

German Accreditation Body

Annex to the Accreditation Certificate D-K-15019-01-01
in accordance with DIN EN ISO/IEC 17025:2018

Valid from: 16 March 2026

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This annex to the certificate forms part of the accreditation certificate D-K-15019-01-00.

Holder of the accreditation certificate:

esz AG calibration & metrology
Max-Planck-Straße 16, 82223 Eichenau

with the following sites

esz AG calibration & metrology
Max-Planck-Straße 16, 82223 Eichenau

esz AG calibration & metrology
Richard-Willstätter-Str. 14, 12489 Berlin

esz AG calibration & metrology Donaustraße
68, 68199 Mannheim

esz AG calibration & metrology Nordostpark
12, 90411 Nuremberg

esz AG calibration & metrology
Webereistraße 3, 48565 Steinfurt

esz AG calibration & metrology Lemböckgasse
49, A-1230 Vienna, AUSTRIA

The calibration laboratory meets the requirements of DIN EN ISO/IEC 17025:2018 to carry out the conformity assessment activities listed in this annex. Where applicable, the calibration laboratory also meets additional legal and normative requirements,

including those in relevant sectoral programmes, provided these are expressly confirmed below.

The requirements for the management system in DIN EN ISO/IEC 17025 are written in language relevant to calibration laboratories and are, on the whole, consistent with the principles of DIN EN ISO 9001.

Calibrations in the following areas:

Electrical quantities

Direct current and low frequency

- Voltage ^{a)}
- Current ^{a)}
- Voltage ratio ^{a)}
- High-voltage measurement parameters ^{a)}
- Resistance ^{a)}
- Charge ^{a)}
- Phase angle ^{a)}
- Electrical power ^{a)}
- Power factor ^{a)}
- Electrical energy ^{a)}
- Inductance ^{a)}
- Capacitance ^{a)}

Time and frequency

- Time interval ^{a)}
- Frequency and rotational speed ^{a)}

Dimensional quantities:

length

- Diameter ^{a)}
- Thread ^{a)}
- Parallel end dimensions
- Length measuring equipment ^{a)}
- Scale marks, distances ^{a)}

Angles

- Inclination

^{a)} also known as on-site calibration

High-frequency and radiation quantities High-frequency quantities

- HF voltage ^{a)}
 - HF current ^{a)}
 - HF impedance (reflection coefficient) ^{a)}
 - RF power ^{a)}
 - RF attenuation ^{a)}
 - Pulse-shaped parameters ^{a)}
 - Oscilloscope measurements ^{a)}
 - Rise time ^{a)}
 - Bandwidth ^{a)}
- Optical measurement parameters**
- Radiometry ^{a)}
 - Photometry ^{a)}

For the measurement quantities/calibration objects marked with *, the calibration laboratory is permitted to apply the standards/calibration guidelines listed here in different editions without the need for prior notification to and approval by DAKkS.

The calibration laboratory maintains an up-to-date list of all standards/calibration guidelines within the flexible scope of accreditation.

This certificate annex was issued by Deutsche Akkreditierungsstelle GmbH and is digitally sealed.

This applies only in conjunction with the written certificate and reflects the status as at the date of issue. The current status of valid and monitored accreditation can be found in the database of accredited bodies maintained by the German Accreditation Body (www.dakks.de)

Electrical quantities – direct current and low frequency Direct

and alternating voltage

Permanent Laboratory – Eichenau site

Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement range	Measurement conditions / Method	Expanded measurement uncertainty	Remarks	
DC voltage	0 V		35 nV	Short-circuit bridge	
	0 V to 200 mV		14 nV	Calibration of voltage sources	
	> 200 mV to 2 V		0.10 µV		
	> 2 V to 10 V		0.16 µV		
	0 mV to < 200 mV		12 nV	Calibration of the non-linearity of voltmeters	
	200 mV to < 2 V		40 nV		
	2 V to 10 V		0.25 µV	Calibration of the Deviation of voltmeters	
	> 0 mV to < 2 V		0.12 µV		
	2 V to 10 V		0.27 µV		
			> 10 V to 100 V	$0.28 \times 10^{(-6)} \cdot U - 0.34 \mu V$	$U = \text{measured value}$
			> 100 V to 1050 V	$0.24 \times 10^{(-6)} \cdot U + 64 \mu V$	
	High voltage		1 kV to 10 kV		$7.9 \times 10^{(-6)} \cdot U + 17 \text{ mV}$
> 10 kV to 60 kV				$46 \times 10^{(-6)} \cdot U + 0.95 \text{ V}$	
AC voltage	2 mV to 10 mV	10 Hz; 12.5 Hz	$26 \times 10^{-6} \cdot U + 0.11 \mu V$	$U = \text{measured value}$ When calibrating measuring instruments, the influence of the load impedance and repeatability must be taken into account.	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$28 \times 10^{-6} \cdot U + 23 \text{ nV}$		
		48 Hz; 60 Hz; 62.5 Hz	$19 \times 10^{-6} \cdot U + 0.11 \mu V$		
		625 Hz; 937.5 Hz; 1 kHz	$17 \times 10^{-6} \cdot U + 0.12 \mu V$		
	> 10 mV to 60 mV	10 Hz; 12.5 Hz	$13 \times 10^{-6} \cdot U + 0.19 \mu V$		
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$8.6 \times 10^{-6} \cdot U + 0.16 \mu V$		
		48 Hz; 60 Hz; 62.5 Hz	$10 \times 10^{-6} \cdot U + 0.16 \mu V$		
		625 Hz; 937.5 Hz; 1 kHz	$9.1 \times 10^{-6} \cdot U + 0.16 \mu V$		
	60 mV to 7.2 V	10 Hz; 12.5 Hz	$10 \times 10^{-6} \cdot U + 0.14 \mu V$		
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$2.2 \times 10^{-6} \cdot U + 0.16 \mu V$		
		48 Hz; 60 Hz; 62.5 Hz	$4.2 \times 10^{-6} \cdot U + 0.14 \mu V$		
		625 Hz; 937.5 Hz; 1 kHz	$1.4 \times 10^{-6} \cdot U + 0.16 \mu V$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measuring range / Measurement range	Measurement conditions / Method	Expanded measurement uncertainty	Remarks	
AC voltage ranges	2 mV to 22 V 2 mV	10 Hz to 1 MHz 10 Hz; 20 Hz; 40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz	$0.29 \times 10^{(-3)} \times U$	<p>U = measured value. When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.</p> <p>Intermediate values increase the measured values</p>	
		500 kHz	$0.32 \times 10^{(-3)} \cdot U$		
			1 MHz		$0.43 \times 10^{(-3)} \times U$
	6 mV	10 Hz	10 Hz		$0.16 \times 10^{(-3)} \cdot U$
			20 Hz		$0.14 \times 10^{(-3)} \cdot U$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz			$0.13 \times 10^{(-3)} \cdot U$
			300 kHz		$0.15 \times 10^{(-3)} \cdot U$
			500 kHz		$0.17 \times 10^{(-3)} \cdot U$
			1 MHz		$0.22 \times 10^{(-3)} \cdot U$
	10 mV	10 Hz	10 Hz		$0.13 \times 10^{(-3)} \times U$
			20 Hz		$0.12 \times 10^{(-3)} \cdot U$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz			$0.10 \times 10^{(-3)} \cdot U$
			300 kHz		$0.12 \times 10^{(-3)} \cdot U$
			500 kHz		$0.16 \times 10^{(-3)} \cdot U$
			1 MHz		$0.21 \times 10^{(-3)} \cdot U$
	20 mV	10 Hz	10 Hz		$0.12 \times 10^{(-3)} \cdot U$
			20 Hz		$0.11 \times 10^{(-3)} \times U$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz			$86 \times 10^{(-6)} \cdot U$
			300 kHz		$0.11 \times 10^{(-3)} \cdot U$
			500 kHz		$0.13 \times 10^{(-3)} \cdot U$
1 MHz			$0.17 \times 10^{(-3)} \cdot U$		
60 mV	10 Hz	10 Hz	$54 \times 10^{(-6)} \cdot U$		
		20 Hz; 40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$32 \times 10^{(-6)} \cdot U$		
	200 kHz; 300 kHz		$46 \times 10^{(-6)} \cdot U$		
		500 kHz	$60 \times 10^{(-6)} \cdot U$		
			$95 \times 10^{(-6)} \cdot U$		
		1 MHz	$95 \times 10^{(-6)} \cdot U$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement range	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage ranges	100 mV	10 Hz	$22 \times 10^{\wedge}(-6) \times U$	<p>U = measured value.</p> <p>When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.</p>
		20 Hz; 40 Hz	$20 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$17 \times 10^{\wedge}(-6) \cdot U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$15 \times 10^{\wedge}(-6) \cdot U$	
		200 kHz; 300 kHz	$25 \times 10^{\wedge}(-6) U$	
		500 kHz	$34 \times 10^{-6} \cdot U$	
		1 MHz	$53 \times 10^{\wedge}(-6) V$	
	200 mV	10 Hz	$37 \times 10^{\wedge}(-6) V$	Intermediate values increase the measured values
		20 Hz; 40 Hz	$18 \times 10^{\wedge}(-6) V$	
		55 Hz; 120 Hz	$15 \times 10^{\wedge}(-6) U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$12 \times 10^{\wedge}(-6) \cdot U$	
		100 kHz	$13 \times 10^{\wedge}(-6) U$	
		200 kHz; 300 kHz	$23 \times 10^{\wedge}(-6) U$	
		500 kHz	$33 \times 10^{\wedge}(-6) \cdot U$	
	1 MHz	$49 \times 10^{\wedge}(-6) V$		
	600 mV	10 Hz	$31 \times 10^{\wedge}(-6) V$	
		20 Hz; 40 Hz	$16 \times 10^{\wedge}(-6) V$	
		55 Hz; 120 Hz	$13 \times 10^{\wedge}(-6) U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$10 \times 10^{\wedge}(-6) \cdot U$	
		100 kHz	$11 \times 10^{\wedge}(-6) \cdot U$	
		200 kHz; 300 kHz	$21 \times 10^{\wedge}(-6) U$	
		500 kHz	$33 \times 10^{\wedge}(-6) \cdot U$	
	1 MHz	$50 \times 10^{\wedge}(-6) \cdot U$		
	1 V	10 Hz	$17 \times 10^{\wedge}(-6) U$	
		20 Hz; 40 Hz	$11 \times 10^{\wedge}(-6) \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \times 10^{\wedge}(-6) \cdot U$	
		100 kHz	$9 \times 10^{\wedge}(-6) U$	
		200 kHz; 300 kHz	$13 \times 10^{\wedge}(-6) U$	
500 kHz		$17 \times 10^{-6} \cdot U$		
1 MHz		$30 \times 10^{-6} \cdot U$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage ranges	2 V	10 Hz	$38 \times 10^{\wedge}(-6) \times U$	<i>U</i> = measured value. When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.
		20 Hz; 40 Hz	$12 \times 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \times 10^{\wedge}(-6) U$	
		100 kHz	$9 \times 10^{\wedge}(-6) U$	
		200 kHz; 300 kHz	$11 \times 10^{\wedge}(-6) U$	
		500 kHz	$16 \times 10^{\wedge}(-6) U$	
		1 MHz	$29 \times 10^{\wedge}(-6) U$	
	4 V; 6 V	10 Hz	$32 \times 10^{\wedge}(-6) V$	Intermediate values increase the measured values
		20 Hz; 40 Hz	$13 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$9 \times 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$21 \times 10^{\wedge}(-6) U$	
		500 kHz	$32 \times 10^{\wedge}(-6) U$	
		1 MHz	$35 \times 10^{\wedge}(-6) U$	
		8 V; 10 V	10 Hz	
	20 Hz	$13 \times 10^{\wedge}(-6) \cdot U$		
	40 Hz	$10 \times 10^{-6} \cdot U$		
	20 V	55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$8 \times 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$15 \times 10^{\wedge}(-6) U$	
		500 kHz	$30 \times 10^{\wedge}(-6) U$	
		1 MHz	$47 \times 10^{\wedge}(-6) V$	
		10 Hz	$29 \times 10^{\wedge}(-6) V$	
		20 Hz	$14 \times 10^{\wedge}(-6) \cdot U$	
		40 Hz	$11 \times 10^{\wedge}(-6) U$	
	12 V; 15 V; 19 V	55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$9 \cdot 10^{-6} \cdot U$	
100 kHz		$10 \times 10^{\wedge}(-6) U$		
200 kHz; 300 kHz		$16 \times 10^{\wedge}(-6) U$		
500 kHz		$32 \times 10^{\wedge}(-6) U$		
1 MHz		$49 \times 10^{\wedge}(-6) V$		
1 kHz; 10 kHz; 100 kHz		$10 \times 10^{\wedge}(-6) V$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments	
AC voltage ranges	> 22 V to 70 V 60 V	10 Hz to 300 kHz		$U = \text{measured value.}$ When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.	
		10 Hz	$23 \times 10^{-(6)} \cdot U$		
		20 Hz; 40 Hz	$15 \cdot 10^{-6} \cdot U$		
		55 Hz; 120 Hz	$13 \cdot 10^{-6} \cdot U$		
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz	$9 \times 10^{-(6)} U$		
		70 kHz	$10 \times 10^{-(6)} V$		
		100 kHz	$14 \times 10^{-(6)} U$		
	200 kHz; 300 kHz	$22 \times 10^{-(6)} V$			
	> 70 V to 110 V 100 V	10 Hz to 200 kHz		$19 \times 10^{-(6)} \cdot U$	Intermediate values increase the measured values
		10 Hz; 20 Hz			
		40 Hz	$15 \cdot 10^{-6} \cdot U$		
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz	$13 \cdot 10^{-6} \cdot U$		
		70 kHz	$20 \times 10^{-(6)} U$		
		100 kHz	$32 \times 10^{-(6)} U$		
		200 kHz	$37 \times 10^{-(6)} V$		
	> 110 V to 700 V 200 V	10 Hz to 100 kHz		$27 \times 10^{-(6)} V$	
		10 Hz			
		20 Hz	$21 \times 10^{-(6)} U$		
		40 Hz	$16 \cdot 10^{-6} \cdot U$		
		55 Hz; 120 Hz	$15 \cdot 10^{-6} \cdot U$		
		400 Hz; 500 Hz; 1 kHz;	$13 \times 10^{-(6)} U$		
		10 kHz; 20 kHz; 50 kHz	$17 \times 10^{-(6)} U$		
		70 kHz	$20 \times 10^{-(6)} U$		
		100 kHz	$31 \times 10^{-(6)} V$		
		100 kHz	$37 \times 10^{-(6)} V$		
	600 V	40 Hz		$17 \times 10^{-(6)} V$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$14 \times 10^{-(6)} \cdot U$		
		1 kHz; 10 kHz; 20 kHz; 50 kHz	$16 \cdot 10^{-6} \cdot U$		
70 kHz		$25 \times 10^{-(6)} \cdot U$			
100 kHz		$37 \times 10^{-(6)} V$			
> 700 V to 1000 V 1000 V	10 Hz to 100 kHz		$16 \times 10^{-(6)} V$		
	40 Hz				
	55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz	$14 \times 10^{-(6)} \cdot U$			
	50 kHz	$25 \times 10^{-(6)} \cdot U$			
	70 kHz	$32 \cdot 10^{-6} \cdot U$			
	100 kHz	$42 \times 10^{-6} \cdot U$			

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
High-voltage sources	1 kV to 10 kV	10 Hz to 20 kHz > 20 kHz up to 50 kHz > 50 kHz to 100 kHz	$50 \times 10^{(-6)} \cdot U + 2 \text{ V}$ $0.34 \times 10^{(-3)} \cdot U + 1.6 \text{ V}$ $1.6 \times 10^{(-3)} \cdot U + 0.9 \text{ V}$	U = measured value
	> 10 kV to 40 kV	10 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.10 \times 10^{(-3)} \cdot U + 3.7 \text{ V}$ $0.43 \times 10^{(-3)} \cdot U + 2.1 \text{ V}$ $1.7 \times 10^{(-3)} \cdot U + 0.7 \text{ V}$	
Measuring instruments	1 kV to 10 kV	45 Hz to 65 Hz	$50 \cdot 10^{(-6)} \cdot U + 2 \text{ V}$	
	10 kV to 30 kV		$0.10 \times 10^{(-3)} \cdot U + 3.7 \text{ V}$	
Square-wave voltage	5 mV to 220 mV	1 Hz to 10 kHz	$10 \times 10^{(-6)} \cdot U + 0.36 \mu\text{V}$ $+ 6.4 \times 10^{(-9)} \text{ V/Hz} \cdot f$	Sampling method at 10 MΩ load Range specification in voltage peak-to-peak U = peak voltage f = frequency The additional influence of varying load conditions (such as e.g. 50 Ω or 1 MΩ must be taken into account)
	> 220 mV to 2.2 V		$9.3 \times 10^{(-6)} \cdot U + 0.35 \mu\text{V}$ $+ 7.0 \times 10^{(-9)} \text{ V/Hz} \cdot f$	
	> 2.2 V to 22 V		$9.3 \times 10^{(-6)} \cdot U + 0.58 \mu\text{V}$ $+ 14 \times 10^{(-9)} \text{ V/Hz} \cdot f$	
	> 22 V to 220 V		$12 \times 10^{(-6)} \cdot U + 35 \mu\text{V}$ $+ 75 \times 10^{(-9)} \text{ V/Hz} \cdot f$	
AC voltage amplitude parameters	5 mV to 5 V	DC to 10 MHz > 10 MHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 1 GHz	$25 \times 10^{(-3)} \cdot U + 0.2 \mu\text{V}$ $37 \times 10^{(-3)} \text{ V} + 0.5 \mu\text{V}$ $44 \times 10^{(-3)} \text{ V} + 0.4 \mu\text{V}$ $70 \times 10^{(-3)} \text{ V}$	Oscilloscope as standard U = measured value
	> 5 V to 50 V	DC to 2 kHz > 2 kHz to 10 MHz	$12 \times 10^{(-3)} \text{ V} + 0.7 \mu\text{V}$ $25 \times 10^{(-3)} \cdot U + 0.7 \mu\text{V}$	

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Direct and alternating current

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Measurement parameter / Calibration object	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range /	Measurement conditions / Method	Expanded measurement uncertainty	
AC current measuring instruments	100 µA to 2 A	10 Hz to 1 kHz	2.2 nA to 61 µA	<i>I</i> = measured value <i>f</i> = frequency Intermediate values and deviating Test conditions increase the measured values
	100 µA; 200 µA; 500 µA	10 Hz; 12.5 Hz; 20 Hz	$62 \times 10^{(-6)} \times I$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$22 \times 10^{(-6)} \times I$	
	1 mA	10 Hz; 12.5 Hz	$25 \times 10^{(-6)} \cdot I$	
		20 Hz	$22 \times 10^{(-6)} \cdot I$	
	1 mA	25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$18 \cdot 10^{-6} \cdot I$	
		10 Hz; 12.5 Hz	$23 \times 10^{-6} \cdot I$	
	2 mA	20 Hz	$20 \times 10^{(-6)} \cdot I$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$15 \times 10^{(-6)} \cdot I$	
	5 mA; 10 mA; 20 mA	10 Hz; 12.5 Hz	$22 \cdot 10^{-6} \cdot I$	
		20 Hz	$20 \cdot 10^{-6} \cdot I$	
	5 mA; 10 mA; 20 mA	25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$14 \times 10^{(-6)} \cdot I$	
		10 Hz; 12.5 Hz	$23 \times 10^{(-6)} \times I$	
	50 mA	20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$21 \times 10^{(-6)} \cdot I$	
48 Hz; 60 Hz; 62.5 Hz		$16 \times 10^{-6} \times I$		
75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz		$15 \times 10^{(-6)} \cdot I$		
10 Hz; 12.5 Hz		$23 \times 10^{(-6)} \times I$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current measuring instruments	100 mA; 200 mA	10 Hz; 12.5 Hz	$25 \times 10^{(-6)} \times I$	<i>I</i> = measured value <i>f</i> = frequency Intermediate values and deviating measurement conditions increase the measured values
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$21 \times 10^{(-6)} \times I$	
		48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$16 \cdot 10^{-6} \cdot I$	
	500 mA; 1 A	10 Hz; 12.5 Hz	$30 \cdot 10^{-6} \cdot I$	
		20 Hz	$28 \cdot 10^{-6} \cdot I$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$23 \times 10^{(-6)} \cdot I$	
		48 Hz; 60 Hz; 62.5 Hz	$24 \times 10^{(-6)} \cdot I$	
	2 A	10 Hz; 12.5 Hz; 20 Hz	$50 \cdot 10^{(-6)} \cdot I$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$45 \times 10^{(-6)} \times I$	
	AC current	100 μ A to 100 A	10 Hz to 10 kHz	
100 μ A		10 Hz; 20 Hz	$76 \times 10^{(-6)} \times I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$44 \times 10^{(-6)} \cdot I$	
		10 kHz	$47 \times 10^{(-6)} \cdot I$	
200 μ A		10 Hz; 20 Hz	$68 \cdot 10^{-6} \cdot I$	
		40 Hz	$39 \times 10^{(-6)} \times I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$36 \times 10^{(-6)} \cdot I$	
		10 kHz	$39 \times 10^{(-6)} \cdot I$	
0.5 mA		10 Hz; 20 Hz	$64 \times 10^{(-6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz	$28 \times 10^{(-6)} \cdot I$	
		400 Hz; 500 Hz; 1 kHz	$27 \times 10^{(-6)} \cdot I$	
		10 kHz	$32 \cdot 10^{-6} \cdot I$	
1 mA		10 Hz	$33 \times 10^{(-6)} \cdot I$	
		20 Hz	$30 \times 10^{(-6)} \cdot I$	
		40 Hz; 55 Hz	$26 \times 10^{(-6)} \cdot I$	
		120 Hz; 400 Hz; 500 Hz; 1 kHz	$25 \times 10^{(-6)} \cdot I$	
		10 kHz	$27 \times 10^{(-6)} \cdot I$	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current	2 mA	10 Hz	$32 \times 10^{(-6)} \times f$	/ = measured value f = frequency
		20 Hz	$29 \times 10^{(-6)} \cdot f$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$24 \cdot 10^{-6} \cdot f$	Intermediate values and deviating measurement conditions increase the measured values
	5 mA	10 Hz	$32 \times 10^{(-6)} \cdot f$	
		20 Hz; 40 Hz	$29 \times 10^{(-6)} \cdot f$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$24 \times 10^{(-6)} \cdot f$	
	10 mA	10 Hz	$26 \times 10^{(-6)} \cdot f$	
		20 Hz	$24 \times 10^{(-6)} \cdot f$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \times 10^{(-6)} \cdot f$	
		10 kHz	$22 \cdot 10^{-6} \cdot f$	
	20 mA	10 Hz	$25 \times 10^{(-6)} \cdot f$	
		20 Hz	$23 \times 10^{(-6)} \cdot f$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \times 10^{(-6)} \cdot f$	
		10 kHz	$19 \times 10^{(-6)} \cdot f$	
	50 mA	10 Hz	$25 \times 10^{(-6)} \cdot f$	
		20 Hz; 40 Hz	$23 \times 10^{(-6)} \cdot f$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot f$	
		10 kHz	$19 \times 10^{(-6)} \cdot f$	
	100 mA	10 Hz	$26 \times 10^{(-6)} \cdot f$	
		20 Hz; 40 Hz	$24 \times 10^{(-6)} \cdot f$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$18 \times 10^{(-6)} \cdot f$	
		1 kHz; 10 kHz	$20 \times 10^{(-6)} \cdot f$	
	200 mA	10 Hz	$27 \times 10^{(-6)} \cdot f$	
20 Hz; 40 Hz		$24 \times 10^{(-6)} \cdot f$		
55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz		$18 \times 10^{-6} \times f$		
10 kHz		$20 \times 10^{(-6)} \cdot f$		
500 mA	10 Hz	$36 \times 10^{(-6)} \cdot f$		
	20 Hz	$34 \times 10^{(-6)} \cdot f$		
	40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$31 \times 10^{(-6)} \cdot f$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Alternating current	1 A	10 Hz	$32 \times 10^{(-6)} \times I$	/ = measured value f = frequency Intermediate values and varying measurement conditions increase the measured values
		20 Hz	$29 \times 10^{(-6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$25 \cdot 10^{-6} \cdot I$	
	2 A	10 Hz; 20 Hz	$40 \cdot 10^{-6} \cdot I$	$34 \times 10^{(-6)} \cdot I$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz		
	5 A; 10 A	10 Hz	$39 \times 10^{(-6)} \cdot I$	$37 \times 10^{(-6)} \cdot I$
		20 Hz		
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$32 \times 10^{(-6)} \cdot I$	
	20 A	10 Hz; 20 Hz	$57 \cdot 10^{-6} \cdot I$	$53 \times 10^{(-6)} \cdot I$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz		
	50 A	10 Hz; 20 Hz	$64 \times 10^{(-6)} \cdot I$	$59 \times 10^{(-6)} \cdot I$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz		
		1 kHz; 10 kHz	$68 \times 10^{(-6)} \cdot I$	
	100 A	10 Hz; 20 Hz	$75 \times 10^{(-6)} \cdot I$	$65 \cdot 10^{(-6)} \cdot I$
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz		
		1 kHz; 10 kHz	$75 \times 10^{(-6)} \cdot I$	
100 A to 200 A			12 mA to 24 mA	
	10 Hz to 10 kHz		$0.13 \times 10^{(-3)} \times I$	

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	200 A to 300 A	10 Hz to 1 kHz	$0.30 \times 10^{(-3)} \times I - 0.53 \text{ mA}$	I = measured value f = frequency
	300 A to 495 A	10 Hz to 65 Hz	$0.48 \times 10^{(-3)} \times I + 11 \text{ mA}$	
		65 Hz to 100 Hz	$0.49 \times 10^{(-3)} \times I + 11 \text{ mA}$	
		100 Hz to 400 Hz	$0.74 \times 10^{(-3)} \times I + 7.7 \text{ mA}$	
		400 Hz to 1 kHz	$1.5 \times 10^{(-3)} \times I + 4.0 \text{ mA}$	
AC current Clamp meters and current transformers	10 μ A to 2400 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/N	$\sqrt{W_m^2 + W_{DUT}^2} \cdot I$ but not less than $90 \times 10^{(-6)} \times I$ or 8 nA	W_{in} is the relative uncertainty of the current in the single winding. W_{DUT} is the relative uncertainty of the device under test in the stray field of the current-carrying.
Equivalent leakage current I	0.2 μ A to 200 mA	at R_N up to 1 G Ω	$10 \cdot 10^{(-6)} \cdot I$ to $5.8 \times 10^{(-3)} \cdot I$ See Matrix M.1	The total uncertainty U depends on the relative uncertainty $U_{(RN)}/R_N$ of the calibration resistor R_N .

Matrix M.1 'Equivalent leakage current'

Reference resistor R_N	1 Ω	10 Ω	100 Ω	1 Ω	10 Ω	100 Ω	1 Ω							
Nominal voltage	Current expanded measurement uncertainty U in μ A/A						Current U in mA/A							
60 V	60 mA	10	6 mA	10	600 μ A	13	60 μ A	19	6 μ A	70	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		1.1 mA		110 μ A		11 μ A		1.1 μ A		110 nA	
230 V	230 mA		23 mA		2.3 mA		230 μ A		23 μ A		2.3 μ A		230 nA	
400 V	400 mA		40 mA		4 mA		400 μ A		40 μ A		4.0 μ A		400 nA	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current Sources, measuring instruments	0 pA to 10 nA		0.85 fA to 51 fA	/ = measured value Intermediate values increase the measured values
	0 pA 1 pA 10 pA 100 pA 1 nA 10 nA		12 fA $0.85 \times 10^{(-3)} \times I$ $0.53 \times 10^{(-3)} \times I$ $75 \times 10^{(-6)} \times I$ $10 \times 10^{(-6)} \cdot I$ $5.1 \times 10^{(-6)} \cdot I$	
	> 10 nA to 100 nA		$4.1 \times 10^{(-6)} \cdot I + 10 \text{ fA}$	/ = measured value
	> 100 nA to < 1 µA		$1.4 \times 10^{(-6)} \times I + 0.21 \text{ pA}$	
	1 µA to 10 µA		$1.4 \times 10^{(-6)} \times I + 0.19 \text{ pA}$	
	> 10 µA to 100 µA		$1.4 \times 10^{(-6)} \times I + 1.8 \text{ pA}$	
	> 100 µA to 500 µA		$1.1 \times 10^{(-6)} \times I + 72 \text{ pA}$	
	20 µA to 200 µA		$1.4 \times 10^{(-6)} \times I + 14 \text{ pA}$	
	200 µA to 2 mA		$0.54 \times 10^{(-6)} \times I + 0.23 \text{ nA}$	
	2 mA to 10 mA		$1.1 \times 10^{(-6)} \times I + 2.4 \text{ nA}$	
	10 mA to 50 mA		$0.90 \times 10^{(-6)} \times I + 25 \text{ nA}$	
	50 mA to 200 mA		$0.33 \times 10^{(-6)} \times I + 0.26 \text{ µA}$	
	200 mA to 1 A		$12 \times 10^{(-6)} \cdot I$	
	1 A to 10 A		$16 \cdot 10^{-6} \cdot I$	
	10 A to 100 A		$28 \cdot 10^{-6} \cdot I$	
100 A to 300 A	$37 \cdot 10^{-6} \cdot I$			
Direct current Sources	300 A to 700 A		$27 \cdot 10^{-6} \cdot I + 2.3 \text{ mA}$	
DC current Measuring instruments	20 µA to 2 mA		$0.48 \times 10^{(-6)} \cdot I + 19 \text{ pA}$	
	2 mA to 20 mA		$1.1 \times 10^{(-6)} \cdot I + 1.0 \text{ nA}$	
	20 mA to 200 mA		$0.26 \times 10^{(-6)} \cdot I + 24 \text{ nA}$	
	200 mA to 2 A		$12 \times 10^{(-6)} \cdot I$	
Direct current Current clamps and current transformer	0 A to 3000 A	1 to N windings	$\sqrt{W^2 + W^2} \cdot I$ but not less than $8 \cdot 10^{-6} \cdot I$ or 6 nA	W_{in} is the relative uncertainty of the current in the single winding. W_{OUT} is the relative uncertainty of the measurement object in the stray field of the current-carrying.

