L) \mu\text{m}$	ISO 3650; DIN 861; BS 888; ISO 3650; BS 4311 Gauge blocks, Comparator Tesa, The calibration method is the comparison
Length Bars <sup>1,3</sup>	[1 to 1000] mm	$(1 + 5 \times L) \mu\text{m}$	BS 870; JIS B 7502; DIN 863-1 Gauge blocks, Comparator (Dial indicator MAHR, length measuring instrument MAHR) The calibration method is the comparison
Caliper <sup>1,2,3</sup>	[0.5 to 1000] mm	$(15 + 20 \times L) \mu\text{m}$	ISO 6906; ISO 3599; DIN 862; JIS B 7507 Gauge blocks, CMC stands for caliper resolution 0.01 mm.
Depth Caliper <sup>1,2,3</sup>	Up to 200 mm	$(10 + 10 \times L) \mu\text{m}$	DIN 862 CMC stands for caliper resolution 0.01 mm. Gauge blocks, Depth micro checker
Micrometer External <sup>1,2,3</sup>	Up to 100 mm <sup>1</sup> Up to 100 mm <sup>2</sup> (100 to 1 000) mm <sup>1</sup>	2 $\mu\text{m}$ 3 $\mu\text{m}$ $(2 + 8 \times L) \mu\text{m}$	ISO 3611; DIN 863; JIS B 7502 Gauge blocks CMC stands for resolution 0.001 mm
Micrometer Internal, Duo-bore <sup>1</sup>	[30 to 100] mm	3 $\mu\text{m}$	DIN 863 Standard Plain rings



**Length – Dimensional metrology**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Micrometer Depth <sup>1</sup>	Up to 200 mm	2 $\mu$ m	DIN 863 Depth micro checker, Mitutoyo, Measuring machine
Micrometers, Indicating, Main Scale <sup>1</sup>	Up to 100 mm	2 $\mu$ m	JIS B 7520 Gauge blocks CMC stands for resolution 0.001 mm
Micrometers, Indicating Indicator Scale <sup>1</sup>	[5 to 100] mm	2 $\mu$ m	DIN 863 Standard Plain Rings
Micrometer Internal, Tri-o- Bore <sup>1</sup>	[5 to 100] mm	2 $\mu$ m	DIN 863 Standard Plain Rings
Height Gauge <sup>1,2,3</sup>	Up to 1 000 mm	(2+4 $\times$ L) $\mu$ m	JIS B7517; BS 1643 Gauge blocks CMC stands for resolution 0.001 mm
Dial Gauge <sup>1</sup>	Up to 100 mm	1 $\mu$ m	DIN 878; JIS B7503; ANSI/ASME B89.1.10M XPE-11-056 Calibration Testers Mitutoyo, Measuring machine, CMC stands for resolution 0.1 $\mu$ m
Dial Gauge Lever <sup>1</sup>	(-0.1 to 0.1) mm	1.5 $\mu$ m	DIN 2270; JIS B 7533 Calibration Testers Mitutoyo, Measuring machine CMC stands for resolution of 0.2 $\mu$ m
Dial Indicator Symmetric Scale <sup>1</sup>	(-0.25 to 0.25) mm	1 $\mu$ m	DIN 879 Calibration testers Mitutoyo, Plain Rings CMC stands for resolution of 0.1 $\mu$ m
Bore Gauges <sup>1</sup>	[3.6 to 100] mm	2 $\mu$ m	JIS B 7515 Calibration Testers Mitutoyo, Plain rings CMC stands for resolution of 0.5 $\mu$ m
Extensometer <sup>1,2</sup>	Up to 5 mm	3.5 $\mu$ m	ISO 9513; JIS B 7741; ASTME B3; BS 3846 Standard Extensometer Standard Dial Gauge