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Charge Q	<p>20 pC to 200 pC</p> <p>> 200 pC to 2 nC</p> <p>> 2 nC –11 C</p>		<p>$0.50 \times 10^{(-3)} \times Q + 0.025 \text{ pC}$</p> <p>$0.33 \times 10^{(-3)} \cdot Q + 0.05 \text{ pC}$</p> <p>$60 \times 10^{(-3)} \cdot Q + 0.5 \text{ pC}$</p>	<p>rectangular current pulses $\geq 1 \text{ s}$, duration t and rise times $\leq 10 \mu\text{s}$ as the product $Q = I \cdot t$; total uncertainty calculated from the relative uncertainty W(lin) of the calibration current</p>
AC voltage harmonic overtones	<p>RMS value of the fundamental wave</p>	<p>$45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$</p> <p>$1 \text{ mV} \leq U_n \leq 200 \text{ V}$</p> <p>$1 \% \leq (U_n / U_1) \leq 40 \%$</p> <p>$2 \leq n \leq 100$</p> <p>$f_n \leq 6 \text{ kHz}$</p>		<p>U_1 = RMS value of the fundamental wave</p> <p>U_n = RMS value of the nth harmonic</p> <p>f_1 = frequency of the fundamental wave</p> <p>f_n = frequency of the harmonic</p> <p>$n = f_n / f_1, n > 1$ The number of harmonics is limited to one harmonic.</p>
Sources and Measuring instruments	<p>100 mV to 500 V</p>		<p>$20 \cdot 10^{-6} \cdot U_1$</p> <p>to</p> <p>$39 \times 10^{-6} \cdot U_1$</p>	
	<p>100 mV</p> <p>200 mV</p> <p>1.2 V</p> <p>8 V</p> <p>16 V</p> <p>30 V</p> <p>60 V</p> <p>120 V</p> <p>240 V</p> <p>460 V</p>		<p>$26 \times 10^{-6} \cdot U_1$</p> <p>$25 \times 10^{-6} \cdot U_1$</p> <p>$20 \times 10^{-6} \cdot U_1$</p> <p>$25 \cdot 10^{-6} \cdot U_1$</p> <p>$30 \cdot 10^{-6} \cdot U_1$</p> <p>$20 \cdot 10^{-6} \cdot U_1$</p> <p>$20 \cdot 10^{-6} \cdot U_1$</p> <p>$30 \cdot 10^{-6} \cdot U_1$</p> <p>$39 \cdot 10^{-6} \cdot U_1$</p> <p>$39 \times 10^{-6} \cdot U_1$</p>	
	<p>RMS value of the harmonic</p>	<p>$45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$</p> <p>$100 \text{ mV} \leq U_1 \leq 500 \text{ V}$</p> <p>$1 \% \leq (U_n / U_1) \leq 40 \%$</p> <p>$2 \leq n \leq 100$</p> <p>$f_n \leq 6 \text{ kHz}$</p>		<p>U_1 = RMS value of the fundamental wave</p> <p>U_n = RMS value of the harmonic</p> <p>f_1 = frequency of the fundamental wave</p> <p>f_n = frequency of the harmonic</p> <p>$n = f_n / f_1, n > 1$</p> <p>The number of harmonics is limited to one harmonic</p>
	<p>1 mV to 200 V</p>		<p>$0.13 \times 10^{-3} \cdot U_n$</p> <p>up to</p> <p>$1.1 \times 10^{-3} \cdot U_n$</p> <p>see Matrix M.15</p>	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Alternating current Harmonic overtones Sources and measuring instruments	RMS value of the fundamental wave			i_1 = RMS value of the fundamental wave i_n = RMS value of the harmonic f_1 = frequency of the fundamental wave f_n = frequency of the harmonic $n = f_n / f_1, n > 1$ The number of Harmonics are limited to a harmonic. i_s = peak value of the current signal For measuring instruments with a connected (clamp-on) current transformer, the measurement uncertainty may increase. The measurement range extends to $i_1 \leq 600$ A. Current transformers are calibrated in conjunction with the display unit for the secondary signal.
	100 mA to 60 A	$45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$ $2 \leq n \leq 100$ $i_s \leq 113 \text{ A}$	$32 \cdot 10^{-6} \quad i_1$ up to $71 \times 10^{-6} \quad i_1$	
	100 mA	$1 \text{ mA} \leq i_n \leq 4.8 \text{ A}$ $f_n \leq 6 \text{ kHz}$	$32 \cdot 10^{-6} \quad i_1$	
	200 mA	$1 \% \leq (i_n / i_1) \leq 30 \%$	$47 \times 10^{-6} \quad i_1$	
	400 mA		$47 \times 10^{-6} \quad i_1$	
	800 mA		$47 \times 10^{-6} \quad i_1$	
	1.6 A		$45 \times 10^{-6} \quad i_1$	
	4 A		$57 \times 10^{-6} \quad i_1$	
	5 A		$57 \times 10^{-6} \quad i_1$	
16 A		$55 \cdot 10^{-6} \quad i_1$		
30 A	$160 \text{ mA} \leq i_n \leq 18 \text{ A}$ $f_n \leq 3 \text{ kHz}$	$71 \times 10^{-6} \quad i_1$		
60 A	$1 \% \leq (i_n / i_1) \leq 30 \%$	$71 \times 10^{-6} \quad i_1$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Alternating current Harmonic overtones Sources and measuring instruments	RMS value of the harmonic	$45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$ $2 \leq n \leq 100$ $I_s \leq 113 \text{ A}$		I_1 = RMS value of the fundamental I_n = RMS value of the harmonic
	1 mA to 4.8 A	$100 \text{ mA} \leq I_1 \leq 16 \text{ A}$ $f_n \leq 6 \text{ kHz}$ $1 \% \leq I_n / I_1 \leq 30 \%$	$0.22 \times 10^{-3} \cdot I_n$ to $0.46 \times 10^{-3} \cdot I_n$ see Matrix M.16	f_1 = frequency of the fundamental wave f_n = frequency of the harmonic $n = f_n / f_1, n > 1$
	160 mA to 18 A	$16 \text{ A} \leq I_1 \leq 60 \text{ A}$ $f_n \leq 3 \text{ kHz}$ $1 \% \leq (I_n / I_1) \leq 30 \%$	$0.22 \times 10^{-3} \cdot I_n$ up to $0.46 \times 10^{-3} \cdot I_n$ see Matrix M.16	The number of harmonics is limited to one harmonic. I_s = peak value of the current signal For measuring instruments with a connected (clamp-on) current transformer, the measurement uncertainty may increase. The measurement range extends to $I_n \leq 200 \text{ A}$. Current transformers are calibrated in conjunction with the display unit for the secondary signal.

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Matrix M.15 – Relative measurement uncertainty of the root mean square value U_n of the harmonic at the frequency $f_1 = 50$ Hz in mV/V

u_1 / V	u_n / V	n													
		2	3	4	5	10	20	30	40	50	60	70	80	90	100
0.10	0.001	1.1	1.1	0.57	0.57	0.50	0.49	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.48
0.10	0.01	0.17	0.17	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.20	0.025	0.17	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1.2	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
8.0	1.0	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
16	4.5	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
30	9.0	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
60	18	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
120	36	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
240	72	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
460	130	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

Matrix M.16 – Relative measurement uncertainty of the root-mean-square value I_n of the harmonic at the frequency $f_1 = 50$ Hz in mA/A

i_1 / A	i_n / A	n													
		2	3	4	5	10	20	30	40	50	60	70	80	90	100
0.1	0.01	0.24	0.24	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
0.2	0.025	0.24	0.24	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
0.4	0.05	0.24	0.24	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
0.8	0.1	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
1.6	0.016	0.46	0.46	0.46	0.46	0.32	0.28	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.22
1.6	0.2	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
4	0.5	0.25	0.25	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
8	1	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
16	2	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
30	8	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	-	-	-	-
60	15	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.24	-	-	-	-

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Flicker modulation depth Sources	0.407 % to 4.837%	$1 \text{ min}^{-1} \leq CPM \leq 4800 \text{ min}^{-1}$ $U = 120 \text{ V}; U = 230 \text{ V}$ Square-wave modulation		$\Delta U/U =$ Modulation depth $U =$ RMS value of the modulated AC signal $f =$ frequency of the modulated AC signal $CPM =$ changes per minute The combinations defined in DIN EN 61000-4-15:2011, Table 5, $\Delta U/U$ and CPM
		$1 \text{ min}^{-1} \leq CPM \leq 39 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$1.0 \times 10^{-3} \%$	
		$CPM = 110 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$3.7 \times 10^{-3} \%$	
		$CPM = 1620 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$12 \times 10^{-3} \%$	
		$CPM = 4000 \text{ min}^{-1};$ $CPM = 4800 \text{ rpm}$ $f = 51 \text{ Hz}; f = 61 \text{ Hz}$	$12 \cdot 10^{-3} \%$	
Flicker modulation depth Measuring instruments	0.407% to 4.837%	$1 \text{ min}^{-1} \leq CPM \leq 4800 \text{ min}^{-1}$ $U = 120 \text{ V}; U = 230 \text{ V}$ Square-wave modulation		$\Delta U/U =$ Modulation depth $U =$ RMS value of the modulated AC signal $f =$ frequency of the modulated AC signal $CPM =$ changes per minute The combinations defined in DIN EN 61000-4-15:2011, Table 5, $\Delta U/U$ and CPM .
		$1 \text{ min}^{-1} \leq CPM \leq 39 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$1.0 \times 10^{-3} \%$	
		$CPM = 110 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$3.7 \times 10^{-3} \%$	
		$CPM = 1620 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$12 \times 10^{-3} \%$	
		$CPM = 4000 \text{ min}^{-1};$ $CPM = 4800 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$28 \times 10^{-3} \%$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / methods	Expanded measurement uncertainty	Comments
Flicker frequency Sources and measuring instruments	8.3 mHz to 40 Hz	$0.407\% \leq (\Delta U/U) \leq 4.837\%$ $1 \text{ min}^{-1} \leq CPM \leq 4800 \text{ min}^{-1}$ $U = 120 \text{ V}; U = 230 \text{ V}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz square-wave}$ modulation	$1.0 \times 10^{-6} \cdot f_{\text{Flicker}}$	$\Delta U/U =$ Modulation depth $U =$ RMS value of the modulated AC signal $f =$ frequency of the modulated AC signal CPM = changes per minute $f_{\text{Flicker}} = CPM / 120$ The combinations of $\Delta U/U$ and CPM defined in DIN EN 61000-4-15:2011, Table 5.
P_{st} value	only $P_{\text{st}} = 1$		$2.5 \times 10^{(-3)}$	Value for $\Delta U/U$ expressed in $\Delta U/U$ of rectangular flicker
AC voltage Distortion factor k	0 % to 30%	45 Hz to 5 kHz > 5 kHz to 30 kHz	$0.5 \times 10^{-3} \times k + 0.012\%$ $0.8 \times 10^{(-3)} \times k + 0.012 \%$	Values expressed as % distortion

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DC and AC resistance Permanent Laboratory – Eichenau

site

Measurement quantity / Calibration	Calibration and measurement capabilities (CMC)			Remarks				
	Measurement range / span	Measurement conditions /	Expanded measurement					
DC resistance Sources, measuring instruments	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value				
		4-wire short circuit	0.35 μΩ					
	10 μΩ to < 1 GΩ 10 μΩ 100 μΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ	I = 100 A I = 50 A I = 10 A	1.6 nΩ to 49 Ω $0.16 \times 10^{(-3)} \cdot R$ $34 \times 10^{(-6)} \cdot R$ $23 \times 10^{(-6)} \cdot R$ $20 \times 10^{(-6)} \cdot R$ $5.6 \times 10^{(-6)} \cdot R$ $0.32 \times 10^{(-6)} \cdot R$ $1.0 \times 10^{(-6)} \cdot R$ $0.59 \times 10^{(-6)} \cdot R$ $0.56 \times 10^{(-6)} \cdot R$ $1.4 \times 10^{(-6)} \cdot R$ $4.1 \times 10^{(-6)} \cdot R$ $4.9 \times 10^{(-6)} \cdot R$	Calibration of measuring instruments to the nominal values of the standards Intermediate values and varying measurement conditions increase the measurement uncertainty				
					1 GΩ to 1 TΩ 1 GΩ; 10 GΩ; 100 GΩ; 1 TΩ	Measuring voltage 100 V; 1000 V	67 kΩ to 72 MΩ $67 \times 10^{(-6)} \cdot R$ $72 \times 10^{(-6)} \cdot R$	
					> 1 TΩ to 120 TΩ 10 TΩ; 100 TΩ	Measuring voltage 1000 V	0.13 GΩ to 23 GΩ $0.13 \times 10^{(-3)} \cdot R$ $0.23 \times 10^{(-3)} \cdot R$	
					100 mΩ to 2 Ω	3 μA ≤ I ≤ 50 mA	$0.39 \times 10^{(-6)} \cdot R + 0.25 \mu\Omega$	R = measured value
					2 Ω to 10 Ω		$0.43 \times 10^{(-6)} \cdot R + 1.0 \mu\Omega$	
					10 Ω to 100 Ω		$1.2 \times 10^{(-6)} \cdot R - 0.50 \mu\Omega$	
					100 Ω to 500 Ω		$0.52 \times 10^{(-6)} \cdot R - 2.5 \mu\Omega$	
					500 Ω to 10 kΩ		$0.47 \times 10^{(-6)} \cdot R + 20 \mu\Omega$	
10 kΩ to 100 kΩ	$0.73 \times 10^{(-6)} \cdot R - 0.13 \text{ m}\Omega$							
100 kΩ to 1.9 MΩ	$0.83 \times 10^{(-6)} \cdot R + 90 \mu\Omega$							

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration	Measurement range /	Measurement conditions /	Expanded measurement	Comments
AC resistance (magnitude of impedance)	1 Ω to 10 kΩ	10 μA ≤ I ≤ 50 mA 10 Hz up to 1 kHz	20 μΩ to 0.77 Ω	R = measured value I = current Intermediate values and varying measurement conditions increase the measurement uncertainty
	1 Ω	10 Hz; 12.5 Hz	$30 \times 10^{(-6)} \times R$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$24 \times 10^{(-6)} \times R$	
		48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$21 \times 10^{(-6)} \times R$	
	2 Ω	10 Hz; 12.5 Hz	$26 \times 10^{(-6)} \cdot R$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$21 \times 10^{(-6)} \cdot R$	
		48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$16 \times 10^{(-6)} \times R$	
	5 Ω	10 Hz; 12.5 Hz	$25 \times 10^{(-6)} \cdot R$	
		20 Hz	$20 \times 10^{(-6)} \cdot R$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$15 \times 10^{(-6)} \times R$	
	10 Ω	10 Hz; 12.5 Hz	$24 \times 10^{(-6)} \times R$	
		20 Hz	$19 \times 10^{(-6)} \cdot R$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$14 \cdot 10^{(-6)} \cdot R$	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC resistance (magnitude of impedance)	20 Ω; 50 Ω; 100 Ω	10 Hz; 12.5 Hz	$59 \times 10^{(-6)} \times R$	<i>R</i> = measured value <i>I</i> = current <i>f</i> = frequency Intermediate values and deviating measurement conditions increase the measurement uncertainty
		20 Hz	$19 \times 10^{(-6)} \times R$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$14 \cdot 10^{(-6)} \cdot R$	
		625 Hz; 937.5 Hz; 1 kHz	$12 \times 10^{(-6)} \cdot R$	
	1 kΩ	10 Hz; 12.5 Hz; 20 Hz	$59 \times 10^{(-6)} \Omega$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$56 \times 10^{(-6)} \times R$	
	10 kΩ	10 Hz; 12.5 Hz; 20 Hz	$81 \times 10^{(-6)} \cdot R$	
		25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 48 Hz; 60 Hz; 62.5 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$78 \times 10^{(-6)} \times R$	
	100 μΩ to 100 Ω	100 μA ≤ <i>I</i> ≤ 100 A 10 Hz to 10 kHz	13 nΩ to 1.7 mΩ	
	100 μΩ	10 Hz; 20 Hz	$0.17 \times 10^{(-3)} \times R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$0.14 \times 10^{(-3)} \cdot R$	
		1 kHz; 10 kHz	$0.15 \times 10^{(-3)} \cdot R$	
	1 mΩ	10 Hz	$65 \times 10^{(-6)} \cdot R$	
		20 Hz	$63 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$58 \times 10^{(-6)} \cdot R$	
		1 kHz	$61 \times 10^{(-6)} \cdot R$	
		10 kHz	$64 \times 10^{(-6)} \cdot R$	
	10 mΩ	10 Hz	$46 \times 10^{(-6)} \cdot \Omega$	
		20 Hz	$43 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$37 \times 10^{(-6)} \cdot R$	
1 kHz; 10 kHz		$35 \times 10^{(-6)} \cdot R$		
20 mΩ	10 Hz	$45 \times 10^{(-6)} \Omega$		
	20 Hz	$42 \times 10^{(-6)} \cdot R$		
	40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$36 \cdot 10^{(-6)} \cdot R$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC resistance (magnitude of impedance)	50 mΩ	10 Hz	$45 \times 10^{(-6)} \cdot R$	<i>R</i> = measured value <i>I</i> = current <i>f</i> = frequency Intermediate values and varying measurement conditions increase the measurement uncertainty
		20 Hz	$42 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$36 \times 10^{(-6)} \cdot R$	
	100 mΩ; 200 mΩ	10 Hz	$39 \times 10^{(-6)} \cdot R$	
		20 Hz	$35 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$30 \times 10^{(-6)} \cdot R$	
	0.5 Ω	10 Hz	$36 \times 10^{(-6)} \cdot R$	
		20 Hz; 40 Hz	$31 \cdot 10^{(-6)} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$26 \times 10^{(-6)} \cdot R$	
	1 Ω	10 Hz	$34 \times 10^{(-6)} \cdot R$	
		20 Hz	$30 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$25 \times 10^{(-6)} \cdot R$	
	2 Ω; 5 Ω	10 Hz	$31 \times 10^{(-6)} \cdot R$	
		20 Hz; 40 Hz	$26 \cdot 10^{(-6)} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$20 \times 10^{(-6)} \cdot \Omega$	
		10 kHz	$23 \times 10^{(-6)} \cdot \Omega$	
	10 Ω	10 Hz	$30 \times 10^{(-6)} \cdot \Omega$	
		20 Hz; 40 Hz	$26 \times 10^{(-6)} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$21 \times 10^{(-6)} \cdot R$	
		10 kHz	$23 \times 10^{(-6)} \cdot \Omega$	
	20 Ω	10 Hz	$29 \times 10^{(-6)} \cdot \Omega$	
		20 Hz; 40 Hz	$25 \times 10^{(-6)} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \times 10^{(-6)} \cdot R$	
		10 kHz	$22 \times 10^{(-6)} \cdot \Omega$	
50 Ω	10 Hz	$29 \times 10^{(-6)} \cdot \Omega$		
	20 Hz	$25 \times 10^{(-6)} \cdot R$		
	40 Hz	$20 \times 10^{(-6)} \cdot R$		
	55 Hz; 120 Hz; 400 Hz; 500 Hz	$19 \times 10^{(-6)} \cdot R$		
	1 kHz	$21 \times 10^{(-6)} \cdot R$		
	10 kHz	$25 \cdot 10^{(-6)} \cdot R$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC resistance (magnitude of impedance)	100 Ω	10 Hz	$29 \times 10^{(-6)} \times R$	
		20 Hz	$25 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz	$19 \times 10^{(-6)} \cdot R$	
		120 Hz; 400 Hz	$18 \cdot 10^{-6} \cdot R$	
		500 Hz	$20 \times 10^{-6} \cdot R$	
		1 kHz	$31 \times 10^{(-6)} \Omega$	
		10 kHz	$75 \times 10^{(-6)} \cdot R$	
	100 μΩ to 10 kΩ	10 Hz to 10 kHz	$\sqrt{U_i^2 + U_u^2} \cdot R$	U_i is the relative uncertainty of the calibration current U_u is the relative uncertainty of the measured voltage across the resistor R
	0 Ω to 10 kΩ	20 Hz to 50 Hz	$2.5 \times 10^{-3} \times R + 3.1 \text{ m}\Omega$	R = measured value Direct measurement method
	> 10 kΩ to 110 MΩ		$2.3 \times 10^{-9} \times R^2/\Omega + 2.5 \times 10^{-3} \times R$	
	0 Ω to 20 kΩ	> 50 Hz to 100 Hz	$1.0 \times 10^{-3} \cdot R + 2.6 \text{ m}\Omega$	
	> 20 kΩ to 110 MΩ		$2.3 \times 10^{-9} \cdot R^2/\Omega + 1.3 \times 10^{-3} \times R$	
	0 Ω to 50 kΩ	> 100 Hz to 1 kHz	$0.5 \times 10^{-3} \times R + 1.3 \text{ m}\Omega$	
	> 50 kΩ to 110 MΩ		$1.1 \times 10^{-9} \cdot R^2/\Omega + 1.2 \times 10^{-3} \cdot R$	
	0 Ω to < 50 Ω	> 1 kHz to 30 kHz	$1.1 \times 10^{-3} \cdot R + 1.2 \text{ m}\Omega$	
	50 Ω to 20 kΩ		$0.5 \times 10^{-3} \cdot R$	
	> 20 kΩ to 110 MΩ		$1.1 \times 10^{-9} \cdot R^2/\Omega + 0.79 \times 10^{-3} \cdot R$	
	0 Ω to 20 Ω	> 30 kHz to 100 kHz	$1.1 \times 10^{-3} \cdot R + 1.2 \text{ m}\Omega$	
	> 20 Ω to 20 kΩ		$0.5 \times 10^{(-3)} \times R$	
	> 20 kΩ to 110 MΩ		$1.3 \times 10^{-9} \cdot R^2/\Omega + 1.0 \times 10^{-3} \cdot R$	
	0 Ω to 100 Ω	> 100 kHz to 300 kHz	$1.1 \times 10^{-3} \cdot R + 2.2 \text{ m}\Omega$	
	> 100 Ω to 2 kΩ		$0.5 \times 10^{-3} \cdot R$	
	> 2 kΩ to 110 MΩ		$4.5 \times 10^{-9} \cdot R^2/\Omega + 0.9 \times 10^{-3} \cdot R$	
	0 Ω to 50 Ω	> 300 kHz to 1 MHz	$1.3 \times 10^{(-3)} \times R + 3.2 \text{ m}\Omega$	
	> 50 Ω to 2 kΩ		$0.7 \times 10^{(-3)} \cdot R$	
	> 2 kΩ to 22 MΩ		$15 \times 10^{-9} \cdot R^2/\Omega + 1.1 \times 10^{-3} \cdot R$	

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Electrical power

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
DC power	0 W to 110 kW	0 mV to 1100 V 0 μA to 100 A	$\sqrt{W_u^2 + W_i^2} \cdot P$ but not less than $44 \times 10^{(-6)} \times P + 5 \text{ fW}$	P = measured value
Power factor sources, measuring instruments	0 to 1	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{(1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$	$6,8 \times 10^{-12}$ to $2,1 \times 10^{-3}$	$PF = \cos(\Delta\varphi) =$ power factor $\Delta\varphi = \varphi_U - \varphi_I =$ phase angle U = RMS value of the AC voltage I = RMS value of the alternating current
		For a measuring instrument with a current clamp/current transformer, the range is extended $10 \text{ Hz} \leq f \leq 100 \text{ Hz}$ the upper current limit extends to 1 kA.	$7,8 \times 10^{-9}$ to $1,5 \times 10^{-4}$	The measurement uncertainties apply to sinusoidal signals. See also matrices M.21 to M.25

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC active power Sources, measuring instruments	0 W to 100 kW	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$ $0 \leq PF \leq 1$	7.5 pW up to 210 W	$P(U; I; PF)$ $= U \cdot I \cdot PF =$ AC active power $PF = \cos(\Delta\varphi) =$ power factor $\Delta\varphi$ $= \varphi_U - \varphi_I =$ phase angle $U =$ RMS value of the AC voltage $I =$ RMS value of the AC current
	0 W to 1 MW	Additional range for measuring instruments with current clamps/current transformers: $10 \text{ Hz} \leq f \leq 100 \text{ Hz}^{1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $100 \text{ A} < I \leq 1 \text{ kA}$ $0 \leq PF \leq 1$	Current transformer: $3.8 \times 10^{-4} \times P$ not less than 2 μW Current clamps: $4.6 \times 10^{-3} \times P$ not less than 2 μW	The measurement uncertainties apply to sinusoidal signals. See also matrices M.26 to M.35
AC reactive power Sources, measuring instruments	-100 kvar to 100 kvar	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$ $0 \leq PF \leq 1$	7.5 pvar to 210 var	$Q = U \cdot I \cdot \sin(\Delta\varphi)$ $= U \cdot I \cdot \sqrt{1 - PF^2}$ AC reactive power $PF = \cos(\Delta\varphi) =$ power factor $\Delta\varphi$ $= \varphi_U - \varphi_I =$ phase angle $U =$ RMS value of the AC voltage $I =$ RMS value of the alternating current
	-1 Mvar to 1 Mvar	Additional range for measuring instruments with current clamps/current transformers: $10 \text{ Hz} \leq f \leq 100 \text{ Hz}^{1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $100 \text{ A} < I \leq 1 \text{ kA}$ $0 \leq PF \leq 1$	Current transformer: $3.8 \times 10^{-4} \times Q$ not less than 2 μvar Current clamps: $4.6 \times 10^{-3} \times C$ not less than 2 μvar	The measurement uncertainties apply to sinusoidal signals. See also matrices M.26 to M.35

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / procedure	Expanded measurement uncertainty	Comments
AC apparent power Sources, measuring instruments	0 VA to 100 kVA	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{(1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$	59 pVA up to 7.6 VA	$S = U \cdot I$ $= P (U; I; PF = 1) =$ AC apparent power $PF = \cos(\Delta\varphi) =$ Power factor $\Delta\varphi = \varphi_U - \varphi_I =$ Phase angle $U =$ RMS value of AC voltage $I =$ RMS value of the AC current $P =$ AC active power The measurement uncertainty These specifications apply to sinusoidal signals. See also matrices M.26 to M.35 for $PF = 1$
	0 VA to 1 MVA	Additional range for measuring instruments with current clamps/current transformers: $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $10 \text{ Hz} \leq f \leq 100 \text{ Hz}^{(1)}$ $1 \text{ mA} \leq I \leq 1 \text{ kA}$	Current transformer: $3.8 \times 10^{-4} \times S$ Current clamps: $4.6 \times 10^{-3} \times S$	
Energy E Defibrillator tester	5 J to 150 J		$2.3 \times 10^{-3} \times E + 49 \text{ mJ}$	$E =$ Energy Monophasic or Biphasic
	> 150 J to 360 J		$1.1 \cdot 10^{-3} \cdot E + 0.27 \text{ J}$	
Voltage ratio between bridge standards and measuring instruments	0 mV/V to 100 mV/V	DC voltage Bridge voltage: 1 V to 10 V	0.1 $\mu\text{V/V}$ to 1.6 $\mu\text{V/V}$ see Matrix M.2	

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Matrix M.2: 'Voltage ratio'

Measured value \ Bridge voltage	Bridge voltage			
	10 V	5 V	2 V	1 V
0 mV/V	0.10 μ V/V	0.10 μ V/V	0.17 μ V/V	0.35 μ V/V
± 2 mV/V	0.10 μ V/V	0.11 μ V/V	0.26 μ V/V	0.51 μ V/V
± 5 mV/V	0.10 μ V/V	0.13 μ V/V	0.27 μ V/V	0.52 μ V/V
± 10 mV/V	0.10 μ V/V	0.16 μ V/V	0.31 μ V/V	0.56 μ V/V
± 20 mV/V	0.16 μ V/V	0.20 μ V/V	0.38 μ V/V	0.66 μ V/V
± 50 mV/V	0.35 μ V/V	0.39 μ V/V	0.58 μ V/V	1 μ V/V
± 100 mV/V	0.65 μ V/V	0.73 μ V/V	1.0 μ V/V	1.6 μ V/V

Matrix M.21: Absolute measurement uncertainty of the measured quantity **power factor PF** when calibrating **sources** in the range **2 A < I \leq 20 A & 15 mV < U \leq 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10	3,1 $\times 10^{-6}$	3,0 $\times 10^{-6}$	2,8 $\times 10^{-6}$	2,5 $\times 10^{-6}$	1,9 $\times 10^{-6}$	1,4 $\times 10^{-6}$	6,8 $\times 10^{-12}$
45	9,8 $\times 10^{-6}$	9,6 $\times 10^{-6}$	9,0 $\times 10^{-6}$	7,9 $\times 10^{-6}$	5,9 $\times 10^{-6}$	4,3 $\times 10^{-6}$	6,8 $\times 10^{-11}$
111	1,9 $\times 10^{-5}$	1,9 $\times 10^{-5}$	1,8 $\times 10^{-5}$	1,5 $\times 10^{-5}$	1,2 $\times 10^{-5}$	8,4 $\times 10^{-6}$	2,6 $\times 10^{-10}$
1000	1,6 $\times 10^{-4}$	1,6 $\times 10^{-4}$	1,5 $\times 10^{-4}$	1,3 $\times 10^{-4}$	9,7 $\times 10^{-5}$	7,1 $\times 10^{-5}$	1,9 $\times 10^{-8}$
10,000	1,6 $\times 10^{-3}$	1,6 $\times 10^{-3}$	1,5 $\times 10^{-3}$	1,3 $\times 10^{-3}$	9,7 $\times 10^{-4}$	7,1 $\times 10^{-4}$	1,6 $\times 10^{-6}$