**Length – Dimensional metrology**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Measuring table scale, Microscope <sup>1,2</sup>	Up to 275 mm	5 $\mu$ m	JIS B 7153 Standard Glass Scale CMC stands for magnification of x50 and resolution of 1 $\mu$ m
Comparator- Tesa Modul UPC <sup>1</sup>	(-0.01 to 0.01) mm	0.05 $\mu$ m	EURAMET/ cg-02 Gauge blocks, CMC stands for max. nom. Length for comparison 100 mm.
Horizontal Measuring Machine <sup>1,3</sup>	Up to 250 mm	(0.12+3×L) $\mu$ m	Gauge blocks CMC stands for resolution of 0.1 $\mu$ m
Depth Microchecker <sup>1,3</sup>	Up to 300 mm	(1+3×L) $\mu$ m	Gauge blocks
Length, Electrical Comparator <sup>1</sup>	(-1 to 1) mm	0.3 $\mu$ m	Gauge blocks CMC stands for resolution of 0.1 $\mu$ m
Length, Calibration Testers For Dial Gauges <sup>1</sup>	Up to 25 mm	0.8 $\mu$ m	Gauge blocks Electrical Comparator L-in meters CMC stands for resolution of 0.5 $\mu$ m
Length, Calibration Testers For Precision Dial Gauges <sup>1</sup>	Up to 5 mm	0.4 $\mu$ m	Gauge blocks Electrical Comparator L-in meters CMC stands for resolution of 0.1 $\mu$ m
Length Laser Distance Measurer <sup>1</sup>	Up to 4 m 24 m	1 mm 3 mm	Standard 4 m long rule Standard 24 m long set up
Thickness, Feeler Gauge <sup>1</sup>	[0.01 to 2] mm	2.5 $\mu$ m	JIS B 7524; DIN 2275 Measuring machine Standard Gauge Block
Diameter Plain Plug Gauges <sup>1,3</sup>	[0.5 to 150] mm	(1+3×D) $\mu$ m	BS 969; ISO/R 1938; DIN 7150; DIN 7162; DIN 2269 Measuring machine Standard Plugs

### Length – Dimensional metrology

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Major Diameter, Thread Plug Gauges, Parallel <sup>1</sup>	[0.5 to 150] mm	2 $\mu$ m	ISO 965; ISO 724; ISO 1502; FED - STD H28/6A; ANSI/ASME B1.2; ISO 5864; ISO 228/1; ISO 228/2; ANSI/ASME B1.20.1; FED-STD H28/7A; BS 84; BS 919; MIL-ST-21309E; BS 3409; BS 2710; Measuring Machine, Standard Plugs
Simple Pitch Diameter, Thread Plug Gauges, Parallel <sup>1</sup>	[0.5 to 150] mm	3 $\mu$ m	ISO 965; ISO 724; ISO 1502; FED - STD H28/6A; ANSI/ASME B1.2; ISO 5864; ISO 228/1; ISO 228/2; ANSI/ASME B1.20.1; FED-STD H28/7A; BS 84; BS 919; MIL-ST-21309E; BS 3409; BS 2710 Measuring machine, Wires for screw thread measuring, Standard Plugs
Pitch Diameter, Thread Plug Gauges, Tapered <sup>1</sup>	[1.5 to 150] mm	5 $\mu$ m	ANSI/ASME B1.20.1; BS 21; ISO 7; DIN 2999; ASME B1.20.5; AS 2710 Measuring machine, Wires for screw thread measuring Standard Plugs
Major Diameter, Thread Plug Gauges, Tapered <sup>1</sup>	[1.5 to 150] mm	3 $\mu$ m	ANSI/ASME B1.20.1; BS 21; ISO 7; DIN 2999; ASME B1.20.5; AS 2710 Measuring machine, Standard Plugs

### Length – Dimensional metrology

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Stand off from Reference Plane Thread Ring Gauges, Tapered sizes 1/16" to 3" <sup>1</sup>	[-5 to 5] mm	20 $\mu$ m	ISO 7-2; ANSI/ASME B1.20.1 Standard Check Plug Gauges
Dimension Thread Ring Gauges, Tapered sizes 1/16" to 6" <sup>1</sup>	[1 to 50] mm	4 $\mu$ m	ISO 7-2; ANSI/ASME B1.20.1 Length dimensions
Diameter, Plain Ring Gauges, Parallel <sup>1</sup>	[2.5 to 200] mm	1.5 $\mu$ m	BS 969; ISO/R 1938; DIN 7150; DIN 7162; BS 4064; ANSI/ASME B89. 1.6 M Standard Ring Gauges, Measuring machine
Diameter, Thread Measuring, Wires <sup>1</sup>	[0.15 to 4] mm	0.6 $\mu$ m	JIS B 0271; BS 5590 Measuring machine, Standard Wires
Simple Pitch Diameter, Minor Diameter Thread Ring Gauges, Parallel <sup>1</sup>	[4 to 200] mm	3 $\mu$ m	ISO 965; ISO 724; ISO 1502; ANSI/ASME B.1.2; ISO 5864; ISO 228/1; ISO 228/2; ANSI/ASME B.1.20.1; FED-STD H28/7A; BS 919; AS 2710 Measuring machine, Standard Feelers for the thread measurement Standard Ring Gauge Parallel
Measuring table scale, Profile Projector <sup>1,2</sup>	Up to 275 mm	5 $\mu$ m	JIS B 7153; JIS B 7184 Standard Glass Scale CMC stands for magnification of x50 and resolution of 1 $\mu$ m

**Length – Dimensional metrology**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Opening size, Test sieves <sup>1,2</sup>	[20 µm to 5.6. mm] <sup>1</sup>  [6.3 mm to 125 mm] <sup>1,2</sup>	4 µm or ¼ of Y whichever greater  0.5 mm or ¼ of Y whichever lower	BS 410-1; BS410-2; ASTM E11; ASTM E323-09 Y – tolerance of average opening size for wire test sieves or individual hole size tolerance for perforated sieve. Caliper Optical projector

**Mass and Mass Related**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Torque Torque Wrenches and Drivers <sup>1</sup>	[0.05 to 1 000] N·m	0.75 % of Readings of Standard Instrument	Standard BS EN ISO 6789; ASME B107.300 Transducer
Torque Torque Wrenches and Drivers <sup>2</sup>	[0.05 to 50] N·m	1 % of Readings of Standard Instrument	Standard BS EN ISO 6789; ASME B107.300 Transducer
Torque Mechanical and Electronic Torque Calibration Equipment <sup>1</sup>	[0.05 to 1 000] N·m	0.1 % of Readings	Standard BS 7882; ASME B107.300; Euramet cg-14 Mass and Lever
Mass, Weights <sup>1</sup>	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	0.003 3 mg 0.003 3 mg 0.003 3 mg 0.003 3 mg 0.003 3 mg 0.004 mg 0.005 mg 0.006 mg 0.007 mg 0.007 mg 0.01 mg 0.01 mg 0.012 mg 0.026 mg 0.05 mg	OIML R111-1; OIML R52; Standard Weights Class E1, Standard Comparator, Comparison.