Matrix M.22: Absolute measurement uncertainty of the measured quantity **power factor PF** for the calibration of **sources** in the range **20 A < I \leq 100 A & 15 mV < U \leq 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.8	1
10	3,4 $\times 10^{-6}$	3,4 $\times 10^{-6}$	3,2 $\times 10^{-6}$	2,8 $\times 10^{-6}$	2,1 $\times 10^{-6}$	1,5 $\times 10^{-6}$	8,4 $\times 10^{-12}$
45	1,1 $\times 10^{-5}$	1,1 $\times 10^{-5}$	1,0 $\times 10^{-5}$	9,1 $\times 10^{-6}$	6,8 $\times 10^{-6}$	5,0 $\times 10^{-6}$	9,2 $\times 10^{-11}$
111	2,4 $\times 10^{-5}$	2,3 $\times 10^{-5}$	2,2 $\times 10^{-5}$	1,9 $\times 10^{-5}$	1,4 $\times 10^{-5}$	1,0 $\times 10^{-5}$	4,0 $\times 10^{-10}$
1000	2,0 $\times 10^{-4}$	2,0 $\times 10^{-4}$	1,9 $\times 10^{-4}$	1,6 $\times 10^{-4}$	1,2 $\times 10^{-4}$	8,8 $\times 10^{-5}$	2,9 $\times 10^{-8}$
10,000	2,0 $\times 10^{-3}$	2,0 $\times 10^{-3}$	1,9 $\times 10^{-3}$	1,6 $\times 10^{-3}$	1,2 $\times 10^{-3}$	8,8 $\times 10^{-4}$	2,9 $\times 10^{-6}$

Matrix M.23: Absolute measurement uncertainty of the measured quantity **power factor PF** for the calibration of **measuring instruments** in the range **2 A < I \leq 20 A & 15 mV < U \leq 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10	3,2 $\times 10^{-6}$	3,2 $\times 10^{-6}$	2,9 $\times 10^{-6}$	2,6 $\times 10^{-6}$	1,9 $\times 10^{-6}$	1,4 $\times 10^{-6}$	7,3 $\times 10^{-12}$
45	1,0 $\times 10^{-5}$	1,0 $\times 10^{-5}$	9,5 $\times 10^{-6}$	8,3 $\times 10^{-6}$	6,2 $\times 10^{-6}$	4,5 $\times 10^{-6}$	7,6 $\times 10^{-11}$
111	2,1 $\times 10^{-5}$	2,0 $\times 10^{-5}$	1,9 $\times 10^{-5}$	1,6 $\times 10^{-5}$	1,2 $\times 10^{-5}$	9,0 $\times 10^{-6}$	3,0 $\times 10^{-10}$
1000	1,7 $\times 10^{-4}$	1,7 $\times 10^{-4}$	1,6 $\times 10^{-4}$	1,4 $\times 10^{-4}$	1,0 $\times 10^{-4}$	7,6 $\times 10^{-5}$	2,1 $\times 10^{-8}$
10,000	1,7 $\times 10^{-3}$	1,7 $\times 10^{-3}$	1,6 $\times 10^{-3}$	1,4 $\times 10^{-3}$	1,0 $\times 10^{-3}$	7,6 $\times 10^{-4}$	2,1 $\times 10^{-6}$

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Matrix M.24: Absolute measurement uncertainty of the measured quantity **power factor PF**
for the calibration of **measuring instruments** in the range **20 A < I ≤ 100 A & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10	3,6×10 ⁻⁶	3,5×10 ⁻⁶	3,3×10 ⁻⁶	2,8×10 ⁻⁶	2,1×10 ⁻⁶	1,5×10 ⁻⁶	8,9×10 ⁻¹²
45	1,2×10 ⁻⁵	1,2×10 ⁻⁵	1,1×10 ⁻⁵	9,5×10 ⁻⁶	7,1×10 ⁻⁶	5,2×10 ⁻⁶	1,0×10 ⁻¹⁰
111	2,5×10 ⁻⁵	2,4×10 ⁻⁵	2,3×10 ⁻⁵	2,0×10 ⁻⁵	1,5×10 ⁻⁵	1,1×10 ⁻⁵	4,4×10 ⁻¹⁰
1000	2,1×10 ⁻⁴	2,1×10 ⁻⁴	2,0×10 ⁻⁴	1,7×10 ⁻⁴	1,3 × 10 ⁻⁴	9,3×10 ⁻⁵	3,3 × 10 ⁻⁸
10,000	2,1×10 ⁻³	2,1×10 ⁻³	2,0×10 ⁻³	1,7×10 ⁻³	1,3×10 ⁻³	9,3×10 ⁻⁴	3,3×10 ⁻⁶

Matrix M.25: Absolute measurement uncertainty of the measured quantity **power factor PF**
for the calibration of **measuring instruments with current clamps/current transformers** in the range **100 A < I ≤ 1 kA & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10 Hz to 100 Hz	1,5×10 ⁻⁴	1,5×10 ⁻⁴	1,4×10 ⁻⁴	1,2×10 ⁻⁴	8,9×10 ⁻⁵	6,5×10 ⁻⁵	7,8×10 ⁻⁹

Matrix M.26: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$)

and **apparent AC power** $S = U \cdot I$ (see values for PF = 1) when calibrating **sources** with **U = 2 mV and I = 100 μA**

f (Hz)	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$					
	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
10	48 pW	54 pW	60 pW	68 pW	72 pW	77 hp
1000	34 pW	39 pW	44 pW	51 pW	55 pW	59 pW
10,000	340 pW	310 pW	270 pW	210 pW	160 pW	59 pW

Matrix M.27: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for PF = 1) during the calibration of **measuring instruments** with **U = 2 mV and I = 1 mA**

f (Hz)	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$					
	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
40	1.0 nW	1.0 nW	1.1 nW	1.1 nW	1.1 nW	1.2 nW
1000	230 pW	320 pW	400 pW	490 pW	530 pW	580 pW
10,000	2.3 nW	2.1 nW	1.9 nW	1.5 nW	1.1 nW	580 pW

Matrix M.28: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for PF = 1) when calibrating **sources** with **U = 20 mV and I = 100 μA**

f (Hz)	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$					
	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
10	7.5 pW	110 pW	170 pW	230 pW	260 pW	280 pW
1000	340 pW	320 pW	290 pW	250 pW	230 pW	190 pW
10,000	3.4 nW	3.1 nW	2.7 nW	2.0 nW	1.5 nW	200 pW

Matrix M.29: Absolute measurement uncertainty of the measured quantities

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AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and

apparent AC power $S = U \cdot I$ (see values for $PF = 1$) when calibrating **measuring instruments** with $U = 20 \text{ mV}$ and $I = 1 \text{ mA}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	150 pW	730 pW	1.1 nW	1.4 nW	1.6 nW	1.8 nW
1000	2.3 nW	2.3 nW	2.2 nW	2.0 nW	1.9 nW	1.8 nW
10,000	23 nW	21 nW	19 nW	14 nW	10 nW	1.8 nW

Matrix M.30: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and

apparent AC power $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 20 \text{ V}$ and $I = 1 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	140 μW	250 μW	350 μW	440 μW	500 μW	550 μW
1000	2.1 mW	1.9 mW	1.7 mW	1.3 mW	1.0 mW	530 μW
10,000	21 mW	19 mW	17 mW	13 mW	9.1 mW	530 μW

Matrix M.31: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and

AC apparent power $S = U \cdot I$ (see values for $PF = 1$) during the calibration of **measuring instruments** with $U = 20 \text{ V}$ and $I = 1 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)^2}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	150 μW	260 μW	350 μW	450 μW	500 μW	550 μW
1000	2.3 mW	2.1 mW	1.9 mW	1.5 mW	1.1 mW	530 μW
10,000	23 mW	21 mW	19 mW	14 mW	10 mW	530 μW

Matrix M.32: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and

AC apparent power $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 20 \text{ V}$ and $I = 20 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	3.5 mW	9.2 mW	13 mW	17 mW	20 mW	22 mW
1000	65 mW	60 mW	53 mW	43 mW	34 mW	22 mW
10,000	650 mW	590 mW	520 mW	390 mW	280 mW	22 mW

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Matrix M.33: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for

$\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) when calibrating **measuring instruments** with $U = 20 \text{ V}$ and $I = 20 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	3.7 mW	9.3 mW	13 mW	17 mW	20 mW	22 mW
1000	70 mW	65 mW	58 mW	46 mW	36 mW	22 mW
10,000	700 mW	650 mW	560 mW	420 mW	310 mW	22 mW

Matrix M.34: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for

$\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 1 \text{ kV}$ and

$I = 100 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	1.0 W	2.8 W	4.1 W	5.4 W	6.0 W	6.7 W
1000	20 W	19 W	17 W	14 W	11 W	7.6 W
10,000	200 W	190 W	160 W	120 W	89 W	7.6 W

Matrix M.35: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for

$\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) during the calibration of **measuring instruments** with $U = 1 \text{ kV}$ and $I =$

100 A

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	1.1 W	2.8 W	4.1 W	5.4 W	6.0 W	6.7 W
1000	21 W	20 W	18 W	14 W	12 W	7.6 W
10,000	210 W	200 W	170 W	130 W	93 W	7.6 W

¹⁾ The specified range applies only if the maximum volt-hertz product, as shown in Figure A of the Operator's Manual for the Multi-Function Calibrator 5700A/5720A Series II, May 1996, Rev. 2, 3/05, is observed.

Phase angle

Permanent Laboratory

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Phase angle between sinusoidal voltage signals multi-channel sources, measuring instruments	-360° to 360°	10 Hz ≤ f ≤ 1 MHz 1 mV ≤ U _{rms,i} ≤ 1 kV	360° · f · 17 ns	$\Delta\varphi = \varphi_2 - \varphi_1 =$ Phase angle $U_i(t) =$ $\sqrt{2}U_{\text{eff},i} \sin(2\pi ft + \varphi_i)$ where $i \in \{1; 2\}$ $f =$ frequency $U_{\text{eff},i} =$ rms value of the AC voltage Measurements at voltages ≤ 15 mV in the frequency range 10 Hz to < 1 kHz, as well as measurements at $f = (50 \pm 5)$ Hz can be measurement uncertainty increase.

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Phase angle between sinusoidal Output voltage and sinusoidal input current resistance standard		$10 \text{ mA} \leq I_{\text{eff.}} \leq 100 \text{ A}$ for $f \leq 10 \text{ kHz}$ $10 \text{ mA} \leq I_{\text{eff.}} \leq 50 \text{ mA}$ for $f \leq 100 \text{ kHz}$		$\Delta\varphi = \varphi_U - \varphi_I =$ Phase angle $I(t) = \sqrt{2} I_{\text{eff.}} \sin(2\pi f t + \varphi_I)$ $U(t) = \sqrt{2} I_{\text{eff.}} Z \sin(2\pi f t + \varphi_U)$ $f =$ frequency $R =$ DC resistance resistance $I_{\text{eff.}} =$ RMS value of the alternating current $Z =$ Impedance of the resistance standard Measurements at voltages $\leq 15 \text{ mV}$ in the frequency range 10 Hz to $< 1 \text{ kHz}$, as well as different measurement conditions may affect measurement uncertainty.
	-90° to 90°	$10 \text{ Hz} \leq f \leq 100 \text{ kHz}$ $10 \text{ m}\Omega \leq R < 50 \text{ m}\Omega$		The stated measurement uncertainties apply to resistors from the SIQ MU series, the Fluke A40B or similar designs with coaxial connection sockets. For resistors of other designs, the measurement uncertainty may increase.
		$f = 10 \text{ Hz}$	0.18 mΩ	
		$f = 45 \text{ Hz}$	0.60 mΩ	
		$f = 111 \text{ Hz}$	1.2 m°	
		$1 \text{ kHz} \leq f \leq 100 \text{ kHz}$	$360^\circ \cdot f \cdot 28 \text{ ns}$	
		$10 \text{ Hz} \leq f \leq 100 \text{ kHz}$ $50 \text{ m}\Omega \leq R \leq 100 \Omega$		
		$f = 40 \text{ Hz}$	0.43 m°	
		$f = 100 \text{ Hz}$	0.79 m°	
		$1 \text{ kHz} \leq f \leq 100 \text{ kHz}$	$360^\circ \cdot f \cdot 20 \text{ ns}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Comments	
Phase angle between sinusoidal output signal and sinusoidal input current Current transformer		$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$		$\Delta\varphi = \varphi_Y - \varphi_I =$ Phase angle $I(t) = \sqrt{2}I_{\text{eff}} \cdot \sin(2\pi ft + \varphi_I)$ $Y(t) = \sqrt{2}Y_{\text{eff}} \cdot \sin(2\pi ft + \varphi_Y)$ $f =$ frequency I_{rms} = root mean square value of the alternating current Y_{rms} = root mean square value of the current transformer's output signal (current or voltage)	
	-90° to 90°	$1 \text{ A} < I_{\text{rms}} \leq 2 \text{ A}$			The stated uncertainties apply in cases where the output signal of the current transformer is a voltage. Measurements at voltages $\leq 15 \text{ mV}$ in the frequency range 10 Hz to $< 1 \text{ kHz}$, different measurement conditions, as well as the case where the output signal of the current transformer is a current, increase the measurement uncertainty.
		$f = 40 \text{ Hz}$		0.43 m°	
		$f = 100 \text{ Hz}$		0.79 m°	
		$1 \text{ kHz} \leq f \leq 10 \text{ kHz}$		$360^\circ \cdot f \cdot 20 \text{ ns}$	
		$2 \text{ A} < I_{\text{rms}} \leq 20 \text{ A}$			
		$f = 10 \text{ Hz}$		0.18 m°	
		$f = 45 \text{ Hz}$		0.60 m°	
		$f = 111 \text{ Hz}$		1.2 m°	
		$1 \text{ kHz} \leq f \leq 10 \text{ kHz}$		$360^\circ \cdot f \cdot 28 \text{ ns}$	
		$20 \text{ A} < I_{\text{rms}} \leq 100 \text{ A}$			
		$f = 10 \text{ Hz}$		0.21 m°	
		$f = 45 \text{ Hz}$		0.68 m°	
		$f = 111 \text{ Hz}$		1.4 m°	
		$1 \text{ kHz} \leq f \leq 10 \text{ kHz}$		$360^\circ \cdot f \cdot 35 \text{ ns}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / methods	Expanded measurement uncertainty	Comments
Phase angle between sinusoidal voltage signal and sinusoidal current signal Sources	-180° to 180°	10 Hz ≤ f ≤ 10 kHz mV ≤ U _{rms} ≤ 1 kV		$\Delta\varphi = \varphi_U - \varphi_I =$ Phase angle $I(t) =$ $\sqrt{2}I_{\text{eff.}} \sin(2\pi ft + \varphi_I)$ $U(t) =$ $\sqrt{2}U_{\text{eff.}} \sin(2\pi ft + \varphi_U)$
		100 μA ≤ I _{eff.} ≤ 10 mA		f = Frequency
		f = 10 Hz	0.21 m°	I _{rms} = root mean square value of the alternating current
		f = 45 Hz	0.57 m°	
		f = 111 Hz	1.1 m°	U _{rms} = root mean square value of the alternating voltage
		1 kHz ≤ f ≤ 10 kHz	360° · f · 27 ns	
		10 mA < I _{rms} ≤ 200 mA		
		f = 40 Hz	0.37 m°	Measurements at voltages ≤ 15 mV in the frequency range 10 Hz to < 1 kHz, as well as deviating measurement conditions may increase the measurement uncertainty.
		f = 100 Hz	0.72 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 18 ns	
		200 mA < I _{eff.} ≤ 2 A		
		f = 40 Hz	0.40 m°	
		f = 100 Hz	0.68 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 17 ns	
		2 A < I _{eff.} ≤ 20 A		
		f = 10 Hz	0.18 m°	
		f = 45 Hz	0.57 m°	
		f = 111 Hz	1.1 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 26 ns	
		20 A < I _{rms} ≤ 100 A		
f = 10 Hz	0.20 m°			
f = 45 Hz	0.65 m°			
f = 111 Hz	1.4 m°			
1 kHz ≤ f ≤ 10 kHz	360° · f · 32 ns			

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Phase angle between a sinusoidal voltage signal and sinusoidal current signal Measuring instruments	-180° to 180°	10 Hz ≤ f ≤ 10 kHz mV ≤ U _{rms} ≤ 1 kV		$\Delta\varphi = \varphi_U - \varphi_I =$ Phase angle $I(t) =$ $\sqrt{2}I_{\text{eff.}} \sin(2\pi ft + \varphi_I)$ $U(t) =$ $\sqrt{2}U_{\text{eff.}} \sin(2\pi ft + \varphi_U)$
		1 mA ≤ I _{rms} ≤ 2 A		f = frequency
		f = 40 Hz	0.42 m°	I _{eff.} = root mean square value of the alternating current
		f = 100 Hz	0.76 m°	U _{eff.} = RMS value of the AC voltage
		1 kHz ≤ f ≤ 10 kHz	360° · f · 19 ns	Measurements at voltages ≤ 15 mV in the frequency range 10 Hz to < 1 kHz, as well as deviating measurement conditions may increase the measurement uncertainty.
		2 A < I _{rms} ≤ 20 A		
		f = 10 Hz	0.18 m°	
		f = 45 Hz	0.60 m°	
		f = 111 Hz	1.2 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 28 ns	
		20 A < I _{rms} ≤ 100 A		
		f = 10 Hz	0.21 m°	
		f = 45 Hz	0.68 m°	
		f = 111 Hz	1.4 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 34 ns	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
nPhase angle between fundamental wave and nth harmonic harmonic of a voltage signal Measuring instruments	-180° to 180°	$1 \leq n \leq 100$ $45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$ $f_n \leq 6 \text{ kHz}$ $U_1 \geq 100 \text{ mV}$ $U_n \geq 10 \text{ mV}$ $U_s \leq 1050 \text{ V}$	$360^\circ \cdot f_n \cdot 225 \text{ ns}$	$\Delta\varphi = \varphi_n - n\varphi_1 =$ Phase angle $U(t) = \sum_{n=1}^{100} \sqrt{2} \bar{U}_n \sin(2\pi f_n t + \varphi_n)$ $f_1 =$ Frequency of the fundamental wave $f_n =$ frequency of the nth harmonic $U_1 =$ RMS value of the fundamental $U_n =$ RMS value of the nth harmonic harmonic $U_s =$ peak value of the voltage signal The range limits and other specifications of the Fluke 6100B/6105A User Manual (September 2009 Rev. 1, 6/10).

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
nPhase angle between fundamental wave and nth harmonic th of a current signal Measuring instruments	-180° to 180°	$1 \leq n \leq 100$ $45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$ $I_S \leq 29.7 \text{ A}; f_n \leq 6 \text{ kHz}$ or $I_S > 29.7 \text{ A}; f_n \leq 3 \text{ kHz}$ $I_1 \geq 100 \text{ mA}$ $I_n \geq 10 \text{ mA}$ $I_S \leq 113 \text{ A}$	$360^\circ \cdot f_n \cdot 228 \text{ ns}$	$\Delta\varphi = \varphi_n - n\varphi_1 =$ Phase angle $I(t) =$ $\sum_{n=1}^{100} \sqrt{2} I_n \sin(2\pi f_n t + \varphi_n)$ f_1 = frequency of the fundamental wave f_n = Frequency of the n-th of the 10th harmonic Harmonic I_1 = RMS value of the fundamental I_n = RMS value of the nth harmonic I_S = peak value of the current signal The range limits and other specifications of the Fluke 6100B/6105A User Manual (September 2009 Rev. 1, 6/10).

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Inductance and Capacitance

Permanent Laboratory – Eichenau site

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	
Inductance	0 µH		0.03 µH	2-wire short-circuit
	0 H to 1.1 H			L = measured value
	100 µH	100 Hz	$0.63 \times 10^{(-3)} \times L$	
		1 kHz	$0.17 \times 10^{(-3)} \cdot L$	
		10 kHz	$0.22 \times 10^{(-3)} \times L$	
	1 mH	100 Hz	$0.14 \times 10^{(-3)} \times L$	Absolute value of impedance $50 \text{ m}\Omega \leq Z \leq 11 \text{ k}\Omega$
		1 kHz	$0.12 \times 10^{(-3)} \cdot L$	
10 kHz		$0.17 \times 10^{(-3)} \cdot L$		
10 mH	100 Hz; 1 kHz	$0.11 \times 10^{(-3)} \cdot L$	Smallest specifiable fixed-value measurement uncertainties for direct measurement or substitution on GR 1482 or equivalent	
	10 kHz	$0.16 \times 10^{(-3)} \cdot L$		
100 mH	100 Hz; 1 kHz	$0.11 \times 10^{(-3)} \times L$		
	10 kHz	$0.25 \times 10^{(-3)} \times L$		
1 H	100 Hz, 1 kHz	$0.13 \times 10^{(-3)} L$		
Capacitance	0 pF		0.2 pF	No-load
	0 pF to 10 µF			C = measured value
	1 pF	1 kHz	$0.21 \times 10^{(-3)} C$	
			10 kHz	$0.31 \times 10^{(-3)} C$
	10 pF	1 kHz	$19 \cdot 10^{(-6)} \cdot C$	Magnitude of impedance $1 \Omega \leq Z \leq 110 \text{ M}\Omega$ Smallest applicable fixed-value measurement uncertainties for direct measurement or substitution on GR 1403 / 1404 / 1409 or equivalent
		10 kHz; 100 kHz	$62 \times 10^{(-6)} \cdot C$	
		1 MHz	$0.10 \times 10^{(-3)} C$	
	100 pF	1 kHz	$26 \times 10^{(-6)} C$	
	1 nF	1 kHz	$31 \times 10^{(-6)} C$	
100 kHz		$0.10 \times 10^{(-3)} C$		
10 nF	100 Hz	$0.20 \times 10^{(-3)} C$		
	1 kHz	$0.12 \times 10^{(-3)} C$		
	10 kHz	$0.11 \times 10^{(-3)} C$		
100 nF	100 Hz; 1 kHz; 10 kHz	$0.15 \times 10^{(-3)} C$		
1 µF	100 Hz; 1 kHz	$0.10 \times 10^{(-3)} C$		
	10 kHz	$0.20 \times 10^{(-3)} C$		

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Electrical quantities – time and frequency Permanent

Laboratory – Eichenau site

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	
Frequency f	1 MHz to 10 MHz in 1 MHz steps	Phase difference time measurements over measurement periods > 1 h	$2.0 \times 10^{(-12)} \times f$	f : measured value U_{TF} : Trigger uncertainty
	0.01 Hz to 350 MHz > 350 MHz to 26.5 GHz > 26.5 GHz to 40 GHz		$2.6 \times 10^{(-12)} \cdot f + U_{TF}$ $11 \times 10^{(-12)} \cdot f + U_{TF}$ $0.6 \text{ Hz} + U_{TF}$	
Time interval Δt	0 ns to 0.7 ms 0 ns to 200 s 1 μ s to 100 h 1 s to 100 h		1.3 ns $1.5 \times 10^{(-6)} \times \Delta t + 50 \text{ ps}$ $10 \times 10^{(-9)} \times \Delta t + 1 \text{ } \mu\text{s}$ $13 \times 10^{(-6)} \cdot \Delta t + 0.82 \text{ s}$	
Rate deviation	0 s/d to 100 s/d		$1.3 \times 10^{(-7)} = 0.011 \text{ s/d}$	Electronic or mechanical watches
Rotational speed	0.02 s^{-1} to 3500 s^{-1}		$3.7 \times 10^{(-6)} \times f$	f : measured value

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High-frequency and radiation quantities – High-frequency quantities Permanent

laboratory – Eichenau site

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
Vertical oscilloscopes	1 mV to 5 V 5 mV to 200 V	DC to 10 kHz	$1.2 \times 10^{(-3)} \times U + 12 \mu\text{V}$	U: measured value 50 Ω 1 MΩ
Oscilloscope horizontal	25 ps to 40 s		$0.12 \times 10^{(-6)} \times T + 0.1 \text{ ps}$	T: measured value
Bandwidth f (frequency response)	40 Hz to 6 GHz		$6.3 \times 10^{(-3)} \times f^2/\text{GHz}$ $+ 20 \times 10^{(-3)} \times f$	f = measured value
	> 6 GHz to 40 GHz		$75 \times 10^{(-3)} \times f$	
Rise time	30 ps to 45 ps > 45 ps to 1 ms	0.1 V to 3 V	5 ps $10 \times 10^{(-3)} \times T + 3 \text{ ps}$	calculated from the 3 dB bandwidth T: measured value
	70 ps to 85 ps > 85 ps to 310 hp > 310 hp to 650 hp > 650 ps to 1 ms	0.1 V to 3 V	$78 \times 10^{(-3)} T$ $67 \times 10^{(-3)} T$ $58 \times 10^{(-3)} T$ $56 \times 10^{(-3)} T$	
Frequency f Time base	10 MHz		$0.2 \times 10^{(-6)} \times f$	
Pulse measurement parameters Rise time (e.g. oscilloscope calibrator)	15 ps to 10 ns	0.1 V to 40 V into 50 Ω	$10 \cdot 10^{(-3)} \cdot T + 3 \text{ ps}$	External trigger signal required
	160 ps to 10 ms	0.1 V to 2 V into 50 Ω	$30 \times 10^{(-3)} \times T + 30 \text{ ps}$	
Burst generator output voltage Peak value U_s	100 V to 4 kV	under 50 Ω or 1 kΩ load	$48 \cdot 10^{(-3)} \cdot U_s$	
Rise time and pulse duration T_r	3 ns to 1 μs		$41 \cdot 10^{(-3)} \cdot T_r$	
Burst duration and burst period T	10 μs to 1 s		$5 \cdot 10^{(-3)} \cdot T$	
Pulse frequency f	100 Hz to 500 kHz		$1 \times 10^{(-3)} \times f$	
ESD generator Rise time t_r of the peak current	300 ps to 3 ns		$3 \% \cdot t_r + 15 \text{ ps}$	Measurement range relative to the peak current I_p
Discharge current I	1.5 A to 35 A		$4.3 \% \cdot I + 0.15 \text{ A}$	
Surge voltage generator Rise time t_{r,U_s} of the open-circuit voltage	15 ns to 100 ms		$3 \% \cdot t_{r,U_s} + 1 \text{ ns}$	
Rise time t_{r,I_s} of the short-circuit current	100 ns to 100 ms		$3 \% \cdot t_{r,I_s} + 2 \text{ ns}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / procedure	Expanded measurement uncertainty	Comments
Half-life t_H of the waveform	0.5 μ s to 100 ms		5 % $\cdot t_H$	
Peak value of the open-circuit voltage U_S	0.1 kV to 7 kV		3.3% $\cdot U_S$	
RMS value of the short-circuit Current I_S	10 A to 5 kA		3.5% $\cdot I_S$	
	> 5 kA to 10 kA		3.8% $\cdot I_S$	
Pulsed measured quantities * Display behaviour of measuring receiver for pulses Amplitude relationship (absolute calibration)		EN 55016-1-1:2015		
	9 kHz to 150 kHz		0.35 dB	Band A
	> 150 kHz to 30 MHz			Band B
	> 30 MHz to 300 MHz		0.40 dB	Band C
	> 300 MHz to 1 GHz			Band D
Change in display with pulse frequency (relative calibration)	Pulse repetition frequency			
	0.1 Hz to 2 kHz		0.30 dB	Band A
	0.1 Hz to 50 kHz		0.35 dB	Band B
	0.1 Hz to 1 MHz			Band C and Band D