**Mass and Mass Related**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Mass, Weights <sup>1</sup>	100 g 200 g 500 g 1 kg 2 kg 5 kg 10 kg 20 kg	0.06 mg 0.07 mg 0.17 mg 1.6 mg 2.0 mg 2.6 mg 150 mg 150 mg	OIML R111-1; OIML R52; Standard Weights Class E1, Standard Comparator, Comparison.
Non-automatic Weighing Instruments <sup>1,2</sup>	Up to 5 000 kg	$2 \times \sqrt{\left(\frac{res}{3.4}\right)^2 + \left(\frac{mpe}{1.7}\right)^2}$	OIML R 76-1 Euramet cg 18 res: the resolution of the balances at the calibration point mpe: maximum permissible error of the weights as defined in Table 1, OIML R 111-1 Available standard weights are: E1 from 1 mg to 5 kg, E2 from 1 mg to 5 kg, F1 from 1 mg to 10 kg F2 from 1 mg to 10 kg M1 from 100 g to 10 kg M2 10 kg (100 pieces)
Pneumatic Pressure - Gauge Pressure measuring instruments <sup>1</sup>	[-98 to -20) kPa [-20 to -7) kPa [-7 to -2.5) kPa [-2.5 to 2.5] kPa (2.5 to 7] kPa (7 to 10) kPa [10 kPa to 7 MPa] (7 to 10] MPa	10 Pa +0.2 Pa/kPa 15 Pa 3 Pa 1 Pa 3 Pa 15 Pa 0.25 Pa/kPa 1 Pa/kPa	OIML R 101; OIML R 109; ASME B40.100; EURAMET cg 17; BS EN 837; BS EN ISO 5171 Gas Dead Weight Tester
Pneumatic Pressure - Gauge Pressure measuring instruments <sup>2</sup>	[-95 to -20) kPa [-20 to -7) kPa [-7 to -2.5) kPa [-2.5 to 2.5] kPa (2.5 to 7] kPa (7 to 20] kPa (20 kPa to 6 MPa) (6 to 70] MPa	20 Pa +0.1 Pa/kPa 15 Pa 3 Pa 1 Pa 3 Pa 15 Pa 1 Pa/kPa 1 Pa/kPa	Pressure in 6 MPa to 70 MPa range generated by customer IDOS UPMP Transducer Standard Pressure Gauge



**Mass and Mass Related**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Pneumatic Pressure - Absolute. Pressure measuring instruments <sup>1</sup>	[2 to 80] kPa (80 to 115] kPa (115 kPa to 7.1 MPa]	35 Pa 20 Pa $\sqrt{[0.00025 * (P_i - P_{barometric})]}$ Pa	$P_i$ – measured value of absolute pressure $P_{barometric}$ – ambient barometric pressure during the $P_i$ measurement.
Pneumatic Pressure - Absolute. Pressure measuring instruments <sup>2</sup>	[5 to 200] kPa [200 kPa to 6.1 MPa]	120 Pa $\sqrt{[0.001 * (P_i - P_{barometric})]^2 +}$ Pa	$P_i$ – measured value of absolute pressure $P_{barometric}$ – ambient barometric pressure during the $P_i$ measurement
Hydraulic pressure - Gauge Pressure measuring instruments <sup>1</sup>	[0.1 to 0.16] MPa [0.16 to 120] MPa	0.3 Pa/kPa 0.25 Pa/kPa	Oil Dead Weight Tester
Hydraulic pressure - Gauge Pressure measuring instruments <sup>2</sup>	[0.1 to 70] MPa (70 to 120] MPa	1 Pa/kPa 0.5 MPa	Pressure Gauge

**Thermodynamic**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Temperature, Liquid in Glass Thermometers <sup>1</sup>	[-60 to 250] °C (250 to 500] °C	0.03 °C 0.095 °C	ASTM E1; ASTM E77; SPRT set, HART 1595A Superthermometer
Temperature, Thermocouples, Base Metal Type K, N, thermocouples <sup>1,2</sup>	[-100 to -60] °C <sup>1</sup> [-60 to 0] °C <sup>1</sup> [0 to 50] °C <sup>1</sup> (50 to 100] °C <sup>1</sup> [100 to 250] °C <sup>1</sup> (250 to 500] °C <sup>1</sup> (500 to 600] °C <sup>1</sup> (600 to 1 100] °C <sup>1</sup> (1 100 to 1 300] °C <sup>1</sup> [-100 to 600] °C <sup>2</sup>	0.3 °C 0.1 °C 0.05 °C 0.1 °C 0.15 °C 0.2 °C 0.4 °C 1.4 °C 2.3 °C 0.5 °C	ASTM E220; ASTM E230 SPRT set HART 1595A Superthermometer Type R standard thermocouple



**Thermodynamic**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Temperature, Thermocouples, Noble Metal Type S, R thermocouples <sup>1,2</sup>	[0 to 500] °C <sup>1</sup> (500 to 600] 0C <sup>1</sup> (600 to 1 100] 0C <sup>1</sup> (1 100 to 1 300] °C <sup>1</sup> [0 to 600] °C <sup>2</sup>	0.4 °C 1 °C 1.4 °C 2.3 °C 1 °C	ASTM E220; ASTM E230 SPRT set, HART 1595A Superthermometer Type R standard thermocouple
Temperature, Extension cables <sup>1</sup>	[-100 to 1 300] °C	As for thermocouples of the same type	ASTM E220; ASTM E230 Extension cables calibrated at room temperatures
Temperature, Temperature indicators and simulators for Noble metal thermocouples <sup>1</sup>	[-200 to 500] °C (500 to 1 800] °C	0.5 °C 0.3 °C	Euramet cg11 Calibration by means of electrical simulation Including cold junction compensation
Temperature, Temperature indicators and simulators for Base metal thermocouples <sup>1</sup>	[-200 to 1 380] °C	0.15 °C	Euramet cg11 Calibration by means of electrical simulation Including cold junction compensation
Temperature, Temperature indicators and simulators for Base metal thermocouples <sup>2</sup> Type E thermocouples Type J thermocouples Type K thermocouples Type N thermocouples Type T thermocouples	[-250 to -100] °C (-100 to 1 000] °C [-210 to -100] °C (-100 to -1 200] °C [-200 to 1 000] °C (1 000 to 1 372] °C [-200 to -100] °C (-100 to 1 300] °C [-250 to -150] °C (-150 to 0] °C (0 to 400] °C	0.6 °C 0.3 °C 0.4 °C 0.3 °C 0.3 °C 0.5 °C 0.5 °C 0.3 °C 0.7 °C 0.3 °C 0.2 °C	Euramet cg11 Calibration by means of electrical simulation Including cold junction compensation
Temperature, Temperature indicators and simulators for Noble metal thermocouples Type R, S thermocouples <sup>2</sup>	[-200 to 1 800] °C	0.8 °C	Euramet cg11
Temperature, Resistance thermometers <sup>1</sup>	0.01 °C	0.003 °C	WTP Standard cell

**Thermodynamic**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Temperature, Resistance thermometers <sup>1,2</sup>	[-100 to -60] °C <sup>1</sup> (-60 to 230] °C <sup>1</sup> (230 to 500] °C <sup>1</sup> (500 to 600] °C <sup>1</sup> (600 to 960] °C <sup>1</sup> [-100 to 600] °C <sup>2</sup>	0.25 °C 0.023 °C 0.06 °C 0.3 °C 1.3 °C 0.3 °C	ASTM E1137; ASTM E644 SPRT set, HART 1595A Superthermometer
Temperature, Temperature indicators and simulators for Resistance sensors <sup>1</sup>	[-200 to 100] °C (100 to 300] °C (300 to 500] °C (500 to 850] °C	0.01 °C 0.02 °C 0.03 °C 0.04 °C	Euramet cg11
Temperature, Infrared Thermometers <sup>1</sup>	[-15 to 120] °C (120 to 200] °C [200 to 500] °C	0.7 °C 1 °C 0.005 °C/°C	Infrared Calibrator Fluke 4180, 4181
Temperature, Block Calibrators <sup>1</sup>	[-100 to 100] °C (100 to 250] °C (250 to 660] °C (660 to 1 100] °C (1 100 to 1 300] °C	0.07 °C 0.1 °C 0.17 °C 1.3 °C 3 °C	Euramet cg13
Temperature, Block Calibrators Stability test <sup>1</sup>	[-100 to 250] °C (250 to 660] °C (660 to 1 300] °C	0.01 °C 0.03 °C 0.2 °C	Euramet cg13
Temperature Block Calibrators Uniformity test <sup>1</sup>	[-100 to 250] °C (250 to 660] °C (660 to 1 300] °C	0.03 °C 0.06 °C 0.4 °C	Euramet cg13
Temperature, Liquid baths <sup>1,2</sup>	[-100 to 250] °C (250 to 500] °C	0.032 °C 0.07 °C	SPRT Type 5699
Temperature Liquid baths Stability test <sup>1</sup>	[-100 to 550] °C	0.001 °C	SPRT Type 5699
Temperature uniformity test, Baths <sup>1</sup>	[-100 to 550] °C	0.01 °C	Standard Thermometer
Temperature, temperature indicators and controllers in Furnaces, Freezers, Climatic Rooms/ Cells <sup>1,2</sup>	[-60 to 90] °C (90 to 120] °C (120 to 370] °C (370 to 800] °C (800 to 1 300] °C	0.5 °C 0.9 °C 1.8 °C 3.8 °C 6 °C	IEC 60397; IEC 60398 Secondary Standard Thermometer sets
Temperature uniformity test, Furnaces, Freezers, Climatic Rooms/ Cells <sup>1,2</sup>	[-60 to 90] °C (90 to 120] °C (120 to 370] °C (370 to 800] °C (800 to 1 300] °C	0.5 °C 0.9 °C 1.8 °C 3.8 °C 6.0 °C	IEC 60397; IEC 60398 Secondary Standard Thermometer sets