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
RF power Input power and calibration factor of RF power meters	10 fW to < 100 fW	DC to 2 GHz	$21 \times 10^{(-3)} \cdot P$	PC Type N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz
		> 2 GHz up to < 5 GHz	$26 \times 10^{(-3)} \times P$	
		5 GHz to < 9 GHz	$34 \times 10^{(-3)} \cdot P$	
		9 GHz to < 12 GHz	$40 \times 10^{(-3)} \cdot P$	
		12 GHz to 15 GHz	$48 \times 10^{(-3)} \cdot P$	
		> 15 GHz to 18 GHz	$54 \times 10^{(-3)} \cdot P$	
	100 fW to 1 pW	DC to 100 MHz	$18 \times 10^{(-3)} \cdot P$	*) Other connectors increase the measurement uncertainty.
		> 100 MHz to 2 GHz	$20 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$22 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 12 GHz	$24 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 40 GHz	$29 \times 10^{(-3)} P$	
	> 1 pW to 10 pW	DC to 100 MHz	$13 \times 10^{(-3)} \cdot P$	P = measured value (W)
		> 100 MHz to 2 GHz	$15 \times 10^{(-3)} P$	
		> 2 GHz to 8 GHz	$18 \cdot 10^{-3} \cdot P$	
		> 8 GHz to 12 GHz	$20 \times 10^{-3} \cdot P$	
		> 12 GHz to 26.5 GHz	$26 \times 10^{(-3)} \cdot P$	
		> 26.5 GHz to 40 GHz	$29 \times 10^{(-3)} P$	
	> 10 pW to 1 nW	DC to 100 MHz	$12 \times 10^{(-3)} \cdot P$	
		> 100 MHz to 2 GHz	$14 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$17 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 12 GHz	$20 \times 10^{-3} \times P$	
		> 12 GHz to 40 GHz	$22 \times 10^{(-3)} P$	
	> 1 nW to 100 nW	DC up to 2 GHz	$10 \times 10^{(-3)} P$	
		> 2 GHz to 8 GHz	$12 \times 10^{-3} \cdot P$	
> 8 GHz to 12 GHz		$13 \times 10^{-3} \cdot P$		
> 12 GHz to 40 GHz		$15 \times 10^{-3} \cdot P$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
RF power Input power and calibration factor of RF power meters	> 100 nW to 10 µW	DC to 100 MHz	$7.1 \times 10^{(-3)} \cdot P$	PC Type N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz
		> 100 MHz to 2 GHz	$9.4 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$11 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 12 GHz	$13 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 40 GHz	$15 \times 10^{(-3)} \cdot P$	
	> 10 µW to 100 mW	DC to 100 MHz	$6.1 \times 10^{(-3)} \cdot P$	*) Other connectors increase the measurement uncertainty. P = measured value (W)
		> 100 MHz to 2 GHz	$7.9 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$9.3 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 12 GHz	$11 \cdot 10^{(-3)} \cdot P$	
		> 12 GHz to 40 GHz	$13 \times 10^{(-3)} \cdot P$	
RF power Output power and calibration factor of RF sources	1 mW	50 MHz	$5 \times 10^{(-3)} \cdot P$	Substitution
	0.1 pW to < 10 pW	50 MHz	$27 \times 10^{(-3)} \cdot P$	PC Type-N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz
		10 MHz to 2 GHz	$30 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 3 GHz	$35 \times 10^{(-3)} \cdot P$	
	10 pW to < 1 nW	50 MHz	$21 \times 10^{(-3)} \cdot P$	*) Other connectors increase the measurement uncertainty.
		10 MHz to 2 GHz	$25 \cdot 10^{(-3)} \cdot P$	
		> 2 GHz to 3 GHz	$31 \cdot 10^{(-3)} \cdot P$	
	1 nW to < 100 nW	50 MHz	$17 \times 10^{(-3)} \cdot P$	$f \leq 5$ GHz: $ \Gamma_G \leq 0.025$ 5 GHz < $f \leq 20$ GHz: $ \Gamma_G \leq 0.1$ 20 GHz < $f \leq 33$ GHz: $ \Gamma_G \leq 0.15$ 33 GHz < $f \leq 40$ GHz: $ \Gamma_G \leq 0.3$
		10 MHz to 2 GHz	$21 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 4 GHz	$25 \times 10^{(-3)} \cdot P$	
		> 4 GHz to 12 GHz	$38 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 18 GHz	$71 \times 10^{(-3)} \cdot P$	
	100 nW to < 1 µW	<10 MHz	$28 \cdot 10^{(-3)} \cdot P$	$f =$ frequency (Hz) P = measured value (W) $ \Gamma_G =$ reflection coefficient of the calibration 10 MHz
		10 MHz to 50 MHz	$13 \cdot 10^{(-3)} \cdot P$	
		> 50 MHz to 4 GHz	$14 \times 10^{(-3)} \cdot P$	
		> 4 GHz to 5 GHz	$17 \times 10^{(-3)} \cdot P$	
		> 5 GHz to 12 GHz	$25 \cdot 10^{(-3)} \cdot P$	
> 12 GHz to 20 GHz		$28 \times 10^{(-3)} \cdot P$		
> 20 GHz to 33 GHz		$37 \cdot 10^{(-3)} \cdot P$		
> 33 GHz to 40 GHz	$90 \cdot 10^{(-3)} \cdot P$			

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
RF power Output power and calibration factor of RF sources	1 μ W to < 10 μ W	8 kHz to < 10 MHz	$18 \cdot 10^{-3} \cdot P$	PC Type-N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz *) Other connectors increase the measurement uncertainty.
		10 MHz to 50 MHz	$13 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 5 GHz	$17 \times 10^{(-3)} \cdot P$	
		> 5 GHz to 12 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 20 GHz	$25 \times 10^{(-3)} \cdot P$	
		> 20 GHz to 33 GHz	$37 \times 10^{(-3)} \cdot P$	
	10 μ W to < 100 μ W	DC to < 10 MHz	$9.0 \times 10^{-3} \cdot P$	$f \leq 5$ GHz: $ \Gamma_G \leq 0.025$ 5 GHz < $f \leq 20$ GHz: $ \Gamma_G \leq 0.1$ 20 GHz < $f \leq 33$ GHz: $ \Gamma_G \leq 0.15$ 33 GHz < $f \leq 40$ GHz: $ \Gamma_G \leq 0.3$
		10 MHz to 100 MHz	$10 \cdot 10^{-3} \cdot P$	
		>100 MHz to 2 GHz	$12 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$13 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 10 GHz	$15 \times 10^{(-3)} \cdot P$	
		> 10 GHz to 12 GHz	$16 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 30 GHz	$20 \times 10^{(-3)} \cdot P$	
		> 30 GHz to 33 GHz	$37 \cdot 10^{-3} \cdot P$	
	100 μ W to 0.1 W	DC to < 10 MHz	$5.6 \times 10^{-3} \cdot P$	f = frequency (Hz) P = measured value (W) $ \Gamma_G $ = reflection coefficient of the calibration object
		10 MHz to 100 MHz	$7.5 \times 10^{(-3)} \cdot P$	
		>100 MHz to 2 GHz	$10 \times 10^{-3} \cdot P$	
		> 2 GHz to 8 GHz	$11 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 10 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 10 GHz to 12 GHz	$15 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 30 GHz	$19 \cdot 10^{-3} \cdot P$	
		> 30 GHz to 33 GHz	$39 \cdot 10^{-3} \cdot P$	
	> 0.1 W to 1 W	DC to 50 MHz	$11 \times 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$13 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 4 GHz	$16 \times 10^{(-3)} \cdot P$	
		> 4 GHz to 12 GHz	$20 \times 10^{(-3)} \cdot P$	
	> 1 W to 70 W	> 12 GHz to 18 GHz	$30 \cdot 10^{-3} \cdot P$	
DC to 3 GHz		$38 \times 10^{-3} \cdot P$		
> 70 W to 250 W	DC to 500 MHz	$37 \cdot 10^{-3} \cdot P$		

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Calibration and measurement capacities (CMC)				
Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
RF voltage _{UHF} sources with RF voltage display relative to 50 Ω	2.2 μV up to 220 μV	DC to 3 GHz	$W(U_{HF}) = \frac{W(P)}{2}$	W(P) is the relative uncertainty of the measured power at $z_0 = 50 \Omega$ **) ***)
	220 μV up to 7 V	DC to 18 GHz		
	2.2 μV up to 220 μV	DC to 3 GHz		
	2.2 mV to 2 V	DC to 40 GHz		
RF voltage _{UHF} measuring instruments and receivers with RF voltage display relative to 50 Ω	0.7 μV to 2 V	DC to 18 GHz	$W(U)_{HF} = \frac{W(P_{inc})}{2}$	W(P _{inc}) is the relative uncertainty of the injected power with respect to $z_0 = 50 \Omega$ **) ***)
	2.2 mV up to 2 V	DC to 40 GHz		
RF power Receiver noise indicator	DC up to 40 GHz		1.6 dB	Performance > -170 dB (1 mW) relative to 1 Hz bandwidth
Signal level difference	0 dBc to 100 dBc	100 Hz to 26.5 GHz 100 Hz to 40 GHz	1.3 dB 2.7 dB	SNR ≥ 12 dB
Filter bandwidth	1 Hz to 10 MHz		0.5%	Signal-to-noise ratio (SNR) ≥ 70 dB
Form factor	> 1:1 up to 5:1		3%	Signal-to-noise ratio (SNR) ≥ 15 dB
	> 5:1 up to 10:1		6%	
	> 10:1 up to 20:1		12%	
Switching deviation			0.02 dB	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Display linearity	0 dB to 30 dB > 30 dB up to 60 dB > 60 dB to 80 dB > 80 dB up to 100 dB > 100 dB to 110 dB	100 kHz to 500 MHz	0.06 dB 0.07 dB 0.09 dB 0.1 dB 0.2 dB	SNR ≥ 50 dB $ r_{r,DUT} \leq 0.05$ $f \leq 500$ MHz
Input attenuator or IF amplifier	0 dB up to 30 dB > 30 dB up to 60 dB > 60 dB to 80 dB > 80 dB up to 100 dB > 100 dB to 110 dB	100 kHz to 500 MHz	0.06 dB 0.07 dB 0.09 dB 0.1 dB 0.2 dB	Comparison with external step attenuator $ r_{r,DUT} \leq 0.05$ $f \leq 500$ MHz
	0 dB up to 30 dB > 30 dB up to 60 dB > 60 dB to 80 dB	100 kHz to 500 MHz	0.04 dB 0.06 dB 0.08 dB	Step-by-step display comparison SNR ≥ 50 dB, Receiver linearity < (0.01 dB + 0.005 dB/10 dB)
RF gain Amplifier	0 dB to 70 dB	DC to 100 MHz > 100 MHz up to 2 GHz > 2 GHz up to 4 GHz > 4 GHz up to 18 GHz	0.19 dB 0.26 dB 0.3 dB 0.5 dB	BNC connector up to max. 2 GHz N-connector and BNC connector, 50 Ω; other connectors increase the measurement uncertainty
	0 dB up to 70 dB	DC to 100 MHz > 100 MHz up to 4 GHz > 4 GHz up to 26.5 GHz > 26.5 GHz to 40 GHz	0.21 dB 0.3 dB 0.6 dB 0.7 dB	2.92 mm compatible connector, 50 Ω; other connectors increase the measurement uncertainty
RF current Current clamps	100 μA up to 50 mA	40 Hz to 10 MHz > 10 MHz to 30 MHz > 30 MHz to 65 MHz	$14 \cdot 10^{-3} \cdot f$ $18 \cdot 10^{-3} \cdot f$ $20 \cdot 10^{-6} f^2 \cdot f$	Tektronix 015-0601-50. In conjunction with oscilloscope f : measured value f : Frequency in MHz
Non-linearity of RF power meters	10 nW to 1 W	50 MHz	5.5×10^{-3} (0.024 dB)	R&S NRVC-B2 60 dB max.

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
HF reflection coefficient * Magnitude $ \Gamma $	0 to 1	9 kHz to 18 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.003 to 0.013 See Matrix M.3	N-connector, 50 Ω ; other connectors increase the measurement uncertainty Measurement uncertainty in units of the magnitude of the reflection coefficient
	0 to 0.1	9 kHz to 33 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.003 to 0.016 See Matrix M.4	3.5 mm connector Measurement uncertainty in units of the reflection coefficient
	0 to 0.1	45 MHz to 45 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.004 to 0.017 See Matrix M.5	2.92 mm connector Measurement uncertainty in units of the magnitude of the reflection coefficient
HF reflection coefficient * Phase angle φ	-180° to +180°	9 kHz to 18 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.2° to 4.7° See Matrix M.6	N-connector, 50 Ω ; other connectors increase the measurement uncertainty
	-180° to +180°	9 kHz to 33 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.3° to 5.8° See Matrix M.7	3.5 mm connector
	-180° to +180°	45 MHz to 45 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.3° to 6.3° See Matrix M.8	2.92 mm connector
RF attenuation Attenuators	0 dB up to 30 dB	100 kHz to 10 GHz > 10 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	0.03 dB 0.05 dB 0.09 dB 0.10 dB	L is the measured attenuation, ****) $ \Gamma_{DUT} \leq 0.01$ $f \leq 500$ MHz $ \Gamma_{r,DUT} \leq 0.05$ 500 MHz < $f \leq 10$ GHz $ \Gamma_{r,DUT} \leq 0.08$
	> 30 dB up to 60 dB	100 kHz to 10 GHz > 10 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	0.01 dB/dB · L 0.02 dB + 0.001 dB/dB · L 0.10 dB + 0.001 dB/dB · L 0.11 dB + 0.001 dB/dB · L	10 GHz < $f \leq 18$ GHz $ \Gamma_{r,DUT} \leq 0.1$ 18 GHz < $f \leq 40$ GHz

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
RF attenuation Attenuators	> 60 dB to 70 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.07 dB 0.10 dB	$ r_{L,DUT} \leq 0.01$ $f \leq 500$ MHz $ r_{L,DUT} \leq 0.05$ 500 MHz < $f \leq 3$ GHz
	> 70 dB to 80 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.08 dB 0.2 dB	
	> 80 dB to 100 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.1 dB 0.3 dB	
RF attenuation *	0 dB to 60 dB	9 kHz to 18 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.01 dB to 0.09 dB See Matrix M.9	N-connector, 50 Ω ; other connectors increase the measurement uncertainty
	0 dB to 60 dB	9 kHz to 33 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.01 dB to 0.22 dB See Matrix M.10	3.5 mm connector
	0 dB to 60 dB	45 MHz to 45 GHz EURAMET Calibration Guide No. 12 Version 3.0	0.01 dB to 0.32 dB See Matrix M.11	2.92 mm connector
RF attenuation * Phase angle φ	-180° to +180°	9 kHz to 18 GHz 0 dB to 60 dB EURAMET Calibration Guide No. 12 Version 3.0	0.2° to 0.8° See Matrix M.12	N-connector, 50 Ω ; other connectors increase the measurement uncertainty
	-180° to +180°	9 kHz to 33 GHz 0 dB to 60 dB EURAMET Calibration Guide No. 12 Version 3.0	0.2° to 1.8° See Matrix M.13	3.5 mm connector
	-180° to +180°	45 MHz to 45 GHz 0 dB to 60 dB EURAMET Calibration Guide No. 12 Version 3.0	0.2° to 2.5° See Matrix M.14	2.92 mm connector

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Matrix M.3 “RF reflection coefficient, magnitude $|\Gamma|$; N-connector 50 Ω ”

Measurement uncertainty expressed in units of the magnitude of the reflectance.

Absolute value $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0	0.003 to 0.004	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.1	0.003 to 0.005	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.2	0.003 to 0.005	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.3	0.003 to 0.006	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.4	0.003 to 0.005	0.004	0.003 to 0.008	0.008 to 0.009
0.5	0.003 to 0.006	0.004	0.004 to 0.009	0.008 to 0.009
0.6	0.004 to 0.006	0.004 to 0.005	0.004 to 0.009	0.009
0.7	0.004 to 0.006	0.005	0.005 to 0.010	0.009 to 0.010
0.8	0.004 to 0.006	0.005 to 0.006	0.005 to 0.010	0.010
0.9	0.004 to 0.007	0.006	0.005 to 0.011	0.011 to 0.012
1	0.003 to 0.006	0.004 to 0.006	0.004 to 0.012	0.011 to 0.013

Matrix M.4 ‘RF reflection coefficient, magnitude $|\Gamma|$; 3.5 mm connector’

Measurement uncertainty in units of the magnitude of the reflection coefficient.

Absolute value $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0	0.003 to 0.004	0.003	0.003 to 0.004	0.004 to 0.005	0.005 to 0.008	0.008 to 0.010
0.1	0.003 to 0.005	0.003	0.003 to 0.004	0.004 to 0.005	0.005 to 0.008	0.008 to 0.010
0.2	0.003 to 0.006	0.003 to 0.004	0.004 to 0.005	0.004 to 0.005	0.005 to 0.008	0.008 to 0.010
0.3	0.003 to 0.006	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.011
0.4	0.004 to 0.005	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.011
0.5	0.004 to 0.006	0.004 to 0.005	0.004 to 0.005	0.005 to 0.006	0.005 to 0.008	0.008 to 0.011
0.6	0.004 to 0.006	0.005	0.005 to 0.006	0.006	0.006 to 0.009	0.009 to 0.012
0.7	0.004 to 0.006	0.005 to 0.006	0.005 to 0.006	0.006 to 0.007	0.006 to 0.010	0.009 to 0.013
0.8	0.004 to 0.007	0.005 to 0.006	0.005 to 0.007	0.006 to 0.007	0.006 to 0.010	0.010 to 0.014
0.9	0.004 to 0.007	0.006 to 0.007	0.006 to 0.008	0.007 to 0.008	0.007 to 0.011	0.011 to 0.015
1	0.004 to 0.006	0.005 to 0.006	0.005 to 0.008	0.006 to 0.009	0.007 to 0.012	0.011 to 0.016

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Matrix M.5 'RF reflection coefficient, magnitude $|\Gamma|$; 2.92 mm connector'

Measurement uncertainty in units of the magnitude of the reflection coefficient.

Absolute value $ \Gamma $	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0	0.004	0.004	0.004	0.004	0.004 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.1	0.004	0.004	0.004	0.004	0.004 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.2	0.004	0.004	0.004	0.004	0.004 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.3	0.004	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.4	0.004	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.5	0.004 to 0.005	0.005	0.005	0.005	0.005 to 0.008	0.008 to 0.010	0.010	0.010 to 0.012
0.6	0.005	0.005	0.005 to 0.006	0.005 to 0.006	0.005 to 0.009	0.008 to 0.011	0.010 to 0.011	0.010 to 0.012
0.7	0.005 to 0.006	0.005	0.005 to 0.006	0.006	0.006 to 0.009	0.009 to 0.012	0.011 to 0.012	0.011 to 0.013
0.8	0.005 to 0.006	0.006	0.006 to 0.007	0.006 to 0.007	0.006 to 0.010	0.009 to 0.013	0.012 to 0.013	0.012 to 0.014
0.9	0.005 to 0.007	0.006 to 0.007	0.006 to 0.008	0.007 to 0.008	0.007 to 0.011	0.010 to 0.014	0.013 to 0.014	0.013 to 0.015
1	0.005 to 0.007	0.005 to 0.006	0.005 to 0.008	0.007 to 0.008	0.006 to 0.012	0.011 to 0.015	0.014 to 0.015	0.014 to 0.017

Matrix M.6 "RF reflection coefficient, phase angle ϕ ; 50 Ω N-connector"

Modulus $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0.1	1.4° to 2.2°	1.5° to 1.9°	1.5° to 4.5°	4.4° to 4.7°
0.2	0.7° to 1.4°	0.8° to 1.0°	0.8° to 2.3°	2.2° to 2.4°
0.3	0.5° to 1.0°	0.6° to 0.7°	0.6° to 1.5°	1.5° to 1.6°
0.4	0.4° to 0.7°	0.5° to 0.6°	0.5° to 1.2°	1.2°
0.5	0.4° to 0.6°	0.4° to 0.5°	0.4° to 1.0°	1.0°
0.6	0.4° to 0.5°	0.4° to 0.5°	0.4° to 0.9°	0.9°
0.7	0.3° to 0.5°	0.4°	0.4° to 0.8°	0.8°
0.8	0.3° to 0.5°	0.4°	0.4° to 0.8°	0.7° to 0.8°
0.9	0.3° to 0.4°	0.4°	0.4° to 0.8°	0.7° to 0.8°
1	0.2° to 0.4°	0.3° to 0.4°	0.3° to 0.7°	0.7° to 0.8°

Matrix M.7 'RF reflection coefficient, phase angle ϕ ; 3.5 mm connector'

Magnitude $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0.1	1.5° to 2.6°	1.6° to 1.7°	1.7° to 2.3°	2.3° to 2.6°	2.4° to 4.2°	4.1° to 5.8°
0.2	0.8° to 1.5°	0.9	0.9° to 1.2°	1.2° to 1.4°	1.3° to 2.2°	2.2° to 3.0°
0.3	0.6° to 1.1°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.0°	1.0° to 1.6°	1.6° to 2.1°
0.4	0.5° to 0.8°	0.5° to 0.6°	0.6° to 0.8°	0.7° to 0.9°	0.8° to 1.3°	1.3° to 1.7°
0.5	0.5° to 0.7°	0.5°	0.5° to 0.7°	0.7° to 0.8°	0.8° to 1.2°	1.1° to 1.5°
0.6	0.4° to 0.6°	0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.1°	1.1° to 1.4°
0.7	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.3°
0.8	0.3° to 0.5°	0.4° to 0.5°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.3°
0.9	0.3° to 0.5°	0.4° to 0.5°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.3°
1	0.3° to 0.4°	0.3° to 0.4°	0.3° to 0.5°	0.5° to 0.7°	0.7° to 1.0°	0.9° to 1.2°

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Matrix M.8 “HF reflection coefficient, phase angle ϕ ; 2.92 mm connector”

Magnitude $ \Gamma $	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0.1	2.0° to 2.1°	2.0°	2.0° to 2.3°	2.2° to 2.3°	2.2° to 4.2°	4.2° to 5.3°	5.3° to 5.4°	5.3° to 6.3°
0.2	1.0° to 1.1°	1.0° to 1.1°	1.0° to 1.2°	1.2°	1.2° to 2.2°	2.1° to 2.7°	2.7°	2.7° to 3.2°
0.3	0.7° to 0.8°	0.7	0.7° to 0.9°	0.8° to 0.9°	0.8° to 1.5°	1.5° to 1.9°	1.9°	1.9° to 2.2°
0.4	0.6°	0.6°	0.6° to 0.7°	0.7°	0.7° to 1.2°	1.1° to 1.5°	1.5°	1.5° to 1.7°
0.5	0.5° to 0.6°	0.5	0.5° to 0.6°	0.6	0.6° to 1.0°	1.0° to 1.3°	1.2° to 1.3°	1.3° to 1.5°
0.6	0.4° to 0.5°	0.5	0.5° to 0.6°	0.5° to 0.6°	0.6° to 0.9°	0.9° to 1.1°	1.1° to 1.2°	1.1° to 1.3°
0.7	0.4° to 0.5°	0.5	0.5° to 0.6°	0.5° to 0.6°	0.5° to 0.8°	0.8° to 1.1°	1.0° to 1.1°	1.1° to 1.2°
0.8	0.4° to 0.5°	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.5° to 0.8°	0.8° to 1.0°	1.0°	1.0° to 1.2°
0.9	0.3° to 0.5°	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.5° to 0.8°	0.8° to 1.0°	1.0°	1.0° to 1.2°
1	0.3° to 0.4°	0.3° to 0.4°	0.3° to 0.5°	0.5°	0.5° to 0.8°	0.7° to 1.0°	0.9° to 1.0°	0.9° to 1.2°

Matrix M.9 ‘HF attenuation; N-connector 50 Ω ’

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0 dB	0.01 dB	0.01 dB to 0.02 dB	0.01 dB to 0.02 dB	0.02 dB
3 dB	0.04 dB to 0.05 dB	0.05 dB	0.05 dB	0.05 dB
6 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB
10 dB	0.05 dB	0.05 dB	0.06 dB	0.05 dB to 0.06 dB
20 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB
30 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB
40 dB	0.05 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.06 dB to 0.07 dB
50 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB
60 dB	0.05 dB to 0.09 dB	0.08 dB to 0.09 dB	0.07 dB to 0.09 dB	0.08 dB to 0.09 dB

Matrix M.10 “HF attenuation; 3.5 mm connector”

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0 dB	0.01 dB	0.01 dB to 0.02 dB	0.01 dB to 0.02 dB	0.02 dB	0.02 dB	0.02 dB
3 dB	0.04 dB to 0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB
6 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB
10 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB
20 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB
30 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB
40 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.07 dB
50 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.09 dB	0.08 dB to 0.10 dB
60 dB	0.05 dB to 0.09 dB	0.07 dB to 0.09 dB	0.07 dB to 0.09 dB	0.08 dB to 0.09 dB	0.08 dB to 0.19 dB	0.15 dB to 0.22 dB

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Matrix M.11 “HF attenuation; 2.92 mm connector”

Absolute attenuation	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0 dB	0.01 dB	0.01 dB to 0.02 dB	0.01 dB to 0.02 dB	0.02 dB	0.02 dB	0.02 dB	0.02 dB to 0.04 dB	0.03 dB
3 dB	0.04 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB
6 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB
10 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB
20 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB	0.07 dB to 0.08 dB
30 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB	0.07 dB	0.07 dB to 0.08 dB
40 dB	0.05 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.07 dB	0.07 dB to 0.08 dB	0.08 dB to 0.09 dB
50 dB	0.05 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.09 dB	0.08 dB to 0.10 dB	0.09 dB to 0.10 dB	0.10 dB to 0.13 dB
60 dB	0.06 dB	0.08 dB to 0.09 dB	0.07 dB to 0.09 dB	0.08 dB to 0.09 dB	0.08 dB to 0.18 dB	0.15 dB to 0.22 dB	0.17 dB to 0.22 dB	0.20 dB to 0.32 dB

Matrix M.12 “RF attenuation; phase angle ϕ ; N-connector 50 Ω ”

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0 dB	0.2°	0.2°	0.2° to 0.4°	0.4° to 0.6°
3 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
6 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
10 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
20 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
30 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
40 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
50 dB	0.4°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°
60 dB	0.4° to 0.6°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 0.8°

Matrix M.13 “HF attenuation; phase angle ϕ ; 3.5 mm connector”

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0 dB	0.2°	0.2°	0.2° to 0.4°	0.4° to 0.6°	0.6° to 0.9°	0.9° to 1.0°
3 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
6 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
10 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
20 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
30 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
40 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°
50 dB	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°
60 dB	0.4° to 0.6°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 0.8°	0.8° to 1.5°	1.3° to 1.8°

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Matrix M.14 “RF attenuation; phase angle ϕ ; 2.92 mm connector”

Absolute attenuation	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0 dB	0.2°	0.2°	0.2° to 0.4°	0.4° to 0.6°	0.6° to 0.9°	0.9° to 1.0°	1.0° to 1.2°	1.2° to 1.4°
3 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
6 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
10 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
20 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
30 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
40 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°	1.2° to 1.3°	1.3° to 1.5°
50 dB	0.4°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°	1.2° to 1.4°	1.4° to 1.7°
60 dB	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 0.8°	0.8° to 1.5°	1.3° to 1.8°	1.6° to 1.9°	1.8° to 2.5°

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**High-frequency and radiation parameters – Optical parameters – Radiometry
Permanent Laboratory – Eichenau site**

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Expanded measurement uncertainty	Remarks
	Measurement range / Measurement span	Measurement conditions / procedures			
Optical radiation power Fibre-optic power meters	1 µW to 0.5 mW	1310 nm, 1550 nm 850 nm 654 nm		1.3%	Connector FC, ST, SC, SMA, HMS-10 or adaptable Other wavelengths (780 nm, 635 nm, 1625 nm) interpolated
				2.2% 2.2%	
Non-linearity of fibre-optic radiation detectors	10 nW to 160 µW	1310 nm, 1550 nm, 850 nm		$1.8 \times 10^{(-3)}$ (0.008 dB)	Addition method
	0.1 nW to < 0.32 nW			$20 \times 10^{(-3)}$ (0.085 dB)	Comparison method
	0.32 nW to < 3.2 nW			$7.1 \times 10^{(-3)}$ (0.031 dB)	
	3.2 nW to 0.5 µW			$6.0 \times 10^{(-3)}$ (0.026 dB)	
Attenuation or gain of fibre-optic components	0 dB to 50 dB	Wavelengths: 1310 nm, 1550 nm, 850 nm		$6.0 \times 10^{(-3)}$ (0.026 dB)	
	> 50 dB to 60 dB			$7.1 \times 10^{(-3)}$ (0.031 dB)	
	> 60 dB to 70 dB			$20 \times 10^{(-3)}$ (0.085 dB)	
Central wavelength λ	350 nm to < 700 nm	Reference power: approx. 0.5 mW		0.5 nm	
	700 nm to < 1250 nm			2.5 pm	
	1250 nm to 1700 nm			2 pm	

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Photometry

Permanent Laboratory – Eichenau site

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Transmission filter Transmission T	16% to 60%	QMH Chapter XXXIV v4.0 Nominal values in the turbidity values of the standard	0.65%	
	> 60% to 76%		0.70%	
	> 76% to < 100%		0.80%	
Turbidity level N	> 0% to < 24%	QMH Chapter XXXIV v4.0 Nominal values in the turbidity values of the standard	0.80%	
	24% to < 40%		0.70%	
	40% to 84%		0.65%	
Turbidity coefficient k	Measuring chamber length 0.43 m > 0 m ⁻¹ to 4.3 m ⁻¹	QMH Chapter XXXIV v4.0 Nominal values in the turbidity values of the standard	0.020 m ⁻¹ to 0.050 m ⁻¹	Turbidity coefficient k calculated from the turbidity level N . Uncertainty interval $U(k)$ calculated from the uncertainty interval of the turbidity degree $U(N)$. Other measuring chamber lengths increase the measurement uncertainty.
Illuminance E	0 lx	QMH XXXI	0.01 lx	Reference zero
	900 lx to 2000 lx		$1.7\% \cdot E$	Standard illuminance
	≥ 5 lx up to < 10 klx		$1.9\% \cdot E$	LED light
	≥ 10 klx up to 110 klx		$9.0 \times 10^{-8} E^2/lx$ $+ 0.02 \times 10^{-13} lx$	

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**Dimensional quantities:
length and angle**

Permanent Laboratory – Eichenau site

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range / Measurement range	Measurement conditions / Method	Expanded measurement uncertainty	
Calipers for external, internal and depth measurements *	> 0 mm to 1000 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$20 \mu\text{m} + 15 \times 10^{(-6)} \times l$	/: measured value
Micrometers *	up to 300 mm > 300 mm – –1000 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	$2 \mu\text{m} + 6 \times 10^{(-6)} l$ $0.30 \mu\text{m} + 12 \times 10^{(-6)} l$	
Dial gauges with dial display *	up to 100 mm	VDI/VDE/DGQ 2618 Sheet 11.1:2014	$1.5 \mu\text{m} + 10 \times 10^{(-6)} l$	
Dial gauges with digital display *	up to 100 mm	VDI/VDE/DGQ/DKD 2618 Sheet 11.4:2020	$1.5 \mu\text{m} + 10 \times 10^{(-6)} l$	
Fine pointer *	up to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	0.9 μm	
Dial gauge *	up to 1.6 mm	VDI/VDE/DGQ 2618 Sheet 11.3:2002		
Steel or ceramic parallel end gauges in accordance with DIN ISO 3650 *	0.5 mm to 100 mm	VDI/VDE/DGQ 2618 Part 3.1:2004 Measurement of the deviation l_c from the nominal dimension l_n by difference measurement	$0.1 \mu\text{m} + 0.8 \times 10^{(-6)} \times l$	
	> 100 mm to 175 mm		0.47 μm	
	in the nominal dimensions of the standards	Measurement of the deviations f_o and f_u from the mean dimension by 5-point difference measurement	0.08 μm	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Cylindrical standard rings * Diameter	3 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006	$0.7 \mu\text{m} + 0.8 \times 10^{-6} \times d$	<i>d</i> is the measured diameter
	> 125 mm to 300 mm	Option 3	$0.6 \mu\text{m} + 2.1 \times 10^{-6} \cdot d$	
Mandrels * Diameter	1 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006	$0.5 \mu\text{m} + 1.2 \times 10^{-6} \times d$	
	> 125 mm to 300 mm	Option 3	$0.3 \mu\text{m} + 2.8 \times 10^{-6} \cdot d$	
Test pins * Diameter	1 mm to 20 mm	VDI/VDE/DGQ 2618 Sheet 4.2:2006 Option 1	$0.5 \mu\text{m} + 1.2 \times 10^{-6} \times d$	
Thread gauges * (single- and multi-start cylindrical external and internal threads with straight flanks, symmetrical profile, nominal pitch and nominal profile angle) External threads Simple flank diameter	1 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Option 1 Three-wire method (perpendicular to thread axis)	$2.8 \mu\text{m} + 0.2 \times 10^{-6} \times d$	<i>d</i> is the measured edge diameter
	> 125 mm to 500 mm		$2.7 \mu\text{m} + 1.0 \times 10^{-6} \cdot d$	
Internal thread Single flank diameter	3 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Option 1 Two-ball method (perpendicular to thread axis)	$2.5 \mu\text{m} + 0.3 \times 10^{-6} \times d$	
Lever systems for force application on brake test benches	up to 600 mm 600 mm to 2500 mm	Work instruction AA0364 Version 8.0	52 μm $23 \times 10^{-6} \times l + 0.12 \text{ mm}$	<i>l</i> : measured value