**Thermodynamic**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Relative Humidity, Hygrometers, Humidity Recorders <sup>1</sup>	23 °C ± 4 °C ambient [10 to 80] %RH)	0.8 %RH	Comparison to Standard humidity probe in Humidity Generator
Relative Humidity, Hygrometers, Humidity Recorders <sup>1</sup>	23 °C ± 4 °C ambient [4 to 95) %RH	0.5 %RH+ 2 % OR	Comparison to Standard GE Dew point humidity monitor with optical sensor in Humidity Generator
Relative Humidity, Hygrometers, Humidity Recorders <sup>1</sup>	(25 to 60) °C [35 to 95] %RH	0.5 %RH+ 2 % OR	Comparison to Standard GE Dew point humidity monitor with optical sensor in Temp & Humidity chamber.
Dew Point <sup>1</sup>	[-30 to 60] °C	0.3 °C	Standard GE Dew point humidity monitor with optical sensor
Relative Humidity, Indicators and controllers, Humidity Rooms/ Cells, Uniformity test <sup>1,2</sup>	23 °C ± 4 °C [10 to 80] %RH  [19 to 60] °C (4 to 95] %RH	1.5 %RH   2%RH+ 1.5% OR	Temperature and humidity sensors

**Time and Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Time Interval, Measuring instruments <sup>1</sup>	[150 ns to 10 s] (10 to 100] s (100 s to 2 h) (2 to 20] h (20 to 27] h	2 x 10 <sup>-9</sup> s 2.3 x 10 <sup>-10</sup> s 3.7 x 10 <sup>-11</sup> s 6.5 x 10 <sup>-12</sup> s 9.3 x 10 <sup>-13</sup> s	Counter HP 53131 A locked to GPS
Time Interval, Mechanical Stopwatch <sup>1</sup>	[10 s- 24 h]	0.5 s	Clock locked to GPS
Time Interval, Source instruments <sup>1</sup>	[150 ns to 100 s]	2 x 10 <sup>-9</sup> s	Counter HP 53131A locked to GPS