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Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Levelling scales for interval measurements	up to 100 mm	QMH-L.VIII.2 Section 4 Version 1.0	40 µm	Measuring range based on the interval between any two graduation marks on the scale
Tape measures	0.1 m to 25 m	QMH-L.VIII.2 Section 2 Version 1.0	2.4 mm + $45 \times 10^{-6} \cdot l$	l = measured length of tape measures for characterisation of headlamp alignment test systems
Steel circumference measuring tapes		QMH-L.VIII.2 Section 3 Version 1.0		Calibration to the nominal values of the standards
Diameter	150 mm to 300 mm > 300 mm to 400 mm		0.62 mm 0.94 mm	
Circumference	470 mm to 950 mm > 950 mm to 1257 mm		0.19 mm 0.297 mm	
Electronic inclinometers	-55° to -30°	QMH-L.VIII.1 Version 1.0	$42 \cdot 10^{-6} \cdot \alpha + 0.00034^\circ$	max. base length 100 mm α = angle in °
	-30° to 30°		0.0016°	
	30° to 55°		$42 \cdot 10^{-6} \cdot \alpha + 0.00034^\circ$	
Point and line lasers Horizontal inclination deviation vertical	0 mm/m to 2 mm/m	AA0356 Version 9.0	0.080 mm/m 0.10 mm/m	
Position Sensitive Detector / PSD diodes X- and Y- axis deviation	up to 5 mm	AA0356 Version 9.0	18 µm	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Length measuring instruments Gauges	0 mm to 75 mm	QMH-L.VIII.3 Section 2.1 Version 1.0 External measurement	31 µm	Assumed temperature range: 20 °C ± 1 K Assumed thermal Coefficient of thermal expansion: $\alpha = 11.5 \times 10^{-6} \text{ K}^{-1}$ Deviating ambient conditions and materials of the gauges to be calibrated increase the measurement uncertainty.
	> 75 mm to 150 mm		37 µm	
	0 mm to 150 mm	QMH-L.VIII.3 Section 2.2 Version 1.0 Internal measurement	36 µm	
	0 mm to 150 mm	QMH-L.VIII.3 Section 2.3 Version 1.0 Depth measurement	39 µm	
	0 to 75 mm	QMH-L.VIII.3 Section 2.4 Version 1.0 Step measurement	55 µm	
	> 75 mm to 150 mm		76 µm	

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Electrical parameters

Permanent Laboratory – Berlin site

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC voltage sources	0 V		120 nV	Short-circuit bridge
	0 V to 0.1 V		$4 \times 10^{(-6)} \times U + 0.36 \mu\text{V}$	U = measured value
	> 0.1 V to 1 V		$3.7 \times 10^{(-6)} \times U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{(-6)} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{(-6)} \cdot U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{(-6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{(-6)} U - 10 \text{ mV}$	
	1050 V to 10 kV		$0.17 \times 10^{(-3)} \cdot U$	
DC voltage measuring instruments	0 V to 220 mV		$6 \times 10^{(-6)} \times U + 0.6 \mu\text{V}$	U = measured value
	> 220 mV to 2.2 V		$5 \cdot 10^{(-6)} \cdot U + 1 \mu\text{V}$	
	> 2.2 V to 11 V		$4 \times 10^{(-6)} \times U + 3.5 \mu\text{V}$	
	> 11 V to 22 V		$4 \times 10^{(-6)} \cdot U + 6.5 \mu\text{V}$	
	> 22 V to 220 V		$5 \times 10^{(-6)} U + 80 \mu\text{V}$	
	> 220 V to 1050 V		$7 \times 10^{(-6)} \cdot U + 0.5 \text{ mV}$	
	0 V to 0.1 V		$4 \times 10^{(-6)} \times U + 0.36 \mu\text{V}$	
	> 0.1 V to 1 V		$3.7 \times 10^{(-6)} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{(-6)} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{(-6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{(-6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{(-6)} U - 10 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC voltage sources, measuring instruments	2 mV to 1000 V	10 Hz to 1 MHz	4.1 μV to 0.48 V	U = measured value
	2 mV to 10 mV	10 Hz to 40 Hz	$0.36 \times 10^{-3} \cdot U + 3.4 \mu\text{V}$	
		> 40 Hz to 1 kHz	$0.24 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.36 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.2 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$5.8 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$46 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
	> 10 mV to 100 mV	10 Hz to 40 Hz	$86 \times 10^{-6} \cdot U + 4.6 \mu\text{V}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 2.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.93 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
	> 100 mV to 1 V	> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
		10 Hz to 40 Hz	$83 \times 10^{-6} \cdot U + 46 \mu\text{V}$	
		> 40 Hz to 1 kHz	$82 \times 10^{-6} \cdot U + 23 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.16 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
	> 1 V to 10 V	> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 0.12 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 0.12 \text{ mV}$	
		10 Hz to 40 Hz	$85 \times 10^{-6} \cdot U + 0.46 \text{ mV}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 0.23 \text{ mV}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
	> 10 V to 100 V	> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
10 Hz to 40 Hz		$0.23 \times 10^{-3} \cdot U + 4.6 \text{ mV}$		
> 40 Hz to 1 kHz		$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
> 100 V to 1000 V	> 1 kHz to 20 kHz	$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	> 20 kHz to 50 kHz	$0.41 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	> 50 kHz to 100 kHz	$1.4 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	50 Hz to 1 kHz	$0.46 \times 10^{-3} \cdot U + 16 \text{ mV}$		

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Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	1 mV to 1100 V	10 Hz to 1 MHz	5 μ V to 81 mV	U = measured value
	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 4.5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 2.2 mV to 22 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 22 mV to 220 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 8 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.28 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 35 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 80 \mu\text{V}$	
	> 220 mV to 2.2 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 80 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 6 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 16 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 70 \mu\text{V}$	
		> 100 kHz to 300 kHz	$0.39 \times 10^{-3} \cdot U + 0.13 \text{ mV}$	
		> 300 kHz to 500 kHz	$0.95 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
		> 500 kHz to 1 MHz	$1.9 \times 10^{-3} \cdot U + 0.85 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	> 2.2 V to 22 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 0.8 \text{ mV}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 0.25 \text{ mV}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 60 \text{ }\mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 0.16 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
		> 100 kHz to 300 kHz	$0.45 \times 10^{-3} \cdot U + 1.5 \text{ mV}$	
		> 300 kHz to 500 kHz	$1.2 \times 10^{-3} \cdot U + 4.3 \text{ mV}$	
		> 500 kHz to 1 MHz	$2.5 \times 10^{-3} \cdot U + 8.5 \text{ mV}$	
	> 22 V to 220 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 2.5 \text{ mV}$	
		> 40 Hz to 20 kHz	$70 \times 10^{-6} \cdot U + 0.8 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.19 \times 10^{-3} \cdot U + 3.5 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
	> 220 V to 1100 V	15 Hz to 50 Hz	$0.36 \times 10^{-3} \cdot U + 16 \text{ mV}$	
		> 50 Hz to 1 kHz	$70 \times 10^{-6} \cdot U + 3.5 \text{ mV}$	
1 mV to 220 V	1 Hz to 10 kHz square-wave voltage	$0.38 \text{ }\mu\text{V}$ to 3.2 mV See Matrix BM.1		
Sources	1100 V to 10 kV	45 Hz to 55 Hz	$0.46 \times 10^{(-3)} \times U$	$U = \text{measured value}$

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current measuring instruments, sources	0 mA to 220 µA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	I = measured value
	> 220 µA to 2.2 mA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	
	> 2.2 mA to 22 mA		$40 \times 10^{(-6)} \times I + 80 \text{ nA}$	
	> 22 mA to 100 mA		$50 \cdot 10^{(-6)} \cdot I + 0.8 \text{ µA}$	
	> 100 mA to 220 mA		$50 \times 10^{(-6)} \cdot I + 200 \times 10^{(-6)} \cdot I^2 + 0.8 \text{ µA}$	
	> 220 mA to 1 A		$65 \times 10^{(-6)} \cdot I + 25 \text{ µA}$	
	> 1 A to 2.2 A		$65 \times 10^{(-6)} \times I + 10 \times 10^{(-6)} \times I^2 + 25 \text{ µA}$	
	> 2.2 A to 3 A		$0.38 \times 10^{(-3)} \times I + 40 \text{ µA}$	
	> 3 A to 10.1 A		$0.5 \times 10^{(-3)} \times I + 0.5 \text{ mA}$	
	> 10.1 A to 20.5 A		$1 \times 10^{(-3)} \times I + 0.75 \text{ mA}$	
	0 pA to 1 pA		1 pA	
	> 1 pA to 100 nA		$35 \cdot 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 100 nA to 1 µA		$23 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 1 µA to 10 µA		$23 \times 10^{(-6)} \times I + 0.12 \text{ nA}$	
	> 10 µA to 100 µA		$23 \times 10^{(-6)} \cdot I + 0.92 \text{ nA}$	
	> 100 µA to 1 mA		$23 \times 10^{(-6)} \times I + 6 \text{ nA}$	
	> 1 mA to 10 mA		$23 \times 10^{(-6)} \times I + 58 \text{ nA}$	
	> 10 mA to 100 mA		$41 \times 10^{(-6)} \cdot I + 580 \text{ nA}$	
	> 100 mA to 1 A		$0.13 \times 10^{(-3)} \cdot I + 12 \text{ µA}$	
	1 A to 400 A		$0.21 \times 10^{(-3)} \times I$	
Direct current Current clamps and current transformers	1 mA – – –1100 A	1 to N windings	$3 \times 10^{(-3)} \times I$	

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current measuring instruments, sources	10 µA to 20.5 A	10 Hz to 10 kHz	25 nA to 0.62 A	I = measured value
	0.01 mA to 0.22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \times I + 25 \text{ nA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \times I + 16 \text{ nA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40 \text{ nA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80 \text{ nA}$	
	> 0.22 mA to 2.2 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 40 \text{ nA}$	
		> 40 Hz to 1 kHz	$0.1, 2 \times 10^{-4} \times I + 35 \text{ nA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 0.4 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 0.8 \text{ µA}$	
	> 2.2 mA to 22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 0.4 \text{ µA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 0.35 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 4 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \times I + 8 \text{ µA}$	
	> 22 mA to 220 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 4 \text{ µA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 3.5 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80 \text{ µA}$	
	> 220 mA to 2.2 A	20 Hz to 1 kHz	$0.55 \times 10^{-3} \times I + 35 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.65 \times 10^{-3} \cdot I + 80 \text{ µA}$	
		> 5 kHz to 10 kHz	$0.75 \times 10^{-3} \cdot I + 0.16 \text{ mA}$	
> 2.2 A to 3 A	10 Hz to 45 Hz	$1.8 \times 10^{-3} \cdot I + 0.1 \text{ mA}$		
	> 45 Hz to 1 kHz	$0.6 \times 10^{-3} \cdot I + 0.1 \text{ mA}$		
> 3 A to 11 A	45 Hz to 100 Hz	$0.6 \times 10^{-3} \times I + 2 \text{ mA}$		
	> 100 Hz to 1 kHz	$1.0 \times 10^{-3} \times I + 2 \text{ mA}$		
> 11 A to 20.5 A	45 Hz to 100 Hz	$1.2 \times 10^{-3} \cdot I + 5 \text{ mA}$		
	> 100 Hz to 1 kHz	$1.5 \times 10^{-3} \cdot I + 5 \text{ mA}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	5 µA to 1 A	20 Hz to 5 kHz	35 nA to 13 mA	I = measured value
	5 µA to 100 µA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \times I + 35 \text{ nA}$	
		> 45 Hz to 1 kHz	$0.76 \times 10^{-3} \times I + 34 \text{ nA}$	
	> 100 µA to 1 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 0.23 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 0.23 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 0.2 \text{ µA}$	
	> 1 mA to 10 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 2.3 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \times I + 2.3 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 2 \text{ µA}$	
	> 10 mA to 100 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 23 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 23 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \times I + 20 \text{ µA}$	
	> 100 mA to 1 A	20 Hz to 45 Hz	$1.8 \times 10^{-3} \times I + 0.23 \text{ mA}$	
		> 45 Hz to 100 Hz	$0.83 \times 10^{-3} \times I + 0.33 \text{ mA}$	
		> 100 Hz to 5 kHz	$1.6 \times 10^{-3} \cdot I + 0.21 \text{ mA}$	
Alternating current sources, measuring instruments	10 mA to 500 A		3 µA to 0.2 A	I = measured value
	10 mA to 1 A	40 Hz to 1 kHz	$0.32 \times 10^{-3} \times I$	
	> 1 A to 100 A		$0.69 \times 10^{-3} \cdot I$	
	> 100 A to 450 A		$0.9 \times 10^{-3} \times I$	
Current clamps and current transformers	1 mA – – – 1100 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/N	$4 \times 10^{-3} \cdot I$	I = measured value
Equivalent current	0.2 µA to 200 mA	at R_N up to 1 GΩ DC up to 60 Hz	$17 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ See Matrix BM.2	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC resistance Fixed values	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value
		4-wire short circuit	0.35 μΩ	
	100 μΩ 1 mΩ 10 mΩ 100 mΩ		0.45 × 10 ^{Λ(-3)} × R 0.17 × 10 ^{Λ(-3)} × R 0.17 × 10 ^{Λ(-3)} × R 0.10 × 10 ⁻³ × R	Intermediate values increase the measurement uncertainty
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ;		40 × 10 ^{Λ(-6)} · R 23 × 10 ^{Λ(-6)} · R 14 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 9.5 × 10 ^{Λ(-6)} · R 11 · 10 ⁻⁶ · R 15 · 10 ⁻⁶ · R 31 · 10 ⁻⁶ · R 100 · 10 ⁻⁶ · R	
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ; 1 GΩ		76 × 10 ^{Λ(-6)} · R 20 × 10 ^{Λ(-6)} · R 17 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 13 · 10 ⁻⁶ · R 19 · 10 ⁻⁶ · R 70 · 10 ⁻⁶ · R 0.59 × 10 ⁻³ · R 5.9 × 10 ⁻³ · R	
Measuring instruments	0 to < 11 Ω		40 × 10 ^{Λ(-6)} · R	
	11 Ω to < 110 Ω		35 × 10 ^{Λ(-6)} · R	
	110 Ω to < 110 kΩ		28 × 10 ^{Λ(-6)} · R	
	110 kΩ to < 1.1 MΩ		32 × 10 ^{Λ(-6)} · R	
	1.1 MΩ to < 3.3 MΩ		60 × 10 ^{Λ(-6)} · R	
	3.3 MΩ to < 11 MΩ		0.13 × 10 ⁻³ × R	
	11 MΩ to < 33 MΩ		0.25 × 10 ^{Λ(-3)} · R	
	33 MΩ to < 110 MΩ		0.5 × 10 ^{Λ(-3)} · R	
	110 MΩ to < 330 MΩ 330 MΩ to < 1.1 GΩ		3 × 10 ^{Λ(-3)} · R 15 × 10 ^{Λ(-3)} · R	
AC resistance (magnitude of impedance)	500 μΩ to 45 kΩ	10 Hz to 10 kHz	$\sqrt{U_I^2 + U_U^2} \cdot R$ 0.17 × 10 ^{Λ(-3)} × R to 1.7 × 10 ^{Λ(-3)} · R See matrix BM.3	R = measured value u _I is the relative uncertainty of the calibration current u _U is the relative uncertainty of the measured voltage across the resistor

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Inductance fixed values	0 µH	2-wire short-circuit	0.03 µH	L = measured value Impedance range: 50 mΩ ≤ Z ≤ 11 kΩ
	100 µH	100 Hz	$0.54 \times 10^{(-3)} \times L$	
		1 kHz	$0.28 \times 10^{(-3)} \cdot L$	
		10 kHz	$0.29 \times 10^{(-3)} \cdot L$	
	1 mH	100 Hz	$0.14 \times 10^{(-3)} \times L$	
		1 kHz	$0.14 \times 10^{(-3)} \times L$	
10 mH	100 Hz;	$0.13 \times 10^{(-3)} L$		
	1 kHz; 10 kHz	$0.16 \times 10^{(-3)} \cdot L$		
100 mH	100 Hz; 1 kHz	$0.13 \times 10^{(-3)} L$		
	10 kHz	$0.28 \times 10^{(-3)} \cdot L$		
1 H	100 Hz, 1 kHz	$0.20 \times 10^{(-3)} \times L$		
Capacitance fixed values	0 pF		0.2 pF	No-load
	1 pF	1 kHz	$0.63 \times 10^{(-3)} C$	C = measured value Absolute value of impedance 1 Ω ≤ Z ≤ 110 MΩ
		10 kHz	$0.31 \times 10^{(-3)} C$	
	10 pF	1 kHz	$42 \times 10^{(-6)} C$	
		10 kHz;	$53 \times 10^{(-6)} \text{ } ^\circ C$	
		100 kHz	$88 \times 10^{(-6)} \text{ } ^\circ C$	
		1 MHz	$0.24 \times 10^{(-3)} C$	
	100 pF	1 kHz	$39 \times 10^{(-6)} C$	
1 nF	1 kHz	$71 \times 10^{(-6)} \text{ } ^\circ C$		
	100 kHz	$0.13 \times 10^{(-3)} C$		
10 nF	100 Hz	$0.49 \times 10^{(-3)} C$		
	1 kHz	$0.21 \times 10^{(-3)} C$		
	10 kHz	$0.23 \times 10^{(-3)} C$		
100 nF	100 Hz;	$0.21 \times 10^{(-3)} C$		
	1 kHz;	$0.20 \times 10^{(-3)} C$		
	10 kHz	$0.17 \times 10^{(-3)} C$		
1 µF	100 Hz; 1 kHz	$0.29 \times 10^{(-3)} C$		
	10 kHz	$0.13 \times 10^{(-3)} C$		
		$0.29 \times 10^{(-3)} \text{ } ^\circ C$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / procedure	Expanded measurement uncertainty	Comments
Direct current power measuring instruments	0 W to 21 kW	0 mV to 1020 V 0 μA to 20.5 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ $0.21 \times 10^{-3} \cdot P$ to $0.70 \times 10^{-3} \cdot P$	P = measured value
with clamp connection	0 W to 300 kW	0 V to 330 V 0 mA to 1000 A	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.2 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding.
Active AC power measuring instruments	0.11 mW to 21 kW	$PF = 1$; 45 Hz to 65 Hz 33 mV to 1020 V 3.3 mA to 20 A	$0.7 \times 10^{-3} \times P$ to $1.4 \times 10^{-3} \times P$	P = measured value PF = power factor (capacitive or inductive)
	15 W; 60 W; 100 W; 400 W; 500 W; 1 kW; 2 kW; 4 kW	$PF = 1$; 45 Hz to 65 Hz 50 V; 200 V 0.3 A; 2 A; 10 A; 20 A	$0.16 \times 10^{-3} \times P$	
	1.5 W; 6 W	30 mA;	$0.26 \times 10^{-3} \times P$	
	2.3 W to 20.6 kW	45 Hz to 65 Hz; $PF = 1$ 23 V to 1020 V 30 mA to 20.5 A	$0.32 \times 10^{-3} \times P$ to $0.48 \times 10^{-3} \times P$	
	220 W	45 Hz to 65 Hz 220 V; 1 A $PF = 1$	$0.16 \times 10^{-3} \times P$	
	198 W	$PF = 0.9$	$0.18 \times 10^{-3} \times P$	
	110 W	$PF = 0.5$	$0.29 \times 10^{-3} \times P$	
	22 W	$PF = 0.1$	$1.4 \times 10^{-3} \times P$	
	11 W	$PF = 0.05$	$2.7 \times 10^{-3} \times P$	
	10 W to 1 kW	33 V to 330 V 330 mA to < 3 A 45 Hz to 65 Hz $0.05 \leq PF < 1$ Inductive, capacitive	0.22 W	
with clamp connection	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \leq PF \leq 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.4 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding. The relative uncertainty of the measurement object W_{DUT} in the measurement circuit and in the stray field of the current-carrying conductor must be taken into account.
Power factor	0. to 0. .04	33 V to 330 V	0.15×10^{-3}	
	> 0.4 to < 1	330 mA to 2.2 A 45 Hz to 65 Hz	$-60 \times 10^{-6} \times P + 0.16 \times 10^{-3}$	
	1		89×10^{-6}	
AC reactive power Meters	0 var to 1 kvar	45 Hz to 65 Hz	$U_P \cdot \text{var}/W$	U_P is the uncertainty of active power

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Frequency f Measurement and synthesis	0.01 Hz to 18 GHz		$0.5 \times 10^{\wedge{-9}} \cdot f + U_{TF}$	U_{TF} : Trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 2 ns to 100 s 1 s to 100 h		1.2 ns $1.5 \times 10^{\wedge{-6}} \times \Delta t + 50 \text{ ps}$ $14 \times 10^{\wedge{-6}} \cdot \Delta t + U_{TF}$	
Rotational speed	0.02 s^{-1} to 18000 s^{-1}		$3.7 \times 10^{\wedge{-6}} \cdot f$	
Oscilloscope vertical	0 V to 5 V 5 V 130 V	DC to 10 kHz	$1.1 \times 10^{\wedge{-3}} \cdot U + 66 \text{ }\mu\text{V}$ $1.2 \times 10^{\wedge{-3}} \cdot U + 44 \text{ }\mu\text{V}$	U : measured value
Oscilloscope horizontal	1 ns to < 100 ns 100 ns to 20 ms > 20 ms to 5 s		$0.6 \times 10^{\wedge{-6}} \times T + 60 \text{ fs}$ $3.1 \times 10^{\wedge{-6}} \times T + 11 \text{ fs}$ $1.2 \times 10^{\wedge{-3}} \times T^2 + 29 \times 10^{\wedge{-6}} \times T$	T = measured value
Oscilloscope bandwidth f (frequency response)	50 kHz > 50 kHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 600 MHz > 600 MHz to 1.1 GHz > 1.1 GHz to 2 GHz > 2 GHz to 4 GHz		$3.3 \times 10^{\wedge{-2}} \times f$ $2.5 \times 10^{-2} \times f$ $3.1 \times 10^{\wedge{-2}} \times f$ $5.5 \times 10^{-2} \times f$ $6.5 \times 10^{\wedge{-2}} \cdot f$ $6.8 \times 10^{\wedge{-2}} \cdot f$ $9.5 \times 10^{\wedge{-2}} \cdot f$	f = measured value
Frequency f Time base	10 MHz		$0.2 \times 10^{\wedge{-6}} \times f$	
Rise time Oscilloscopes	50 ps to 1 ms 1 ns to 1 ms	0.05 V to 1.2 V 0.1 to 3 V	$4 \text{ ps} + 5.7 \times 10^{\wedge{-3}} \times T$ $2.5 \text{ ps} + 5.8 \times 10^{-3} \times T$	
Rise time of generators, pulses	0.5 ns to < 2.5 ns 2.5 ns to 5 ms		$28 \text{ ps} + 14 \times 10^{\wedge{-3}} \cdot T$ $13 \text{ ps} + 28 \times 10^{\wedge{-3}} \cdot T$	
RF power Output power and calibration factor of RF sources	10 μW to 80 mW	DC to 50 MHz 50 MHz to 4 GHz 4 GHz to 12 GHz 12 GHz to 18 GHz	$9.5 \times 10^{\wedge{-3}} \cdot P$ $14 \times 10^{\wedge{-3}} P$ $22 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$	N-connector, 50 ohms $ r_{RG} \leq 0.035 f$ $\leq 4 \text{ GHz}$ $ r_{RG} \leq 0.056 f$ $\leq 12 \text{ GHz}$ $ r_{RG} \leq 0.075 f$ $\leq 18 \text{ GHz}$ Other connectors and reflection factors increase the measurement uncertainty
RF voltage U_{HF} sources with RF voltage display relative to 50 Ω	22 mV to 2 V	DC to 18 MHz	$W(U_{HF}) = \frac{W(P)}{2}$	$W(P)$ is the relative uncertainty of the measured power at $Z_0 = 50 \text{ }\Omega$

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Matrix BM.1 Square-wave voltage

Square-wave voltage [V] \ Frequency [Hz]	0.001	0.01	0.1	0.1	0.5	1	5	10	50	100
10	3.8E-07	512.2E-9	2.44E-06	2.37E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
100	7.4E-07	814.6E-9	2.52E-06	2.46E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
1000	6.4E-06	6.4E-6	6.99E-06	6.97E-06	1.34E-05	2.4E-05	111.6E-6	251.5E-6	1.2E-3	2.3E-3
10,000	6.3E-05	63.7E-6	6.56E-05	6.56E-05	7.47E-05	8.7E-05	200.5E-6	369.5E-6	1.6E-3	3.2E-3

Matrix BM.2 Replacement leakage current

Normal resistance R_N	1 k Ω	10 k Ω	100 k Ω	1 M Ω	10 M Ω	100 M Ω	1 G Ω							
Nominal voltage	Current expanded measurement uncertainty U in $\mu A/A$						Current U in mA/A							
60 V	60 mA	12	6 mA	12	600 μA	12	60 μA	20	6 μA	71	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		110 μA		11 μA		1.1 μA					
230 V	230 mA		23 mA		230 μA		23 μA		2.3 μA					
400 V	400 mA		40 mA		400 μA		40 μA		4.0 μA					

Matrix BM.3 AC resistance

Voltage [V] \ Current [A]	0.001 V	0.010 V	0.010 V	0.100 V	0.100 V	1.000 V	1.000 V	10.000 V	10,000 V	100,000 V
$2.2 \times 10^{-3} A$	1.57E-03	4.66E-04	4.66E-04	3.00E-04	3.00E-04	2.98E-04	2.98E-04	3.00E-04	3.00E-04	3.78E-04
$2.2 \cdot 10^{-2} A$	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
0.22 A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
2.2 A	1.64E-03	6.78E-04	6.78E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	6.21×10^{-4}

Dimensional quantities

Permanent Laboratory – Berlin site

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / methods	Expanded measurement uncertainty	Remarks
Length Calipers for external, internal and depth measurements *	0 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	$20 \mu m + 15 \times 10^{(-6)} \times l$	l: measured value
Micrometers *	0 mm to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	$2 \mu m + 6 \times 10^{(-6)} \times l$	