**Time and Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Oscilloscopes Horizontal Sensitivity <sup>1,2</sup>	1 ns/div	0.18 % OR	Fluke 5522A Multiproduct Calibrator
	2 ns/div	0.18 % OR	
	5 ns/div	0.15 % OR	
	10 ns/div	0.18 % OR	
	20 ns/div	0.18 % OR	
	50 ns/div	0.15 % OR	
	100 ns/div	0.18 % OR	
	200 ns/div	0.18 % OR	
	500 ns/div	0.15 % OR	
	1 $\mu$ s/div	0.18 % OR	
	2 $\mu$ s/div	0.18 % OR	
	5 $\mu$ s/div	0.15 % OR	
	10 $\mu$ s/div	0.18 % OR	
	20 $\mu$ s/div	0.18 % OR	
	50 $\mu$ s/div	0.15 % OR	
	100 $\mu$ s/div	0.18 % OR	
	200 $\mu$ s/div	0.18 % OR	
	500 $\mu$ s/div	0.15 % OR	
	1 ms/div	0.18 % OR	
	2 ms/div	0.18 % OR	
Oscilloscopes Vertical Sensitivity <sup>1,2</sup>	50 V/div	0.33 % OR	Fluke 5522A Multiproduct Calibrator
	20 V/div	0.29 % OR	
	10 V/div	0.29 % OR	
	2 V/div	0.29 % OR	
	1 V/div	0.29 % OR	
	5 V/div	0.29 % OR	
	500 mV/div	0.29 % OR	
	200 mV/div	0.29 % OR	
	100 mV/div	0.3 % OR	
	50 mV/div	0.31 % OR	
	20 mV/div	0.33 % OR	
	10 mV/div	0.37 % OR	
	5 mV/div	0.45 % OR	
	2 mV/div	0.76 % OR	
	1 mV/div	1.1 % OR	

### Time and Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes Bandwidth <sup>1,2</sup>	[50 kHz to 100 MHz] Level= 4.0 %	1.2 minor divisions for a major graticule divided in 5 minor divisions	Uncertainties are for RF voltage displayed relative to a reference voltage level at 50 kHz, /6 graticules (=30 minor divisions ).
	(100 MHz to 300 MHz] Level= 4.3 %	1.3 minor divisions for a major graticule divided in 5 minor divisions	
	(300 MHz to 500 MHz] Level= 5.9 %	1.8 minor divisions for a major graticule divided in 5 minor divisions	
Oscilloscopes Bandwidth <sup>1,2</sup>	(500 MHz to 1100 MHz] Level= 6.8 %	2.0 minor divisions for a major graticule divided in 5 minor divisions	Uncertainties are for RF voltage displayed relative to a reference voltage level at 50 kHz, /6 graticules (=30 minor divisions ).
Frequency, Measuring Instruments <sup>1</sup>	100 $\mu$ Hz to 26 GHz	$2.8 \times 10^{-11}$ OR	IEC 60351; IEC 60548: IEC 60 624 Function Generator HP 33120A, Signal Generator HP 4432B, HP 8673B with the time base locked to GPS, Phase Comparator locked to GPS
Frequency, Measuring Instruments <sup>2</sup>	100 $\mu$ Hz to 26 GHz	$5 \times 10^{-10}$ OR	Function Generator HP 33120A, Signal Generator HP 4432B, HP 8673B with the time base locked to the Fluke 910B
Frequency, Sources <sup>1</sup> 24 h average	0.01 Hz	$9.6 \times 10^{-6}$ OR	The CMC is based on square wave. Phase comparator STANFORD RESEARCH FS 700 Counter HP 53131A and counter HP 5351B locked to GPS