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Electrical parameters

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
DC voltage sources	0 V		120 nV	Short-circuit bridge
	0 V to 0.1 V		$4 \times 10^{-(6)} \times U + 0.36 \mu\text{V}$	U = measured value
	> 0.1 V to 1 V		$3.7 \times 10^{-6} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	
	1050 V to 10 kV		$0.17 \times 10^{-3} \cdot U$	
DC voltage measuring instruments	0 V to 220 mV		$6 \times 10^{-6} \times U + 0.6 \mu\text{V}$	
	> 220 mV to 2.2 V		$5 \times 10^{-(6)} \times U + 1 \mu\text{V}$	
	> 2.2 V to 11 V		$4 \times 10^{-(6)} U + 3.5 \mu\text{V}$	
	> 11 V to 22 V		$4 \times 10^{-(6)} \cdot U + 6.5 \mu\text{V}$	
	> 22 V to 220 V		$5 \times 10^{-(6)} U + 80 \mu\text{V}$	
	> 220 V to 1050 V		$7 \times 10^{-(6)} \cdot U + 0.5 \text{ mV}$	
	0 V to 0.1 V		$4 \times 10^{-6} \times U + 0.36 \mu\text{V}$	
	> 0.1 V to 1 V		$3.7 \times 10^{-(6)} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \times U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Comments
AC voltage sources, measuring instruments	2 mV to 1000 V	10 Hz to 1 MHz	4.1 μV to 0.48 V	U = measured value
	2 mV to 10 mV	10 Hz to 40 Hz	$0.36 \times 10^{-3} \times U + 3.4 \mu\text{V}$	
		> 40 Hz to 1 kHz	$0.24 \times 10^{-3} \times U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.36 \times 10^{-3} \times U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.2 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$5.8 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$46 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
	> 10 mV to 100 mV	10 Hz to 40 Hz	$86 \times 10^{-6} \cdot U + 4.6 \mu\text{V}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 2.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.93 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
	> 100 mV to 1 V	> 300 kHz to 1 MHz	$12 \times 10^{-3} \times U + 12 \mu\text{V}$	
		10 Hz to 40 Hz	$83 \times 10^{-6} \cdot U + 46 \mu\text{V}$	
		> 40 Hz to 1 kHz	$82 \times 10^{-6} \cdot U + 23 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.16 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
	> 1 V to 10 V	> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \times U + 0.12 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \times U + 0.12 \text{ mV}$	
		10 Hz to 40 Hz	$85 \times 10^{-6} \cdot U + 0.46 \text{ mV}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 0.23 \text{ mV}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
	> 10 V to 100 V	> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
10 Hz to 40 Hz		$0.23 \times 10^{-3} \cdot U + 4.6 \text{ mV}$		
> 40 Hz to 1 kHz		$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
> 100 V to 1000 V	> 1 kHz to 20 kHz	$0.23 \times 10^{-3} \times U + 2.3 \text{ mV}$		
	> 20 kHz to 50 kHz	$0.41 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	> 50 kHz to 100 kHz	$1.4 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	50 Hz to 1 kHz	$0.46 \times 10^{-3} \cdot U + 16 \text{ mV}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	1 mV to 1100 V	10 Hz to 1 MHz	5 µV to 81 mV	U = measured value
	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 4.5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 2.2 mV to 22 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 22 mV to 220 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 8 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.28 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 35 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 80 \mu\text{V}$	
	> 220 mV to 2.2 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 80 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 6 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 16 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 70 \mu\text{V}$	
		> 100 kHz to 300 kHz	$0.39 \times 10^{-3} \cdot U + 0.13 \text{ mV}$	
		> 300 kHz to 500 kHz	$0.95 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
> 500 kHz to 1 MHz		$1.9 \times 10^{-3} \cdot U + 0.85 \text{ mV}$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	> 2.2 V to 22 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 0.8 \text{ mV}$	$U = \text{measured value}$
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 0.25 \text{ mV}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 60 \text{ } \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 0.16 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
		> 100 kHz to 300 kHz	$0.45 \times 10^{-3} \cdot U + 1.5 \text{ mV}$	
		> 300 kHz to 500 kHz	$1.2 \times 10^{-3} \times U + 4.3 \text{ mV}$	
		> 500 kHz to 1 MHz	$2.5 \times 10^{-3} \cdot U + 8.5 \text{ mV}$	
	> 22 V to 220 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 2.5 \text{ mV}$	
		> 40 Hz to 20 kHz	$70 \times 10^{-6} \cdot U + 0.8 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.19 \times 10^{-3} \cdot U + 3.5 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.45 \times 10^{-3} \times U + 8 \text{ mV}$	
	> 220 V to 1100 V	15 Hz to 50 Hz	$0.36 \times 10^{-3} \cdot U + 16 \text{ mV}$	
		> 50 Hz to 1 kHz	$70 \times 10^{-6} \cdot U + 3.5 \text{ mV}$	
1 mV to 220 V	1 Hz to 10 kHz square-wave voltage	$0.38 \text{ } \mu\text{V to } 3.2 \text{ mV}$ See Matrix MM.1		
Sources	1100 V to 10 kV	45 Hz to 55 Hz	$0.46 \times 10^{(-3)} \times U$	$U = \text{measured value}$

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current measuring instruments, sources	0 mA to 220 µA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	I = measured value
	> 220 µA to 2.2 mA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	
	> 2.2 mA to 22 mA		$40 \times 10^{(-6)} \times I + 80 \text{ nA}$	
	> 22 mA to 100 mA		$50 \cdot 10^{(-6)} \cdot I + 0.8 \text{ µA}$	
	> 100 mA to 220 mA		$50 \times 10^{(-6)} \cdot I + 200 \times 10^{(-6)} \cdot I^2 + 0.8 \text{ µA}$	
	> 220 mA to 1 A		$65 \times 10^{(-6)} \cdot I + 25 \text{ µA}$	
	> 1 A to 2.2 A		$65 \times 10^{(-6)} \times I + 10 \times 10^{(-6)} \times I^2 + 25 \text{ µA}$	
	> 2.2 A to 3 A		$0.38 \times 10^{(-3)} \times I + 40 \text{ µA}$	
	> 3 A to 10.1 A		$0.5 \times 10^{(-3)} \times I + 0.5 \text{ mA}$	
	> 10.1 A to 20.5 A		$1 \times 10^{(-3)} \times I + 0.75 \text{ mA}$	
	0 pA to 1 pA		1 pA	
	> 1 pA to 100 nA		$35 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 100 nA to 1 µA		$23 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 1 µA to 10 µA		$23 \cdot 10^{(-6)} \cdot I + 0.12 \text{ nA}$	
	> 10 µA to 100 µA		$23 \times 10^{(-6)} \cdot I + 0.92 \text{ nA}$	
	> 100 µA to 1 mA		$23 \times 10^{(-6)} \times I + 6 \text{ nA}$	
	> 1 mA to 10 mA		$23 \times 10^{(-6)} \times I + 58 \text{ nA}$	
	> 10 mA to 100 mA		$41 \times 10^{(-6)} \cdot I + 580 \text{ nA}$	
	> 100 mA to 1 A		$0.13 \times 10^{(-3)} \cdot I + 12 \text{ µA}$	
	1 A to 400 A		$0.21 \times 10^{(-3)} \times I$	
Direct current Current clamps and current transformers	1 mA – – –1100 A	1 to N windings	$3 \times 10^{(-3)} \times I$	

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current measuring instruments, sources	10 μ A to 20.5 A	10 Hz to 10 kHz	25 nA to 0.62 A	I = measured value
	0.01 mA to 0.22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 25$ nA	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 16$ nA	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \cdot I + 40$ nA	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80$ nA	
	> 0.22 mA to 2.2 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 40$ nA	
		> 40 Hz to 1 kHz	$0.1, 2 \times 10^{-4} \cdot I + 35$ nA	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \cdot I + 0.4$ μ A	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 0.8$ μ A	
	> 2.2 mA to 22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 0.4$ μ A	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 0.35$ μ A	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \cdot I + 4$ μ A	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 8$ μ A	
	> 22 mA to 220 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 4$ μ A	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 3.5$ μ A	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \cdot I + 40$ μ A	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80$ μ A	
	> 220 mA to 2.2 A	20 Hz to 1 kHz	$0.55 \times 10^{-3} \cdot I + 35$ μ A	
		> 1 kHz to 5 kHz	$0.65 \times 10^{-3} \cdot I + 80$ μ A	
		> 5 kHz to 10 kHz	$0.75 \times 10^{-3} \cdot I + 0.16$ mA	
> 2.2 A to 3 A	10 Hz to 45 Hz	$1.8 \times 10^{-3} \cdot I + 0.1$ mA		
	> 45 Hz to 1 kHz	$0.6 \times 10^{-3} \cdot I + 0.1$ mA		
> 3 A to 11 A	45 Hz to 100 Hz	$0.6 \times 10^{-3} \cdot I + 2$ mA		
	> 100 Hz to 1 kHz	$1.0 \times 10^{-3} \cdot I + 2$ mA		
> 11 A to 20.5 A	45 Hz to 100 Hz	$1.2 \times 10^{-3} \cdot I + 5$ mA		
	> 100 Hz to 1 kHz	$1.5 \times 10^{-3} \cdot I + 5$ mA		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	5 μ A to 1 A	20 Hz to 5 kHz	35 nA to 13 mA	I = measured value
	5 μ A to 100 μ A	20 Hz to 45 Hz	$1.7 \times 10^{-3} \times I + 35$ nA	
		> 45 Hz to 1 kHz	$0.76 \times 10^{-3} \times I + 34$ nA	
	> 100 μ A to 1 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 0.23$ μ A	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 0.23$ μ A	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 0.2$ μ A	
	> 1 mA to 10 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 2.3$ μ A	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \times I + 2.3$ μ A	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 2$ μ A	
	> 10 mA to 100 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 23$ μ A	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 23$ μ A	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \times I + 20$ μ A	
	> 100 mA to 1 A	20 Hz to 45 Hz	$1.8 \times 10^{-3} \times I + 0.23$ mA	
		> 45 Hz to 100 Hz	$0.83 \times 10^{-3} \times I + 0.33$ mA	
> 100 Hz to 5 kHz		$1.6 \times 10^{-3} \cdot I + 0.21$ mA		
Alternating current sources, measuring instruments	10 mA to 500 A		3 μ A to 0.2 A	I = measured value
	10 mA to 1 A	40 Hz to 1 kHz	$0.32 \times 10^{-3} \times I$	
	> 1 A to 100 A		$0.69 \times 10^{-3} \cdot I$	
	> 100 A to 450 A		$0.9 \times 10^{-3} \times I$	
Current clamps and current transformers	1 mA – – – 1100 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/N	$4 \times 10^{-3} \cdot I$	I = measured value
Equivalent current	0.2 μ A to 200 mA	at R_N up to 1 G Ω DC up to 60 Hz	$17 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ See Matrix MM.2	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC resistance Fixed values	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value
		4-wire short circuit	0.35 μΩ	
	100 μΩ 1 mΩ 10 mΩ 100 mΩ		0.45 × 10 ^{Λ(-3)} × R 0.17 × 10 ^{Λ(-3)} × R 0.17 × 10 ^{Λ(-3)} × R 0.10 × 10 ^{Λ(-3)} · R	
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ;		40 × 10 ^{Λ(-6)} R 23 × 10 ^{Λ(-6)} R 14 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 9.5 × 10 ^{Λ(-6)} · R 11 · 10 ⁻⁶ · R 15 · 10 ⁻⁶ · R 31 · 10 ⁻⁶ · R 100 · 10 ⁻⁶ · R	
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ; 1 GΩ		76 × 10 ^{Λ(-6)} R 20 × 10 ^{Λ(-6)} · R 17 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 13 · 10 ⁻⁶ · R 19 · 10 ⁻⁶ · R 70 · 10 ⁻⁶ · R 0.59 × 10 ⁻³ · R 5.9 × 10 ⁻³ · R	
	0 to < 11 Ω 11 Ω to < 110 Ω 110 Ω to < 110 kΩ 110 kΩ to < 1.1 MΩ 1.1 MΩ to < 3.3 MΩ 3.3 MΩ to < 11 MΩ 11 MΩ to < 33 MΩ 33 MΩ to < 110 MΩ 110 MΩ to < 330 MΩ 330 MΩ to < 1.1 GΩ		40 × 10 ^{Λ(-6)} R 35 × 10 ^{Λ(-6)} · R 28 × 10 ^{Λ(-6)} · R 32 × 10 ^{Λ(-6)} · R 60 × 10 ^{Λ(-6)} · R 0.13 × 10 ⁻³ · R 0.25 × 10 ⁻³ × R 0.5 × 10 ^{Λ(-3)} · R 3 × 10 ^{Λ(-3)} · R 15 × 10 ^{Λ(-3)} · R	
	500 μΩ to 45 kΩ	10 Hz to 10 kHz	$\sqrt{U_I^2 + U_U^2} \cdot R$ 0.17 × 10 ^{Λ(-3)} × R to 1.7 × 10 ^{Λ(-3)} · R See matrix MM.3	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Inductance Fixed values	0 µH	2-wire short-circuit	0.03 µH	L = measured value Absolute value of impedance $50 \text{ m}\Omega \leq Z \leq 11 \text{ k}\Omega$
	100 µH	100 Hz	$0.54 \times 10^{(-3)} \times L$	
		1 kHz	$0.28 \times 10^{(-3)} \cdot L$	
		10 kHz	$0.29 \times 10^{(-3)} \cdot L$	
	1 mH	100 Hz	$0.14 \times 10^{(-3)} \times L$	
		1 kHz	$0.14 \times 10^{(-3)} \times L$	
10 mH	100 Hz; 1 kHz; 10 kHz	$0.13 \times 10^{(-3)} L$ $0.16 \times 10^{(-3)} \cdot L$		
100 mH	100 Hz; 1 kHz 10 kHz	$0.13 \times 10^{(-3)} L$ $0.28 \times 10^{(-3)} \cdot L$		
1 H	100 Hz, 1 kHz	$0.20 \times 10^{(-3)} L$		
Capacitance fixed values	0 pF		0.2 pF	No-load
	1 pF	1 kHz	$0.63 \times 10^{(-3)} C$	C = measured value Absolute value of impedance $1 \Omega \leq Z \leq 110 \text{ M}\Omega$
		10 kHz	$0.31 \times 10^{(-3)} C$	
	10 pF	1 kHz	$42 \times 10^{(-6)} C$	
		10 kHz;	$53 \times 10^{(-6)} C$	
		100 kHz	$88 \times 10^{(-6)} C$	
		1 MHz	$0.24 \times 10^{(-3)} C$	
	100 pF	1 kHz	$39 \times 10^{(-6)} C$	
1 nF	1 kHz	$71 \times 10^{(-6)} C$		
	100 kHz	$0.13 \times 10^{(-3)} \cdot C$		
10 nF	100 Hz	$0.49 \times 10^{(-3)} C$		
	1 kHz	$0.21 \times 10^{(-3)} C$		
	10 kHz	$0.23 \times 10^{(-3)} C$		
100 nF	100 Hz;	$0.21 \times 10^{(-3)} C$		
	1 kHz;	$0.20 \times 10^{(-3)} C$		
	10 kHz	$0.17 \times 10^{(-3)} C$		
1 µF	100 Hz; 1 kHz	$0.29 \times 10^{(-3)} C$ $0.13 \times 10^{(-3)} C$		
	10 kHz	$0.29 \times 10^{(-3)} C$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
Direct current power measuring instruments	0 W to 21 kW	0 mV to 1020 V 0 μA to 20.5 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ $0.21 \times 10^{-3} \times P$ to $0.70 \times 10^{-3} \times P$	P = measured value
with clamp connection	0 W to 300 kW	0 V to 330 V 0 mA to 1000 A	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.2 \times 10^{-3} \times P$	w_{in} is the relative uncertainty of the active power of the single winding.
Active AC power measuring instruments	0.11 mW to 21 kW	$PF = 1$; 45 Hz to 65 Hz 33 mV to 1020 V 3.3 mA to 20 A	$0.7 \times 10^{-3} \times P$ to $1.4 \times 10^{-3} \times P$	P = measured value PF = Power factor (capacitive or inductive)
	15 W; 60 W; 100 W; 400 W; 500 W; 1 kW; 2 kW; 4 kW	$PF = 1$; 45 Hz to 65 Hz 50 V; 200 V 0.3 A; 2 A; 10 A; 20 A	$0.16 \times 10^{-3} \times P$	
	1.5 W; 6 W	30 mA;	$0.26 \times 10^{-3} \times W$	
	2.3 W to 20.6 kW	45 Hz to 65 Hz; $PF = 1$ 23 V to 1020 V 30 mA to 20.5 A	$0.32 \times 10^{-3} \times P$ to $0.48 \times 10^{-3} \times P$	
	220 W	45 Hz to 65 Hz 220 V; 1 A $PF = 1$	$0.16 \times 10^{-3} \times P$	
	198 W	$PF = 0.9$	$0.18 \times 10^{-3} \times P$	
	110 W	$PF = 0.5$	$0.29 \times 10^{-3} \times P$	
	22 W	$PF = 0.1$	$1.4 \times 10^{-3} \times P$	
	11 W	$PF = 0.05$	$2.7 \times 10^{-3} \times P$	
	10 W to 1 kW	33 V to 330 V 330 mA to < 3 A 45 Hz to 65 Hz $0.05 \leq PF < 1$ Inductive, capacitive	0.22 W	
with clamp connection	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \leq PF \leq 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.4 \times 10^{-3} \times P$	w_{in} is the relative uncertainty of the active power of the single winding. The relative uncertainty of the measurement object w_{DUT} in the measurement circuit and in the stray field of the current-carrying conductor must be taken into account.
Power factor	0. to 0.4	33 V to 330 V	0.15×10^{-3}	
	> 0.4 to < 1	330 mA to 2.2 A 45 Hz to 65 Hz	$-60 \times 10^{-6} \times P + 0.16 \times 10^{-3}$	
	1		89×10^{-6}	
AC reactive power Meters	0 var to 1 kvar	45 Hz to 65 Hz	$u_p \cdot \text{var}/W$	u_p is the uncertainty of the active power

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Comments
Frequency f Measurement and synthesis	0.01 Hz to 18 GHz		$0.5 \times 10^{-9} \cdot f + U_{TF}$	U_{TF} : Trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 2 ns to 100 s 1 s to 100 h		1.2 ns $1.5 \times 10^{(-6)} \times \Delta t + 50$ ps $14 \times 10^{(-6)} \cdot \Delta t + U_{TF}$	
Rotational speed	$0.02^{s^{-1}}$ to $18000^{s^{-1}}$		$3.7 \times 10^{(-6)} \cdot f$	
Oscilloscope vertical	0 V to 5 V 5 V to 130 V	DC to 10 kHz	$1.1 \times 10^{(-3)} \cdot U + 66$ μ V $1.2 \times 10^{(-3)} \cdot U + 44$ μ V	U : measured value
Oscilloscope horizontal	1 ns to < 100 ns 100 ns to 20 ms > 20 ms to 5 s		$0.6 \times 10^{(-6)} \times T + 60$ fs $3.1 \times 10^{(-6)} \cdot T + 11$ fs $1.2 \times 10^{(-3)} \times T^2 + 29 \times 10^{(-6)} \times T$	T = measured value
Oscilloscope bandwidth f (frequency response)	50 kHz > 50 kHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 600 MHz > 600 MHz to 1.1 GHz > 1.1 GHz to 2 GHz > 2 GHz to 4 GHz		$3.3 \times 10^{(-2)} \times f$ $2.5 \times 10^{(-2)} \times f$ $3.1 \times 10^{-2} \times f$ $5.5 \times 10^{-2} \times f$ $6.5 \times 10^{(-2)} \cdot f$ $6.8 \times 10^{(-2)} \cdot f$ $9.5 \times 10^{(-2)} \cdot f$	f = measured value
Frequency f Time base	10 MHz		$0.2 \times 10^{(-6)} \times f$	
Rise time Oscilloscopes	50 ps to 1 ms 1 ns to 1 ms	0.05 V to 1.2 V 0.1 to 3 V	4 ps + $5.7 \times 10^{(-3)}$ T 2.5 ps + $5.8 \times 10^{(-3)}$ T	
Rise time of generators, pulses	0.5 ns to < 2.5 ns 2.5 ns to 5 ms		28 ps + $14 \times 10^{(-3)}$ T 13 ps + $28 \times 10^{(-3)} \times T$	
RF power Output power and calibration factor of RF sources	10 μ W to 80 mW	DC to 50 MHz 50 MHz to 4 GHz 4 GHz to 12 GHz 12 GHz to 18 GHz	$9.5 \times 10^{(-3)} \cdot P$ $14 \times 10^{(-3)} P$ $22 \times 10^{(-3)} \cdot P$ $36 \times 10^{(-3)} \cdot P$	N-connector, 50 ohms $ r_{RG} \leq 0.035$ f ≤ 4 GHz $ r_{RG} \leq 0.056$ f ≤ 12 GHz $ r_{RG} \leq 0.075$ f ≤ 18 GHz Other connectors and reflection factors increase the measurement uncertainty
RF voltage U_{HF} sources with RF voltage display relative to 50 Ω	22 mV to 2 V	DC to 18 MHz	$W(U_{HF}) = \frac{W(P)}{2}$	$W(P)$ is the relative uncertainty of the measured power at $Z_0 = 50 \Omega$

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Matrix MM.1 Square-wave voltage

Square-wave voltage [V] \ Frequency [Hz]	Frequency [Hz]									
	0.001	0.01	0.1	0.1	0.5	1	5	10	50	100
10	3.8E-07	512.2E-9	2.44E-06	2.37E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
100	7.4E-07	814.6E-9	2.52E-06	2.46E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
1000	6.4E-06	6.4E-6	6.99E-06	6.97E-06	1.34E-05	2.4E-05	111.6E-6	251.5E-6	1.2E-3	2.3E-3
10,000	6.3E-05	63.7E-6	6.56E-05	6.56E-05	7.47E-05	8.7E-05	200.5E-6	369.5E-6	1.6E-3	3.2E-3

Matrix MM.2 Replacement leakage current

Normal resistance R_N	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 MΩ	100 MΩ	1 GΩ							
Nominal voltage	Current expanded measurement uncertainty U in $\mu A/A$						Current U in mA/A							
60 V	60 mA	12	6 mA	12	600 μA	12	60 μA	20	6 μA	71	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		1.1 mA		110 μA		11 μA		1.1 μA		110 nA	
230 V	230 mA		23 mA		2.3 mA		230 μA		23 μA		2.3 μA		230 nA	
400 V	400 mA		40 mA		4 mA		400 μA		40 μA		4.0 μA		400 nA	

Matrix MM.3 AC resistance

Voltage [V] \ Current [A]	Current [A]									
	0.001 V	0.010 V	0.010 V	0.100 V	0.100 V	1.000 V	1.000 V	10.000 V	10,000 V	100,000 V
$2.2 \times 10^{-3} A$	1.57E-03	4.66E-04	4.66E-04	3.00E-04	3.00E-04	2.98E-04	2.98E-04	3.00E-04	3.00E-04	3.78E-04
$22 \cdot 10^{-3} A$	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
0.22 A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
2.2 A	1.64E-03	6.78E-04	6.78E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	6.21E-04

Dimensional quantities

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Length Calipers for external, internal and depth measurements *	0 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	$20 \mu m + 15 \times 10^{(-6)} \times l$	l : measured value
Micrometers *	0 mm to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	$2 \mu m + 6 \times 10^{(-6)} \times l$	

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Electrical quantities

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
DC voltage sources	0 V		120 nV	Short-circuit bridge
	0 V to 0.1 V		$4 \times 10^{-(6)} \times U + 0.36 \mu\text{V}$	U = measured value
	> 0.1 V to 1 V		$3.7 \times 10^{-6} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	
	1050 V to 10 kV		$0.17 \times 10^{-3} \cdot U$	
DC voltage measuring instruments	0 V to 220 mV		$6 \times 10^{-6} \times U + 0.6 \mu\text{V}$	
	> 220 mV to 2.2 V		$5 \times 10^{-(6)} \times U + 1 \mu\text{V}$	
	> 2.2 V to 11 V		$4 \times 10^{-(6)} U + 3.5 \mu\text{V}$	
	> 11 V to 22 V		$4 \times 10^{-(6)} \cdot U + 6.5 \mu\text{V}$	
	> 22 V to 220 V		$5 \times 10^{-(6)} U + 80 \mu\text{V}$	
	> 220 V to 1050 V		$7 \times 10^{-(6)} \cdot U + 0.5 \text{ mV}$	
	0 V to 0.1 V		$4 \times 10^{-6} \times U + 0.36 \mu\text{V}$	
	> 0.1 V to 1 V		$3.7 \times 10^{-(6)} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \times U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Comments
AC voltage sources, measuring instruments	2 mV to 1000 V	10 Hz to 1 MHz	4.1 μV to 0.48 V	U = measured value
	2 mV to 10 mV	10 Hz to 40 Hz	$0.36 \times 10^{-3} \times U + 3.4 \mu\text{V}$	
		> 40 Hz to 1 kHz	$0.24 \times 10^{-3} \times U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.36 \times 10^{-3} \times U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.2 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$5.8 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$46 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
	> 10 mV to 100 mV	10 Hz to 40 Hz	$86 \times 10^{-6} \cdot U + 4.6 \mu\text{V}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 2.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.93 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
	> 100 mV to 1 V	> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
		10 Hz to 40 Hz	$83 \times 10^{-6} \cdot U + 46 \mu\text{V}$	
		> 40 Hz to 1 kHz	$82 \times 10^{-6} \cdot U + 23 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.16 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
	> 1 V to 10 V	> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \times U + 0.12 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \times U + 0.12 \text{ mV}$	
		10 Hz to 40 Hz	$85 \times 10^{-6} \cdot U + 0.46 \text{ mV}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 0.23 \text{ mV}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
	> 10 V to 100 V	> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
10 Hz to 40 Hz		$0.23 \times 10^{-3} \cdot U + 4.6 \text{ mV}$		
> 40 Hz to 1 kHz		$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
> 100 V to 1000 V	> 1 kHz to 20 kHz	$0.23 \times 10^{-3} \times U + 2.3 \text{ mV}$		
	> 20 kHz to 50 kHz	$0.41 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	> 50 kHz to 100 kHz	$1.4 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	50 Hz to 1 kHz	$0.46 \times 10^{-3} \cdot U + 16 \text{ mV}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	1 mV to 1100 V	10 Hz to 1 MHz	5 μ V to 81 mV	U = measured value
	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \times U + 4.5 \mu$ V	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 4.5 \mu$ V	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 4.5 \mu$ V	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 4.5 \mu$ V	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu$ V	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 13 \mu$ V	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu$ V	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu$ V	
	> 2.2 mV to 22 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 5 \mu$ V	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 5 \mu$ V	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 5 \mu$ V	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 5 \mu$ V	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu$ V	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \times U + 12 \mu$ V	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu$ V	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu$ V	
	> 22 mV to 220 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 13 \mu$ V	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 8 \mu$ V	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 8 \mu$ V	
		> 20 kHz to 50 kHz	$0.28 \times 10^{-3} \cdot U + 8 \mu$ V	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 25 \mu$ V	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 25 \mu$ V	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 35 \mu$ V	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 80 \mu$ V	
	> 220 mV to 2.2 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 80 \mu$ V	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 25 \mu$ V	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 6 \mu$ V	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 16 \mu$ V	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 70 \mu$ V	
		> 100 kHz to 300 kHz	$0.39 \times 10^{-3} \cdot U + 0.13$ mV	
		> 300 kHz to 500 kHz	$0.95 \times 10^{-3} \times U + 0.35$ mV	
> 500 kHz to 1 MHz		$1.9 \times 10^{-3} \cdot U + 0.85$ mV		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	> 2.2 V to 22 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 0.8 \text{ mV}$	$U = \text{measured value}$
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 0.25 \text{ mV}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 60 \text{ } \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 0.16 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
		> 100 kHz to 300 kHz	$0.45 \times 10^{-3} \cdot U + 1.5 \text{ mV}$	
		> 300 kHz to 500 kHz	$1.2 \times 10^{-3} \times U + 4.3 \text{ mV}$	
		> 500 kHz to 1 MHz	$2.5 \times 10^{-3} \cdot U + 8.5 \text{ mV}$	
	> 22 V to 220 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 2.5 \text{ mV}$	
		> 40 Hz to 20 kHz	$70 \times 10^{-6} \cdot U + 0.8 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.19 \times 10^{-3} \cdot U + 3.5 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.45 \times 10^{-3} \times U + 8 \text{ mV}$	
	> 220 V to 1100 V	15 Hz to 50 Hz	$0.36 \times 10^{-3} \cdot U + 16 \text{ mV}$	
		> 50 Hz to 1 kHz	$70 \times 10^{-6} \cdot U + 3.5 \text{ mV}$	
1 mV to 220 V	1 Hz to 10 kHz square-wave voltage	$0.38 \text{ } \mu\text{V to } 3.2 \text{ mV}$ See Matrix NM.1		
Sources	1100 V to 10 kV	45 Hz to 55 Hz	$0.46 \times 10^{(-3)} \times U$	$U = \text{measured value}$

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current measuring instruments, sources	0 mA to 220 µA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	I = measured value
	> 220 µA to 2.2 mA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	
	> 2.2 mA to 22 mA		$40 \times 10^{(-6)} \times I + 80 \text{ nA}$	
	> 22 mA to 100 mA		$50 \cdot 10^{(-6)} \cdot I + 0.8 \text{ µA}$	
	> 100 mA to 220 mA		$50 \times 10^{(-6)} \cdot I + 200 \times 10^{(-6)} \cdot I^2 + 0.8 \text{ µA}$	
	> 220 mA to 1 A		$65 \times 10^{(-6)} \cdot I + 25 \text{ µA}$	
	> 1 A to 2.2 A		$65 \times 10^{(-6)} \times I + 10 \times 10^{(-6)} \times I^2 + 25 \text{ µA}$	
	> 2.2 A to 3 A		$0.38 \times 10^{(-3)} \times I + 40 \text{ µA}$	
	> 3 A to 10.1 A		$0.5 \times 10^{(-3)} \times I + 0.5 \text{ mA}$	
	> 10.1 A to 20.5 A		$1 \times 10^{(-3)} \times I + 0.75 \text{ mA}$	
	0 pA to 1 pA		1 pA	
	> 1 pA to 100 nA		$35 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 100 nA to 1 µA		$23 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 1 µA to 10 µA		$23 \cdot 10^{(-6)} \cdot I + 0.12 \text{ nA}$	
	> 10 µA to 100 µA		$23 \times 10^{(-6)} \cdot I + 0.92 \text{ nA}$	
	> 100 µA to 1 mA		$23 \times 10^{(-6)} \times I + 6 \text{ nA}$	
	> 1 mA to 10 mA		$23 \times 10^{(-6)} \times I + 58 \text{ nA}$	
	> 10 mA to 100 mA		$41 \times 10^{(-6)} \cdot I + 580 \text{ nA}$	
	> 100 mA to 1 A		$0.13 \times 10^{(-3)} \cdot I + 12 \text{ µA}$	
	1 A to 400 A		$0.21 \times 10^{(-3)} \times I$	
Direct current Current clamps and current transformers	1 mA – – –1100 A	1 to N windings	$3 \times 10^{(-3)} \times I$	

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current measuring instruments, sources	10 µA to 20.5 A	10 Hz to 10 kHz	25 nA to 0.62 A	I = measured value
	0.01 mA to 0.22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \times I + 25 \text{ nA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \times I + 16 \text{ nA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40 \text{ nA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80 \text{ nA}$	
	> 0.22 mA to 2.2 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 40 \text{ nA}$	
		> 40 Hz to 1 kHz	$0.1, 2 \times 10^{-4} \times I + 35 \text{ nA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 0.4 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 0.8 \text{ µA}$	
	> 2.2 mA to 22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 0.4 \text{ µA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 0.35 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 4 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \times I + 8 \text{ µA}$	
	> 22 mA to 220 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 4 \text{ µA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 3.5 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80 \text{ µA}$	
	> 220 mA to 2.2 A	20 Hz to 1 kHz	$0.55 \times 10^{-3} \times I + 35 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.65 \times 10^{-3} \cdot I + 80 \text{ µA}$	
		> 5 kHz to 10 kHz	$0.75 \times 10^{-3} \cdot I + 0.16 \text{ mA}$	
> 2.2 A to 3 A	10 Hz to 45 Hz	$1.8 \times 10^{-3} \cdot I + 0.1 \text{ mA}$		
	> 45 Hz to 1 kHz	$0.6 \times 10^{-3} \cdot I + 0.1 \text{ mA}$		
> 3 A to 11 A	45 Hz to 100 Hz	$0.6 \times 10^{-3} \times I + 2 \text{ mA}$		
	> 100 Hz to 1 kHz	$1.0 \times 10^{-3} \times I + 2 \text{ mA}$		
> 11 A to 20.5 A	45 Hz to 100 Hz	$1.2 \times 10^{-3} \cdot I + 5 \text{ mA}$		
	> 100 Hz to 1 kHz	$1.5 \times 10^{-3} \cdot I + 5 \text{ mA}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	5 µA to 1 A	20 Hz to 5 kHz	35 nA to 13 mA	I = measured value
	5 µA to 100 µA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \times I + 35 \text{ nA}$	
		> 45 Hz to 1 kHz	$0.76 \times 10^{-3} \times I + 34 \text{ nA}$	
	> 100 µA to 1 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 0.23 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 0.23 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 0.2 \text{ µA}$	
	> 1 mA to 10 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 2.3 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \times I + 2.3 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 2 \text{ µA}$	
	> 10 mA to 100 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 23 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 23 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \times I + 20 \text{ µA}$	
	> 100 mA to 1 A	20 Hz to 45 Hz	$1.8 \times 10^{-3} \times I + 0.23 \text{ mA}$	
		> 45 Hz to 100 Hz	$0.83 \times 10^{-3} \times I + 0.33 \text{ mA}$	
		> 100 Hz to 5 kHz	$1.6 \times 10^{-3} \cdot I + 0.21 \text{ mA}$	
Alternating current sources, measuring instruments	10 mA to 500 A		3 µA to 0.2 A	I = measured value
	10 mA to 1 A	40 Hz to 1 kHz	$0.32 \times 10^{-3} \times I$	
	> 1 A to 100 A		$0.69 \times 10^{-3} \cdot I$	
	> 100 A to 450 A		$0.9 \times 10^{-3} \times I$	
Current clamps and current transformers	1 mA – – – 1100 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/N	$4 \times 10^{-3} \cdot I$	I = measured value
Equivalent current	0.2 µA to 200 mA	at R_N up to 1 GΩ DC up to 60 Hz	$17 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ See Matrix NM.2	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks				
DC resistance Fixed values	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value				
		4-wire short circuit	0.35 μΩ					
	100 μΩ 1 mΩ 10 mΩ 100 mΩ			0.45 × 10 ^{Λ(-3)} × R	Intermediate values increase the measurement uncertainty			
				0.17 × 10 ^{Λ(-3)} × R				
				0.17 × 10 ^{Λ(-3)} × R				
1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ;			40 × 10 ^{Λ(-6)} · R					
			23 × 10 ^{Λ(-6)} · R					
			14 × 10 ^{Λ(-6)} · R					
			10 × 10 ^{Λ(-6)} · R					
1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ; 1 GΩ			9.5 × 10 ^{Λ(-6)} · R					
			11 · 10 ⁻⁶ · R					
			15 · 10 ⁻⁶ · R					
			31 · 10 ⁻⁶ · R					
Measuring instruments	0 to < 11 Ω 11 Ω to < 110 Ω 110 Ω to < 110 kΩ 110 kΩ to < 1.1 MΩ 1.1 MΩ to < 3.3 MΩ 3.3 MΩ to < 11 MΩ 11 MΩ to < 33 MΩ 33 MΩ to < 110 MΩ 110 MΩ to < 330 MΩ 330 MΩ to < 1.1 GΩ		40 × 10 ^{Λ(-6)} · R 35 × 10 ^{Λ(-6)} · R 28 × 10 ^{Λ(-6)} · R 32 × 10 ^{Λ(-6)} · R 60 × 10 ^{Λ(-6)} · R 0.13 × 10 ⁻³ × R 0.25 × 10 ^{Λ(-3)} · R 0.5 × 10 ⁻³ · R 3 × 10 ^{Λ(-3)} · R 15 × 10 ^{Λ(-3)} · R					
				AC resistance (magnitude of impedance)	500 μΩ to 45 kΩ	10 Hz to 10 kHz	$\sqrt{U_I^2 + U_U^2} \cdot R$ 0.17 × 10 ^{Λ(-3)} × R to 1.7 × 10 ^{Λ(-3)} · R See matrix NM.3	R = measured value u _I is the relative uncertainty of the calibration current u _U is the relative uncertainty of the measured voltage across the resistor

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Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
Inductance fixed values	0 µH	2-wire short-circuit	0.03 µH	L = measured value Impedance range: 50 mΩ ≤ Z ≤ 11 kΩ
	100 µH	100 Hz	$0.54 \times 10^{(-3)} \times L$	
		1 kHz	$0.28 \times 10^{(-3)} \cdot L$	
		10 kHz	$0.29 \times 10^{(-3)} \cdot L$	
	1 mH	100 Hz	$0.14 \times 10^{(-3)} \times L$	
		1 kHz	$0.14 \times 10^{(-3)} \times L$	
10 mH	10 kHz	$0.24 \times 10^{(-3)} L$		
100 mH	100 Hz; 1 kHz	$0.13 \times 10^{(-3)} L$ $0.16 \times 10^{(-3)} \cdot L$		
1 H	100 Hz; 1 kHz	$0.13 \times 10^{(-3)} L$ $0.28 \times 10^{(-3)} \cdot L$		
Capacitance fixed values	0 pF		0.2 pF	No-load
	1 pF	1 kHz	$0.63 \times 10^{(-3)} C$	C = measured value Absolute value of impedance 1 Ω ≤ Z ≤ 110 MΩ
		10 kHz	$0.31 \times 10^{(-3)} C$	
	10 pF	1 kHz	$42 \times 10^{(-6)} C$	
		10 kHz;	$53 \times 10^{(-6)} C$	
		100 kHz	$88 \times 10^{(-6)} C$	
	1 MHz	$0.24 \times 10^{(-3)} C$		
	100 pF	1 kHz	$39 \times 10^{(-6)} C$	
1 nF	1 kHz	$71 \times 10^{(-6)} C$		
	100 kHz	$0.13 \times 10^{(-3)} C$		
10 nF	100 Hz	$0.49 \times 10^{(-3)} C$		
	1 kHz	$0.21 \times 10^{(-3)} C$		
	10 kHz	$0.23 \times 10^{(-3)} C$		
100 nF	100 Hz;	$0.21 \times 10^{(-3)} C$		
	1 kHz;	$0.20 \times 10^{(-3)} C$		
10 kHz	$0.17 \times 10^{(-3)} C$			
1 µF	100 Hz; 1 kHz	$0.29 \times 10^{(-3)} C$ $0.13 \times 10^{(-3)} C$		
	10 kHz	$0.29 \times 10^{(-3)} C$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current power measuring instruments	0 W to 21 kW	0 mV to 1020 V 0 μA to 20.5 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ $0.21 \times 10^{-3} \cdot P$ to $0.70 \times 10^{-3} \cdot P$	P = measured value
with clamp connection	0 W to 300 kW	0 V to 330 V 0 mA to 1000 A	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.2 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding.
Active AC power measuring instruments	0.11 mW to 21 kW	$PF = 1$; 45 Hz to 65 Hz 33 mV to 1020 V 3.3 mA to 20 A	$0.7 \times 10^{-3} \times P$ to $1.4 \times 10^{-3} \times P$	P = measured value PF = power factor (capacitive or inductive)
	15 W; 60 W; 100 W; 400 W; 500 W; 1 kW; 2 kW; 4 kW	$PF = 1$; 45 Hz to 65 Hz 50 V; 200 V 0.3 A; 2 A; 10 A; 20 A	$0.16 \times 10^{-3} \times P$	
	1.5 W; 6 W	30 mA;	$0.26 \times 10^{-3} \times P$	
	2.3 W to 20.6 kW	45 Hz to 65 Hz; $PF = 1$ 23 V to 1020 V 30 mA to 20.5 A	$0.32 \times 10^{-3} \times P$ to $0.48 \times 10^{-3} \times P$	
	220 W	45 Hz to 65 Hz 220 V; 1 A $PF = 1$	$0.16 \times 10^{-3} \times P$	
	198 W	$PF = 0.9$	$0.18 \times 10^{-3} \times P$	
	110 W	$PF = 0.5$	$0.29 \times 10^{-3} \times P$	
	22 W	$PF = 0.1$	$1.4 \times 10^{-3} \times P$	
	11 W	$PF = 0.05$	$2.7 \times 10^{-3} \times P$	
	10 W to 1 kW	33 V to 330 V 330 mA to < 3 A 45 Hz to 65 Hz $0.05 \leq PF < 1$ Inductive, capacitive	0.22 W	
with clamp connection	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \leq PF \leq 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.4 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding. The relative uncertainty of the measurement object W_{DUT} in the measurement circuit and in the stray field of the current-carrying conductor must be taken into account.
Power factor	0. to 0.4	33 V to 330 V	0.15×10^{-3}	
	> 0.4 to < 1	330 mA to 2.2 A 45 Hz to 65 Hz	$-60 \times 10^{-6} \times P + 0.16 \times 10^{-3}$	
	1		89×10^{-6}	
AC reactive power Meters	0 var to 1 kvar	45 Hz to 65 Hz	$U_P \cdot \text{var}/W$	U_P is the uncertainty of active power

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Frequency f Measurement and synthesis	0.01 Hz to 18 GHz		$0.5 \times 10^{-9} \cdot f + U_{TF}$	U_{TF} : Trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 2 ns to 100 s 1 s to 100 h		1.2 ns $1.5 \times 10^{(-6)} \times \Delta t + 50 \text{ ps}$ $14 \times 10^{(-6)} \cdot \Delta t + U_{TF}$	
Rotational speed	0.02 s^{-1} to 18000 s^{-1}		$3.7 \times 10^{(-6)} \cdot f$	
Oscilloscope vertical	0 V to 5 V 5 V 130 V	DC to 10 kHz	$1.1 \times 10^{(-3)} \cdot U + 66 \mu\text{V}$ $1.2 \times 10^{(-3)} \cdot U + 44 \mu\text{V}$	U : measured value
Oscilloscope horizontal	1 ns to < 100 ns 100 ns to 20 ms > 20 ms to 5 s		$0.6 \times 10^{(-6)} \times T + 60 \text{ fs}$ $3.1 \times 10^{(-6)} \times T + 11 \text{ fs}$ $1.2 \times 10^{(-3)} \times T^2 + 29 \times 10^{(-6)} \times T$	T = measured value
Oscilloscope bandwidth f (frequency response)	50 kHz > 50 kHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 600 MHz > 600 MHz to 1.1 GHz > 1.1 GHz to 2 GHz > 2 GHz to 4 GHz		$3.3 \times 10^{(-2)} \times f$ $2.5 \times 10^{-2} \times f$ $3.1 \times 10^{(-2)} \times f$ $5.5 \times 10^{-2} \times f$ $6.5 \times 10^{(-2)} \cdot f$ $6.8 \times 10^{(-2)} \cdot f$ $9.5 \times 10^{(-2)} \cdot f$	f = measured value
Frequency f Time base	10 MHz		$0.2 \times 10^{(-6)} \times f$	
Rise time of oscilloscopes	50 ps to 1 ms 1 ns to 1 ms	0.05 V to 1.2 V 0.1 to 3 V	$4 \text{ ps} + 5.7 \times 10^{(-3)} \times T$ $2.5 \text{ ps} + 5.8 \times 10^{-3} \times T$	
Rise time of generators, pulses	0.5 ns to < 2.5 ns 2.5 ns to 5 ms		$28 \text{ ps} + 14 \times 10^{(-3)} \cdot T$ $13 \text{ ps} + 28 \times 10^{(-3)} \cdot T$	
RF power Output power and calibration factor of RF sources	10 μW to 80 mW	DC to 50 MHz 50 MHz to 4 GHz 4 GHz to 12 GHz 12 GHz to 18 GHz	$9.5 \times 10^{(-3)} \cdot P$ $14 \times 10^{(-3)} P$ $22 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$	N-connector, 50 ohms $ r_{RG} \leq 0.035 f$ $\leq 4 \text{ GHz}$ $ r_{RG} \leq 0.056 f$ $\leq 12 \text{ GHz}$ $ r_{RG} \leq 0.075 f$ $\leq 18 \text{ GHz}$ Other connectors and reflection factors increase the measurement uncertainty
RF voltage U_{HF} sources with RF voltage display relative to 50 Ω	22 mV to 2 V	DC to 18 MHz	$W(U_{HF}) = \frac{W(P)}{2}$	$W(P)$ is the relative uncertainty of the measured power at $Z_0 = 50 \Omega$

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Matrix NM.1 Square-wave voltage

Square-wave voltage [V] \ Frequency [Hz]	0.001	0.01	0.1	0.1	0.5	1	5	10	50	100
10	3.8E-07	512.2E-9	2.44E-06	2.37E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
100	7.4E-07	814.6E-9	2.52E-06	2.46E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
1000	6.4E-06	6.4E-6	6.99E-06	6.97E-06	1.34E-05	2.4E-05	111.6E-6	251.5E-6	1.2E-3	2.3E-3
10,000	6.3E-05	63.7E-6	6.56E-05	6.56E-05	7.47E-05	8.7E-05	200.5E-6	369.5E-6	1.6E-3	3.2E-3

Matrix NM.2 Replacement leakage current

Normal resistance <i>R_N</i>	1 kΩ		10 kΩ		100 kΩ		1 MΩ		10 MΩ		100 MΩ		1 GΩ	
Nominal voltage	Current expanded measurement uncertainty <i>U</i> in μA/A										Current <i>U</i> in mA/A			
60 V	60 mA	12	6 mA	12	600 μA	12	60 μA	20	6 μA	71	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		1.1 mA		110 μA		11 μA		1.1 μA			
230 V	230 mA		23 mA		2.3 mA		230 μA		23 μA		2.3 μA			
400 V	400 mA		40 mA		4 mA		400 μA		40 μA		4.0 μA			

Matrix NM.3 AC resistance

Voltage [V] \ Current [A]	0.001 V	0.010 V	0.010 V	0.100 V	0.100 V	1.000 V	1.000 V	10.000 V	10,000 V	100,000 V
2.2 × 10 ⁻³ A	1.57E-03	4.66E-04	4.66E-04	3.00E-04	3.00E-04	2.98E-04	2.98E-04	3.00E-04	3.00E-04	3.78E-04
22 · 10 ⁻³ A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
0.22 A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
2.2 A	1.64E-03	6.78E-04	6.78E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	6.21 × 10 ⁻⁴

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Dimensional quantities

Permanent Laboratory, Nuremberg site

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Expanded measurement uncertainty	Remarks
	Measurement range / span	Measurement conditions / Methods			
Length Calipers for External, internal and depth measurements *	0 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006		$20 \mu\text{m} + 15 \times 10^{(-6)} l$	l: measured value
Micrometers *	0 mm to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001		$2 \mu\text{m} + 6 \times 10^{(-6)} l$	
Cylindrical standard rings * Diameter	1 mm to 90 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3		$0.9 \mu\text{m} + 10 \times 10^{(-6)} \times d$	d is the measured diameter
Gauge pins * Diameter	1 mm to 120 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3		$0.6 \mu\text{m} + 1.8 \times 10^{(-6)} \times d$	
Test pins * Diameter	1 mm to 120 mm	VDI/VDE/DGQ 2618 Sheet 4.2:2007 Option 1		$0.6 \mu\text{m} + 1.8 \times 10^{(-6)} \times d$	
Thread gauges * (single-start and multi-start cylindrical external and internal threads with straight flanks, a symmetrical profile, a nominal pitch and a nominal profile angle) External thread Single Flank diameter	1 mm to 120 mm	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Option 1 Three-wire method (perpendicular to the thread axis)		$2.9 \mu\text{m} + 7.7 \times 10^{(-6)} \times d$	
Internal thread Simple flank diameter		VDI/VDE/DGQ 2618 Sheet 4.9:2006 Option 1 Two-ball method (perpendicular to the thread axis)		$2.6 \mu\text{m} + 5.5 \times 10^{(-6)} \cdot d$	

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Electrical parameters

Permanent Laboratory – Steinfurt site

Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC voltage sources	0 V		120 nV	Short-circuit bridge
	0 V to 0.1 V		$4 \times 10^{-(6)} \times U + 0.36 \mu\text{V}$	$U = \text{measured value}$
	> 0.1 V to 1 V		$3.7 \times 10^{-(6)} \times U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-6} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \cdot U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	
	1050 V to 10 kV		$0.17 \times 10^{-3} \cdot U$	
DC voltage measuring instruments	0 V to 220 mV		$6 \times 10^{-(6)} \times U + 0.6 \mu\text{V}$	
	> 220 mV to 2.2 V		$5 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$	
	> 2.2 V to 11 V		$4 \times 10^{-6} \times U + 3.5 \mu\text{V}$	
	> 11 V to 22 V		$4 \times 10^{-(6)} \cdot U + 6.5 \mu\text{V}$	
	> 22 V to 220 V		$5 \times 10^{-(6)} U + 80 \mu\text{V}$	
	> 220 V to 1050 V		$7 \times 10^{-(6)} \cdot U + 0.5 \text{ mV}$	
	0 V to 0.1 V		$4 \times 10^{-(6)} \times U + 0.36 \mu\text{V}$	
	> 0.1 V to 1 V		$3.7 \times 10^{-6} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC voltage sources, measuring instruments	2 mV to 1000 V	10 Hz to 1 MHz	4.1 μV to 0.48 V	U = measured value
	2 mV to 10 mV	10 Hz to 40 Hz	$0.36 \times 10^{-3} \cdot U + 3.4 \mu\text{V}$	
		> 40 Hz to 1 kHz	$0.24 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.36 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.2 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$5.8 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$46 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
	> 10 mV to 100 mV	10 Hz to 40 Hz	$86 \times 10^{-6} \cdot U + 4.6 \mu\text{V}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 2.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.93 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
	> 100 mV to 1 V	> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
		10 Hz to 40 Hz	$83 \times 10^{-6} \cdot U + 46 \mu\text{V}$	
		> 40 Hz to 1 kHz	$82 \times 10^{-6} \cdot U + 23 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.16 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
	> 1 V to 10 V	> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 0.12 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 0.12 \text{ mV}$	
		10 Hz to 40 Hz	$85 \times 10^{-6} \cdot U + 0.46 \text{ mV}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 0.23 \text{ mV}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
	> 10 V to 100 V	> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
10 Hz to 40 Hz		$0.23 \times 10^{-3} \cdot U + 4.6 \text{ mV}$		
> 40 Hz to 1 kHz		$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
> 1 kHz to 20 kHz		$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
> 100 V to 1000 V	> 20 kHz to 50 kHz	$0.41 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	> 50 kHz to 100 kHz	$1.4 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
> 100 V to 1000 V	50 Hz to 1 kHz	$0.46 \times 10^{-3} \cdot U + 16 \text{ mV}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	1 mV to 1100 V	10 Hz to 1 MHz	5 µV to 81 mV	U = measured value
	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \times U + 4.5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 4.5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 2.2 mV to 22 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \times U + 12 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 22 mV to 220 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 8 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.28 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 35 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 80 \mu\text{V}$	
	> 220 mV to 2.2 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 80 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 6 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 16 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 70 \mu\text{V}$	
		> 100 kHz to 300 kHz	$0.39 \times 10^{-3} \cdot U + 0.13 \text{ mV}$	
		> 300 kHz to 500 kHz	$0.95 \times 10^{-3} \times U + 0.35 \text{ mV}$	
		> 500 kHz to 1 MHz	$1.9 \times 10^{-3} \cdot U + 0.85 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	> 2.2 V to 22 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 0.8 \text{ mV}$	$U = \text{measured value}$
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 0.25 \text{ mV}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 60 \text{ } \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 0.16 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
		> 100 kHz to 300 kHz	$0.45 \times 10^{-3} \cdot U + 1.5 \text{ mV}$	
		> 300 kHz to 500 kHz	$1.2 \times 10^{-3} \times U + 4.3 \text{ mV}$	
		> 500 kHz to 1 MHz	$2.5 \times 10^{-3} \cdot U + 8.5 \text{ mV}$	
	> 22 V to 220 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 2.5 \text{ mV}$	
		> 40 Hz to 20 kHz	$70 \times 10^{-6} \cdot U + 0.8 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.19 \times 10^{-3} \cdot U + 3.5 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.45 \times 10^{-3} \times U + 8 \text{ mV}$	
	> 220 V to 1100 V	15 Hz to 50 Hz	$0.36 \times 10^{-3} \cdot U + 16 \text{ mV}$	
		> 50 Hz to 1 kHz	$70 \times 10^{-6} \cdot U + 3.5 \text{ mV}$	
1 mV to 220 V	1 Hz to 10 kHz square-wave voltage	$0.38 \text{ } \mu\text{V}$ to 3.2 mV See Matrix SM.1		
Sources	1100 V to 10 kV	45 Hz to 55 Hz	$0.46 \times 10^{(-3)} \times U$	$U = \text{measured value}$

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current measuring instruments, sources	0 mA to 220 µA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	I = measured value
	> 220 µA to 2.2 mA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	
	> 2.2 mA to 22 mA		$40 \times 10^{(-6)} \times I + 80 \text{ nA}$	
	> 22 mA to 100 mA		$50 \cdot 10^{(-6)} \cdot I + 0.8 \text{ µA}$	
	> 100 mA to 220 mA		$50 \times 10^{(-6)} \cdot I + 200 \times 10^{(-6)} \cdot I^2 + 0.8 \text{ µA}$	
	> 220 mA to 1 A		$65 \times 10^{(-6)} \cdot I + 25 \text{ µA}$	
	> 1 A to 2.2 A		$65 \times 10^{(-6)} \times I + 10 \times 10^{(-6)} \times I^2 + 25 \text{ µA}$	
	> 2.2 A to 3 A		$0.38 \times 10^{(-3)} \times I + 40 \text{ µA}$	
	> 3 A to 10.1 A		$0.5 \times 10^{(-3)} \times I + 0.5 \text{ mA}$	
	> 10.1 A to 20.5 A		$1 \times 10^{(-3)} \times I + 0.75 \text{ mA}$	
	0 pA to 1 pA		1 pA	
	> 1 pA to 100 nA		$35 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 100 nA to 1 µA		$23 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 1 µA to 10 µA		$23 \cdot 10^{(-6)} \cdot I + 0.12 \text{ nA}$	
	> 10 µA to 100 µA		$23 \times 10^{(-6)} \cdot I + 0.92 \text{ nA}$	
	> 100 µA to 1 mA		$23 \times 10^{(-6)} \times I + 6 \text{ nA}$	
	> 1 mA to 10 mA		$23 \times 10^{(-6)} \times I + 58 \text{ nA}$	
	> 10 mA to 100 mA		$41 \times 10^{(-6)} \cdot I + 580 \text{ nA}$	
	> 100 mA to 1 A		$0.13 \times 10^{(-3)} \cdot I + 12 \text{ µA}$	
	1 A to 400 A		$0.21 \times 10^{(-3)} \times I$	
Direct current Current clamps and current transformers	1 mA – – –1100 A	1 to N windings	$3 \times 10^{(-3)} \times I$	

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current measuring instruments, sources	10 μ A to 20.5 A	10 Hz to 10 kHz	25 nA to 0.62 A	I = measured value
	0.01 mA to 0.22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \times I + 25$ nA	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \times I + 16$ nA	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40$ nA	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80$ nA	
	> 0.22 mA to 2.2 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 40$ nA	
		> 40 Hz to 1 kHz	$0.1, 2 \times 10^{-4} \times I + 35$ nA	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 0.4$ μ A	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 0.8$ μ A	
	> 2.2 mA to 22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 0.4$ μ A	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 0.35$ μ A	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 4$ μ A	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \times I + 8$ μ A	
	> 22 mA to 220 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 4$ μ A	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 3.5$ μ A	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40$ μ A	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80$ μ A	
	> 220 mA to 2.2 A	20 Hz to 1 kHz	$0.55 \times 10^{-3} \times I + 35$ μ A	
		> 1 kHz to 5 kHz	$0.65 \times 10^{-3} \cdot I + 80$ μ A	
		> 5 kHz to 10 kHz	$0.75 \times 10^{-3} \cdot I + 0.16$ mA	
> 2.2 A to 3 A	10 Hz to 45 Hz	$1.8 \times 10^{-3} \cdot I + 0.1$ mA		
	> 45 Hz to 1 kHz	$0.6 \times 10^{-3} \cdot I + 0.1$ mA		
> 3 A to 11 A	45 Hz to 100 Hz	$0.6 \times 10^{-3} \times I + 2$ mA		
	> 100 Hz to 1 kHz	$1.0 \times 10^{-3} \times I + 2$ mA		
> 11 A to 20.5 A	45 Hz to 100 Hz	$1.2 \times 10^{-3} \cdot I + 5$ mA		
	> 100 Hz to 1 kHz	$1.5 \times 10^{-3} \cdot I + 5$ mA		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	5 µA to 1 A	20 Hz to 5 kHz	35 nA to 13 mA	I = measured value
	5 µA to 100 µA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \times I + 35 \text{ nA}$	
		> 45 Hz to 1 kHz	$0.76 \times 10^{-3} \times I + 34 \text{ nA}$	
	> 100 µA to 1 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 0.23 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 0.23 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 0.2 \text{ µA}$	
	> 1 mA to 10 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 2.3 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \times I + 2.3 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 2 \text{ µA}$	
	> 10 mA to 100 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 23 \text{ µA}$	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 23 \text{ µA}$	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \times I + 20 \text{ µA}$	
	> 100 mA to 1 A	20 Hz to 45 Hz	$1.8 \times 10^{-3} \times I + 0.23 \text{ mA}$	
		> 45 Hz to 100 Hz	$0.83 \times 10^{-3} \times I + 0.33 \text{ mA}$	
		> 100 Hz to 5 kHz	$1.6 \times 10^{-3} \cdot I + 0.21 \text{ mA}$	
Alternating current sources, measuring instruments	10 mA to 500 A		3 µA to 0.2 A	I = measured value
	10 mA to 1 A	40 Hz to 1 kHz	$0.32 \times 10^{-3} \times I$	
	> 1 A to 100 A		$0.69 \times 10^{-3} \cdot I$	
	> 100 A to 450 A		$0.9 \times 10^{-3} \times I$	
Current clamps and current transformers	1 mA – – – 1100 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/N	$4 \times 10^{-3} \cdot I$	I = measured value
Equivalent current	0.2 µA to 200 mA	at R_N up to 1 GΩ DC up to 60 Hz	$17 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ See Matrix SM.2	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC resistance Fixed values	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value
		4-wire short circuit	0.35 μΩ	
	100 μΩ 1 mΩ 10 mΩ 100 mΩ		0.45 × 10 ^{^(-3)} × R 0.17 × 10 ^{^(-3)} × R 0.17 × 10 ^{^(-3)} × R 0.10 × 10 ^{^-3} × R	Intermediate values increase the measurement uncertainty
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ;		40 × 10 ^{^(-6)} · R 23 × 10 ^{^(-6)} · R 14 × 10 ^{^(-6)} · R 10 × 10 ^{^(-6)} · R 9.5 × 10 ^{^(-6)} · R 11 · 10 ^{^-6} · R 15 · 10 ^{^-6} · R 31 · 10 ^{^-6} · R 100 · 10 ^{^-6} · R	
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ; 1 GΩ		76 × 10 ^{^(-6)} · R 20 × 10 ^{^(-6)} · R 17 × 10 ^{^(-6)} · R 10 × 10 ^{^(-6)} · R 10 × 10 ^{^(-6)} · R 13 · 10 ^{^-6} · R 19 · 10 ^{^-6} · R 70 · 10 ^{^-6} · R 0.59 × 10 ^{^-3} · R 5.9 × 10 ^{^-3} · R	
Measuring instruments	0 to < 11 Ω 11 Ω to < 110 Ω 110 Ω to < 110 kΩ 110 kΩ to < 1.1 MΩ 1.1 MΩ to < 3.3 MΩ 3.3 MΩ to < 11 MΩ 11 MΩ to < 33 MΩ 33 MΩ to < 110 MΩ 110 MΩ to < 330 MΩ 330 MΩ to < 1.1 GΩ		40 × 10 ^{^(-6)} · R 35 × 10 ^{^(-6)} · R 28 × 10 ^{^(-6)} · R 32 × 10 ^{^(-6)} · R 60 × 10 ^{^(-6)} · R 0.13 × 10 ^{^-3} · R 0.25 × 10 ^{^(-3)} · R 0.5 × 10 ^{^-3} · R 3 × 10 ^{^(-3)} · R 15 × 10 ^{^(-3)} · R	
AC resistance (magnitude of impedance)	500 μΩ to 45 kΩ	10 Hz to 10 kHz	$\sqrt{U_I^2 + U_U^2} \cdot R$ 0.17 × 10 ^{^(-3)} × R to 1.7 × 10 ^{^(-3)} · R See matrix SM.3	R = measured value u _I is the relative uncertainty of the calibration current u _U is the relative uncertainty of the measured voltage across the resistor