**Time and Frequency**

<b>Parameter/Equipment</b>	<b>Range<sup>5</sup></b> [including end point] (does not include end point)	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Frequency, Sources <sup>1</sup> 24 h average	0.01 Hz 0.025 Hz 0.05 Hz 0.1 Hz 0.25 Hz 0.5 Hz 1 Hz 2.5 Hz 5 Hz	9.6 x 10 <sup>-6</sup> OR 9.6 x 10 <sup>-6</sup> OR 9.6 x 10 <sup>-7</sup> OR 9.6 x 10 <sup>-7</sup> OR 9.6 x 10 <sup>-7</sup> OR 9.6 x 10 <sup>-8</sup> OR 9.6 x 10 <sup>-8</sup> OR 9.6 x 10 <sup>-8</sup> OR 9.6 x 10 <sup>-8</sup> OR	The CMC is based on square wave. Phase comparator STANFORD RESEARCH FS 700, Counter HP 53131A and counter HP 5351B locked to GPS
Frequency, Sources <sup>1</sup> 24 h average	10 Hz 25 Hz 50 Hz 100 Hz 250 Hz 500 Hz 1 kHz 2.5 kHz 5 kHz 10 kHz 25 kHz 50 kHz 100 kHz 250 kHz 500 kHz 1 MHz 2.5 MHz 5 MHz 10 MHz [0.1 to 1] Hz [1 to 10] Hz [10 to 100] Hz [100 Hz to 1 kHz] [1 to 10] kHz [10 to 100] kHz [100 kHz to 3 GHz] [3 to 5] GHz [5 to 10] GHz [10 to 15] GHz [15 to 20] GHz [20 to 26] GHz	9.6 x 10 <sup>-9</sup> OR 9.6 x 10 <sup>-9</sup> OR 9.6 x 10 <sup>-10</sup> OR 9.6 x 10 <sup>-10</sup> OR 9.6 x 10 <sup>-10</sup> OR 9.6 x 10 <sup>-10</sup> OR 9.6 x 10 <sup>-11</sup> OR 9.6 x 10 <sup>-11</sup> OR 9.6 x 10 <sup>-11</sup> OR 1 x 10 <sup>-11</sup> OR 1 x 10 <sup>-11</sup> OR 1 x 10 <sup>-11</sup> OR 0.18 x 10 <sup>-12</sup> OR 1 x 10 <sup>-12</sup> OR 1 x 10 <sup>-12</sup> OR 1 x 10 <sup>-12</sup> OR 1 x 10 <sup>-12</sup> OR 1 x 10 <sup>-12</sup> OR 1 x 10 <sup>-12</sup> OR 4.4 x 10 <sup>-10</sup> OR 1.7 x 10 <sup>-10</sup> OR 8.3 x 10 <sup>-11</sup> OR 5.5 x 10 <sup>-11</sup> OR 4.7 x 10 <sup>-11</sup> OR 4.4 x 10 <sup>-11</sup> OR 4.3 x 10 <sup>-11</sup> OR 3.6 x 10 <sup>-10</sup> OR 2.3 x 10 <sup>-10</sup> OR 1.3 x 10 <sup>-10</sup> OR 9.4 x 10 <sup>-11</sup> OR 7.7 x 10 <sup>-11</sup> OR	The CMC is based on square wave. Phase comparator STANFORD RESEARCH FS 700, Counter HP 53131A and counter HP 5351B locked to GPS and Fluke 910R



### Time and Frequency

Parameter/Equipment	Range <sup>5</sup> [including end point] (does not include end point)	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency, Sources <sup>2</sup> 24 h average	[10 Hz to 1 GHz) [1 to 10) GHz [10 to 15) GHz [15 to 20) GHz [20 to 26.5] GHz	$5.8 \times 10^{-10}$ OR $8.1 \times 10^{-10}$ OR $6.9 \times 10^{-10}$ OR $6.6 \times 10^{-10}$ OR $6.4 \times 10^{-10}$ OR	Counter HP 53151A locked to Fluke 910B

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. Available ranges and uncertainty for calibrations being performed on Permanent Site.
2. Available ranges and uncertainty for calibrations being performed on Temporary Site.
3. D = diameter in meters, L = length in meters, OR = "of reading"
4. Unitless linear measure.
5. The use of brackets "[ ]" indicate that the endpoints of the range are included within the range for the uncertainty of measurement listed and the use of parenthesis "(" )" indicate the endpoints are not included within the range for the uncertainty of measurement listed.
6. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2699.



Vice President