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Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Inductance fixed values	0 µH	2-wire short-circuit	0.03 µH	L = measured value Impedance range: 50 mΩ ≤ Z ≤ 11 kΩ
	100 µH	100 Hz	$0.54 \times 10^{(-3)} \times L$	
		1 kHz	$0.28 \times 10^{(-3)} \cdot L$	
		10 kHz	$0.29 \times 10^{(-3)} \cdot L$	
	1 mH	100 Hz	$0.14 \times 10^{(-3)} \times L$	
		1 kHz	$0.14 \times 10^{(-3)} \times L$	
10 mH	100 Hz; 1 kHz; 10 kHz	$0.13 \times 10^{(-3)} L$ $0.16 \times 10^{(-3)} \cdot L$		
100 mH	100 Hz; 1 kHz 10 kHz	$0.13 \times 10^{(-3)} L$ $0.28 \times 10^{(-3)} \cdot L$		
1 H	100 Hz, 1 kHz	$0.20 \times 10^{(-3)} \times L$		
Capacitance fixed values	0 pF		0.2 pF	No-load
	1 pF	1 kHz	$0.63 \times 10^{(-3)} C$	C = measured value Absolute value of impedance 1 Ω ≤ Z ≤ 110 MΩ
		10 kHz	$0.31 \times 10^{(-3)} C$	
	10 pF	1 kHz	$42 \times 10^{(-6)} C$	
		10 kHz;	$53 \times 10^{(-6)} \text{ } ^\circ C$	
		100 kHz	$88 \times 10^{(-6)} \text{ } ^\circ C$	
		1 MHz	$0.24 \times 10^{(-3)} C$	
	100 pF	1 kHz	$39 \times 10^{(-6)} C$	
1 nF	1 kHz	$71 \times 10^{(-6)} C$		
	100 kHz	$0.13 \times 10^{(-3)} C$		
10 nF	100 Hz	$0.49 \times 10^{(-3)} C$		
	1 kHz	$0.21 \times 10^{(-3)} C$		
	10 kHz	$0.23 \times 10^{(-3)} C$		
100 nF	100 Hz;	$0.21 \times 10^{(-3)} C$		
	1 kHz;	$0.20 \times 10^{(-3)} C$		
	10 kHz	$0.17 \times 10^{(-3)} C$		
1 µF	100 Hz; 1 kHz	$0.29 \times 10^{(-3)} C$ $0.13 \times 10^{(-3)} C$		
	10 kHz	$0.29 \times 10^{(-3)} \text{ } ^\circ C$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Direct current power measuring instruments	0 W to 21 kW	0 mV to 1020 V 0 μA to 20.5 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ $0.21 \times 10^{-3} \cdot P$ to $0.70 \times 10^{-3} \cdot P$	P = measured value
with clamp connection	0 W to 300 kW	0 V to 330 V 0 mA to 1000 A	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.2 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding.
Active AC power measuring instruments	0.11 mW to 21 kW	$PF = 1$; 45 Hz to 65 Hz 33 mV to 1020 V 3.3 mA to 20 A	$0.7 \times 10^{-3} \times P$ to $1.4 \times 10^{-3} \times P$	P = measured value PF = power factor (capacitive or inductive)
	15 W; 60 W; 100 W; 400 W; 500 W; 1 kW; 2 kW; 4 kW	$PF = 1$; 45 Hz to 65 Hz 50 V; 200 V 0.3 A; 2 A; 10 A; 20 A	$0.16 \times 10^{-3} \times P$	
	1.5 W; 6 W	30 mA;	$0.26 \times 10^{-3} \times P$	
	2.3 W to 20.6 kW	45 Hz to 65 Hz; $PF = 1$ 23 V to 1020 V 30 mA to 20.5 A	$0.32 \times 10^{-3} \times P$ to $0.48 \times 10^{-3} \times P$	
	220 W	45 Hz to 65 Hz 220 V; 1 A $PF = 1$	$0.16 \times 10^{-3} \times P$	
	198 W	$PF = 0.9$	$0.18 \times 10^{-3} \times P$	
	110 W	$PF = 0.5$	$0.29 \times 10^{-3} \times P$	
	22 W	$PF = 0.1$	$1.4 \times 10^{-3} \times P$	
	11 W	$PF = 0.05$	$2.7 \times 10^{-3} \times P$	
	10 W to 1 kW	33 V to 330 V 330 mA to < 3 A 45 Hz to 65 Hz $0.05 \leq PF < 1$ Inductive, capacitive	0.22 W	
with clamp connection	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \leq PF \leq 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.4 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding. The relative uncertainty of the measurement object W_{DUT} in the measurement circuit and in the stray field of the current-carrying conductor must be taken into account.
Power factor	0. to 0. .04	33 V to 330 V	0.15×10^{-3}	
	> 0.4 to < 1	330 mA to 2.2 A 45 Hz to 65 Hz	$-60 \times 10^{-6} \times P + 0.16 \times 10^{-3}$	
	1		89×10^{-6}	
AC reactive power Meters	0 var to 1 kvar	45 Hz to 65 Hz	$U_P \cdot \text{var}/W$	U_P is the uncertainty of active power

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Frequency f Measurement and synthesis	0.01 Hz to 18 GHz		$0.5 \times 10^{-9} \cdot f + U_{TF}$	U_{TF} : Trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 2 ns to 100 s 1 s to 100 h		1.2 ns $1.5 \times 10^{(-6)} \times \Delta t + 50 \text{ ps}$ $14 \times 10^{(-6)} \cdot \Delta t + U_{TF}$	
Rotational speed	0.02 s^{-1} to 18000 s^{-1}		$3.7 \times 10^{(-6)} \cdot f$	
Oscilloscope vertical	0 V to 5 V 5 V 130 V	DC to 10 kHz	$1.1 \times 10^{(-3)} \cdot U + 66 \mu\text{V}$ $1.2 \times 10^{(-3)} \cdot U + 44 \mu\text{V}$	U : measured value
Oscilloscope horizontal	1 ns to < 100 ns 100 ns to 20 ms > 20 ms to 5 s		$0.6 \times 10^{(-6)} \times T + 60 \text{ fs}$ $3.1 \times 10^{(-6)} \times T + 11 \text{ fs}$ $1.2 \times 10^{(-3)} \times T^2 + 29 \times 10^{(-6)} \times T$	T = measured value
Oscilloscope bandwidth f (frequency response)	50 kHz > 50 kHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 600 MHz > 600 MHz to 1.1 GHz > 1.1 GHz to 2 GHz > 2 GHz to 4 GHz		$3.3 \times 10^{(-2)} \times f$ $2.5 \times 10^{-2} \times f$ $3.1 \times 10^{(-2)} \times f$ $5.5 \times 10^{-2} \times f$ $6.5 \times 10^{(-2)} \cdot f$ $6.8 \times 10^{(-2)} \cdot f$ $9.5 \times 10^{(-2)} \cdot f$	f = measured value
Frequency f Time base	10 MHz		$0.2 \times 10^{(-6)} \times f$	
Rise time of oscilloscopes	50 ps to 1 ms 1 ns to 1 ms	0.05 V to 1.2 V 0.1 to 3 V	$4 \text{ ps} + 5.7 \times 10^{(-3)} \times T$ $2.5 \text{ ps} + 5.8 \times 10^{(-3)} \times T$	
Rise time of generators, pulses	0.5 ns to < 2.5 ns 2.5 ns to 5 ms		$28 \text{ ps} + 14 \times 10^{(-3)} \cdot T$ $13 \text{ ps} + 28 \times 10^{(-3)} \cdot T$	
RF power Output power and calibration factor of RF sources	10 μW to 80 mW	DC to 50 MHz 50 MHz to 4 GHz 4 GHz to 12 GHz 12 GHz to 18 GHz	$9.5 \times 10^{(-3)} \cdot P$ $14 \times 10^{(-3)} \cdot P$ $22 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$	N-connector, 50 ohms $ r_{RG} \leq 0.035$ f $\leq 4 \text{ GHz}$ $ r_{RG} \leq 0.056$ f $\leq 12 \text{ GHz}$ $ r_{RG} \leq 0.075$ f $\leq 18 \text{ GHz}$ Other connectors and reflection factors increase the measurement uncertainty
RF voltage U_{HF} sources with RF voltage display relative to 50 Ω	22 mV to 2 V	DC to 18 MHz	$W(U_{HF}) = \frac{W(P)}{2}$	$W(P)$ is the relative uncertainty of the measured power at $Z_0 = 50 \Omega$

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Matrix SM.1 Square-wave voltage

Square-wave voltage [V] \ Frequency [Hz]	0.001	0.01	0.1	0.1	0.5	1	5	10	50	100
10	3.8E-07	512.2E-9	2.44E-06	2.37E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
100	7.4E-07	814.6E-9	2.52E-06	2.46E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
1000	6.4E-06	6.4E-6	6.99E-06	6.97E-06	1.34E-05	2.4E-05	111.6E-6	251.5E-6	1.2E-3	2.3E-3
10,000	6.3E-05	63.7E-6	6.56E-05	6.56E-05	7.47E-05	8.7E-05	200.5E-6	369.5E-6	1.6E-3	3.2E-3

Matrix SM.2 Replacement leakage current

Normal resistance R_N	1 kΩ		10 kΩ		100 kΩ		1 MΩ		10 MΩ		100 MΩ		1 GΩ	
Nominal voltage	Current expanded measurement uncertainty U in μA/A										Current U in mA/A			
60 V	60 mA	12	6 mA	12	600 μA	12	60 μA	20	6 μA	71	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		1.1 mA		110 μA		11 μA		1.1 μA		110 nA	
230 V	230 mA		23 mA		2.3 mA		230 μA		23 μA		2.3 μA		230 nA	
400 V	400 mA		40 mA		4 mA		400 μA		40 μA		4.0 μA		400 nA	

Matrix SM.3 AC resistance

Voltage [V] \ Current [A]	0.001 V	0.010 V	0.010 V	0.100 V	0.100 V	1.000 V	1.000 V	10.000 V	10,000 V	100,000 V
2.2×10^{-3} A	1.57E-03	4.66E-04	4.66E-04	3.00E-04	3.00E-04	2.98E-04	2.98E-04	3.00E-04	3.00E-04	3.78E-04
$22 \cdot 10^{-3}$ A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
0.22 A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
2.2 A	1.64E-03	6.78E-04	6.78E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	6.21E-04

Dimensional quantities

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
Length Calipers for external, internal and depth measurements *	0 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	$20 \mu\text{m} + 15 \times 10^{(-6)} \times l$	l : measured value
Micrometers *	0 mm to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	$2 \mu\text{m} + 6 \times 10^{(-6)} \times l$	

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Electrical quantities

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Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
DC voltage sources	0 V		120 nV	Short-circuit bridge
	0 V to 0.1 V		$4 \times 10^{-(6)} \times U + 0.36 \mu\text{V}$	U = measured value
	> 0.1 V to 1 V		$3.7 \times 10^{-6} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \cdot U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	
	1050 V to 10 kV		$0.17 \times 10^{-3} \cdot U$	
DC voltage measuring instruments	0 V to 220 mV		$6 \times 10^{-6} \times U + 0.6 \mu\text{V}$	U = measured value
	> 220 mV to 2.2 V		$5 \times 10^{-(6)} \times U + 1 \mu\text{V}$	
	> 2.2 V to 11 V		$4 \times 10^{-(6)} U + 3.5 \mu\text{V}$	
	> 11 V to 22 V		$4 \times 10^{-(6)} \cdot U + 6.5 \mu\text{V}$	
	> 22 V to 220 V		$5 \times 10^{-(6)} U + 80 \mu\text{V}$	
	> 220 V to 1050 V		$7 \times 10^{-(6)} \cdot U + 0.5 \text{ mV}$	
	0 V to 0.1 V		$4 \times 10^{-6} \times U + 0.36 \mu\text{V}$	
	> 0.1 V to 1 V		$3.7 \times 10^{-(6)} \cdot U + 0.35 \mu\text{V}$	
	> 1 V to 10 V		$3.2 \times 10^{-(6)} \times U + 0.56 \mu\text{V}$	
	> 10 V to 100 V		$5.3 \times 10^{-(6)} \times U + 34 \mu\text{V}$	
	> 100 V to 500 V		$9.6 \times 10^{-(6)} U - 0.34 \text{ mV}$	
	> 500 V to 1050 V		$30 \times 10^{-(6)} U - 10 \text{ mV}$	

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC voltage sources, measuring instruments	2 mV to 1000 V	10 Hz to 1 MHz	4.1 μV to 0.48 V	U = measured value
	2 mV to 10 mV	10 Hz to 40 Hz	$0.36 \times 10^{-3} \times U + 3.4 \mu\text{V}$	
		> 40 Hz to 1 kHz	$0.24 \times 10^{-3} \times U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.36 \times 10^{-3} \times U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.2 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$5.8 \times 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$46 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
	> 10 mV to 100 mV	10 Hz to 40 Hz	$86 \times 10^{-6} \cdot U + 4.6 \mu\text{V}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 2.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.93 \times 10^{-3} \cdot U + 2.3 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 12 \mu\text{V}$	
	> 100 mV to 1 V	> 300 kHz to 1 MHz	$12 \times 10^{-3} \times U + 12 \mu\text{V}$	
		10 Hz to 40 Hz	$83 \times 10^{-6} \cdot U + 46 \mu\text{V}$	
		> 40 Hz to 1 kHz	$82 \times 10^{-6} \cdot U + 23 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.16 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 23 \mu\text{V}$	
	> 1 V to 10 V	> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \times U + 0.12 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \times U + 0.12 \text{ mV}$	
		10 Hz to 40 Hz	$85 \times 10^{-6} \cdot U + 0.46 \text{ mV}$	
		> 40 Hz to 1 kHz	$87 \times 10^{-6} \cdot U + 0.23 \text{ mV}$	
		> 1 kHz to 20 kHz	$0.17 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.35 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
	> 10 V to 100 V	> 50 kHz to 100 kHz	$0.92 \times 10^{-3} \cdot U + 0.23 \text{ mV}$	
		> 100 kHz to 300 kHz	$3.5 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
		> 300 kHz to 1 MHz	$12 \times 10^{-3} \cdot U + 1.2 \text{ mV}$	
		10 Hz to 40 Hz	$0.23 \times 10^{-3} \cdot U + 4.6 \text{ mV}$	
		> 40 Hz to 1 kHz	$0.23 \times 10^{-3} \cdot U + 2.3 \text{ mV}$	
> 100 V to 1000 V	> 1 kHz to 20 kHz	$0.23 \times 10^{-3} \times U + 2.3 \text{ mV}$		
	> 20 kHz to 50 kHz	$0.41 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	> 50 kHz to 100 kHz	$1.4 \times 10^{-3} \cdot U + 2.3 \text{ mV}$		
	50 Hz to 1 kHz	$0.46 \times 10^{-3} \cdot U + 16 \text{ mV}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	1 mV to 1100 V	10 Hz to 1 MHz	5 μ V to 81 mV	U = measured value
	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \times U + 4.5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 4.5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 4.5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 2.2 mV to 22 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 5 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.33 \times 10^{-3} \cdot U + 5 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 7 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \times U + 12 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
	> 22 mV to 220 mV	10 Hz to 20 Hz	$0.5 \times 10^{-3} \cdot U + 13 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.19 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 40 Hz to 20 kHz	$95 \times 10^{-6} \cdot U + 8 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.28 \times 10^{-3} \cdot U + 8 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.75 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 100 kHz to 300 kHz	$1 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 300 kHz to 500 kHz	$1.5 \times 10^{-3} \cdot U + 35 \mu\text{V}$	
		> 500 kHz to 1 MHz	$3.1 \times 10^{-3} \cdot U + 80 \mu\text{V}$	
	> 220 mV to 2.2 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 80 \mu\text{V}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 25 \mu\text{V}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 6 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 16 \mu\text{V}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 70 \mu\text{V}$	
		> 100 kHz to 300 kHz	$0.39 \times 10^{-3} \cdot U + 0.13 \text{ mV}$	
		> 300 kHz to 500 kHz	$0.95 \times 10^{-3} \times U + 0.35 \text{ mV}$	
> 500 kHz to 1 MHz		$1.9 \times 10^{-3} \cdot U + 0.85 \text{ mV}$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage measuring instruments, sources	> 2.2 V to 22 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \times U + 0.8 \text{ mV}$	$U =$ measured value
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 0.25 \text{ mV}$	
		> 40 Hz to 20 kHz	$65 \times 10^{-6} \cdot U + 60 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.11 \times 10^{-3} \cdot U + 0.16 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.21 \times 10^{-3} \cdot U + 0.35 \text{ mV}$	
		> 100 kHz to 300 kHz	$0.45 \times 10^{-3} \cdot U + 1.5 \text{ mV}$	
		> 300 kHz to 500 kHz	$1.2 \times 10^{-3} \cdot U + 4.3 \text{ mV}$	
		> 500 kHz to 1 MHz	$2.5 \times 10^{-3} \cdot U + 8.5 \text{ mV}$	
	> 22 V to 220 V	10 Hz to 20 Hz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
		> 20 Hz to 40 Hz	$0.14 \times 10^{-3} \cdot U + 2.5 \text{ mV}$	
		> 40 Hz to 20 kHz	$70 \times 10^{-6} \cdot U + 0.8 \text{ mV}$	
		> 20 kHz to 50 kHz	$0.19 \times 10^{-3} \cdot U + 3.5 \text{ mV}$	
		> 50 kHz to 100 kHz	$0.45 \times 10^{-3} \cdot U + 8 \text{ mV}$	
	> 220 V to 1100 V	15 Hz to 50 Hz	$0.36 \times 10^{-3} \cdot U + 16 \text{ mV}$	
		> 50 Hz to 1 kHz	$70 \times 10^{-6} \cdot U + 3.5 \text{ mV}$	
1 mV to 220 V	1 Hz to 10 kHz square-wave voltage	$0.38 \mu\text{V to } 3.2 \text{ mV}$ See Matrix WM.1		
Sources	1 kV to 10 kV	45 Hz to 55 Hz	$0.46 \times 10^{(-3)} \times U$	$U =$ measured value

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Direct current measuring instruments, sources	0 mA to 220 µA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	I = measured value
	> 220 µA to 2.2 mA		$40 \times 10^{(-6)} \times I + 8 \text{ nA}$	
	> 2.2 mA to 22 mA		$40 \times 10^{(-6)} \times I + 80 \text{ nA}$	
	> 22 mA to 100 mA		$50 \cdot 10^{(-6)} \cdot I + 0.8 \text{ µA}$	
	> 100 mA to 220 mA		$50 \times 10^{(-6)} \cdot I + 200 \times 10^{(-6)} \cdot I^2 + 0.8 \text{ µA}$	
	> 220 mA to 1 A		$65 \times 10^{(-6)} \cdot I + 25 \text{ µA}$	
	> 1 A to 2.2 A		$65 \times 10^{(-6)} \times I + 10 \times 10^{(-6)} \times I^2 + 25 \text{ µA}$	
	> 2.2 A to 3 A		$0.38 \times 10^{(-3)} \times I + 40 \text{ µA}$	
	> 3 A to 10.1 A		$0.5 \times 10^{(-3)} \times I + 0.5 \text{ mA}$	
	> 10.1 A to 20.5 A		$1 \times 10^{(-3)} \times I + 0.75 \text{ mA}$	
	0 pA to 1 pA		1 pA	
	> 1 pA to 100 nA		$35 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 100 nA to 1 µA		$23 \times 10^{(-6)} \cdot I + 46 \text{ pA}$	
	> 1 µA to 10 µA		$23 \cdot 10^{(-6)} \cdot I + 0.12 \text{ nA}$	
	> 10 µA to 100 µA		$23 \times 10^{(-6)} \cdot I + 0.92 \text{ nA}$	
	> 100 µA to 1 mA		$23 \times 10^{(-6)} \times I + 6 \text{ nA}$	
	> 1 mA to 10 mA		$23 \times 10^{(-6)} \times I + 58 \text{ nA}$	
	> 10 mA to 100 mA		$41 \times 10^{(-6)} \cdot I + 580 \text{ nA}$	
	> 100 mA to 1 A		$0.13 \times 10^{(-3)} \cdot I + 12 \text{ µA}$	
	1 A to 400 A		$0.21 \times 10^{(-3)} \times I$	
Direct current Current clamps and current transformers	1 mA – – –1100 A	1 to N windings	$3 \times 10^{(-3)} \times I$	

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Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current measuring instruments, sources	10 µA to 20.5 A	10 Hz to 10 kHz	25 nA to 0.62 A	I = measured value
	0.01 mA to 0.22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \times I + 25 \text{ nA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \times I + 16 \text{ nA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40 \text{ nA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 80 \text{ nA}$	
	> 0.22 mA to 2.2 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \times I + 40 \text{ nA}$	
		> 40 Hz to 1 kHz	$0.1, 2 \times 10^{-4} \cdot I + 35 \text{ nA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \cdot I + 0.4 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \cdot I + 0.8 \text{ µA}$	
	> 2.2 mA to 22 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 0.4 \text{ µA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 0.35 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 4 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \times I + 8 \text{ µA}$	
	> 22 mA to 220 mA	10 Hz to 40 Hz	$0.6 \times 10^{-3} \cdot I + 4 \text{ µA}$	
		> 40 Hz to 1 kHz	$0.12 \times 10^{-3} \cdot I + 3.5 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.5 \times 10^{-3} \times I + 40 \text{ µA}$	
		> 5 kHz to 10 kHz	$1.4 \times 10^{-3} \times I + 80 \text{ µA}$	
	> 220 mA to 2.2 A	20 Hz to 1 kHz	$0.55 \times 10^{-3} \cdot I + 35 \text{ µA}$	
		> 1 kHz to 5 kHz	$0.65 \times 10^{-3} \cdot I + 80 \text{ µA}$	
		> 5 kHz to 10 kHz	$0.75 \times 10^{-3} \times I + 0.16 \text{ mA}$	
> 2.2 A to 3 A	10 Hz to 45 Hz	$1.8 \times 10^{-3} \cdot I + 0.1 \text{ mA}$		
	> 45 Hz to 1 kHz	$0.6 \times 10^{-3} \times I + 0.1 \text{ mA}$		
> 3 A to 11 A	45 Hz to 100 Hz	$0.6 \times 10^{-3} \times I + 2 \text{ mA}$		
	> 100 Hz to 1 kHz	$1.0 \times 10^{-3} \cdot I + 2 \text{ mA}$		
> 11 A to 20.5 A	45 Hz to 100 Hz	$1.2 \times 10^{-3} \cdot I + 5 \text{ mA}$		
	> 100 Hz to 1 kHz	$1.5 \times 10^{-3} \cdot I + 5 \text{ mA}$		

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	5 μ A to 1 A	20 Hz to 5 kHz	35 nA to 13 mA	I = measured value
	5 μ A to 100 μ A	20 Hz to 45 Hz	$1.7 \times 10^{-3} \times I + 35$ nA	
		> 45 Hz to 1 kHz	$0.76 \times 10^{-3} \times I + 34$ nA	
	> 100 μ A to 1 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 0.23$ μ A	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 0.23$ μ A	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 0.2$ μ A	
	> 1 mA to 10 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 2.3$ μ A	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \times I + 2.3$ μ A	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \cdot I + 2$ μ A	
	> 10 mA to 100 mA	20 Hz to 45 Hz	$1.7 \times 10^{-3} \cdot I + 23$ μ A	
		> 45 Hz to 100 Hz	$0.71 \times 10^{-3} \cdot I + 23$ μ A	
		> 100 Hz to 5 kHz	$0.73 \times 10^{-3} \times I + 20$ μ A	
	> 100 mA to 1 A	20 Hz to 45 Hz	$1.8 \times 10^{-3} \times I + 0.23$ mA	
		> 45 Hz to 100 Hz	$0.83 \times 10^{-3} \times I + 0.33$ mA	
		> 100 Hz to 5 kHz	$1.6 \times 10^{-3} \cdot I + 0.21$ mA	
Alternating current sources, measuring instruments	10 mA to 500 A		3 μ A to 0.2 A	I = measured value
	10 mA to 1 A	40 Hz to 1 kHz	$0.32 \times 10^{-3} \times I$	
	> 1 A to 100 A		$0.69 \times 10^{-3} \cdot I$	
	> 100 A to 450 A		$0.9 \times 10^{-3} \times I$	
Current clamps and current transformers	1 mA – – – 1100 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/N	$4 \times 10^{-3} \cdot I$	I = measured value
Equivalent current	0.2 μ A to 200 mA	at R_N up to 1 G Ω DC up to 60 Hz	$17 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ See Matrix WM.2	

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Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC resistance Fixed values	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value
		4-wire short circuit	0.35 μΩ	
	100 μΩ 1 mΩ 10 mΩ 100 mΩ		0.45 × 10 ^{Λ(-3)} × R 0.17 × 10 ^{Λ(-3)} × R 0.17 × 10 ^{Λ(-3)} × R 0.10 × 10 ⁻³ × R	Intermediate values increase the measurement uncertainty
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ;		40 × 10 ^{Λ(-6)} · R 23 × 10 ^{Λ(-6)} · R 14 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 9.5 × 10 ^{Λ(-6)} · R 11 · 10 ⁻⁶ · R 15 · 10 ⁻⁶ · R 31 · 10 ⁻⁶ · R 100 · 10 ⁻⁶ · R	
	1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ; 1 GΩ		76 × 10 ^{Λ(-6)} · R 20 × 10 ^{Λ(-6)} · R 17 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 10 × 10 ^{Λ(-6)} · R 13 · 10 ⁻⁶ · R 19 · 10 ⁻⁶ · R 70 · 10 ⁻⁶ · R 0.59 × 10 ⁻³ · R 5.9 × 10 ⁻³ · R	
Measuring instruments	0 to < 11 Ω 11 Ω to < 110 Ω 110 Ω to < 110 kΩ 110 kΩ to < 1.1 MΩ 1.1 MΩ to < 3.3 MΩ 3.3 MΩ to < 11 MΩ 11 MΩ to < 33 MΩ 33 MΩ to < 110 MΩ 110 MΩ to < 330 MΩ 330 MΩ to < 1.1 GΩ		40 × 10 ^{Λ(-6)} · R 35 × 10 ^{Λ(-6)} · R 28 × 10 ^{Λ(-6)} · R 32 × 10 ^{Λ(-6)} · R 60 × 10 ^{Λ(-6)} · R 0.13 × 10 ⁻³ × R 0.25 × 10 ^{Λ(-3)} · R 0.5 × 10 ^{Λ(-3)} · R 3 × 10 ^{Λ(-3)} · R 15 × 10 ^{Λ(-3)} · R	
AC resistance (magnitude of impedance)	500 μΩ to 45 kΩ	10 Hz to 10 kHz	$\sqrt{U_I^2 + U_U^2} \cdot R$ 0.17 × 10 ^{Λ(-3)} × R to 1.7 × 10 ^{Λ(-3)} · R See matrix WM.3	R = measured value u _I is the relative uncertainty of the calibration current u _U is the relative uncertainty of the measured voltage across the resistor

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
Inductance Fixed values	0 µH	2-wire short-circuit	0.03 µH	L = measured value Impedance range: 50 mΩ ≤ Z ≤ 11 kΩ
	100 µH	100 Hz	$0.54 \times 10^{(-3)} \times L$	
		1 kHz	$0.28 \times 10^{(-3)} \cdot L$	
		10 kHz	$0.29 \times 10^{(-3)} \cdot L$	
	1 mH	100 Hz	$0.14 \times 10^{(-3)} \times L$	
		1 kHz	$0.14 \times 10^{(-3)} \times L$	
10 mH	100 Hz;	$0.13 \times 10^{(-3)} L$		
	1 kHz; 10 kHz	$0.16 \times 10^{(-3)} \cdot L$		
100 mH	100 Hz; 1 kHz	$0.13 \times 10^{(-3)} L$		
	10 kHz	$0.28 \times 10^{(-3)} \cdot L$		
1 H	100 Hz, 1 kHz	$0.20 \times 10^{(-3)} \times L$		
Capacitance fixed values	0 pF		0.2 pF	No-load
	1 pF	1 kHz	$0.63 \times 10^{(-3)} C$	C = measured value Absolute value of impedance 1 Ω ≤ Z ≤ 110 MΩ
		10 kHz	$0.31 \times 10^{(-3)} C$	
	10 pF	1 kHz	$42 \times 10^{(-6)} C$	
		10 kHz;	$53 \times 10^{(-6)} \text{ } ^\circ C$	
		100 kHz	$88 \times 10^{(-6)} \text{ } ^\circ C$	
		1 MHz	$0.24 \times 10^{(-3)} C$	
	100 pF	1 kHz	$39 \times 10^{(-6)} C$	
1 nF	1 kHz	$71 \times 10^{(-6)} \text{ } ^\circ C$		
	100 kHz	$0.13 \times 10^{(-3)} C$		
10 nF	100 Hz	$0.49 \times 10^{(-3)} C$		
	1 kHz	$0.21 \times 10^{(-3)} C$		
	10 kHz	$0.23 \times 10^{(-3)} C$		
100 nF	100 Hz;	$0.21 \times 10^{(-3)} C$		
	1 kHz;	$0.20 \times 10^{(-3)} C$		
	10 kHz	$0.17 \times 10^{(-3)} C$		
1 µF	100 Hz; 1 kHz	$0.29 \times 10^{(-3)} C$		
	10 kHz	$0.13 \times 10^{(-3)} \cdot C$		
		$0.29 \times 10^{(-3)} C$		

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / procedure	Expanded measurement uncertainty	Remarks
Direct current power measuring instruments	0 W to 21 kW	0 mV to 1020 V 0 μA to 20.5 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ $0.21 \times 10^{-3} \cdot P$ to $0.70 \times 10^{-3} \cdot P$	P = measured value
with clamp connection	0 W to 300 kW	0 V to 330 V 0 mA to 1000 A	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.2 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding.
Active AC power measuring instruments	0.11 mW to 21 kW	$PF = 1$; 45 Hz to 65 Hz 33 mV to 1020 V 3.3 mA to 20 A	$0.7 \times 10^{-3} \times P$ to $1.4 \times 10^{-3} \times P$	P = measured value PF = power factor (capacitive or inductive)
	15 W; 60 W; 100 W; 400 W; 500 W; 1 kW; 2 kW; 4 kW	$PF = 1$; 45 Hz to 65 Hz 50 V; 200 V 0.3 A; 2 A; 10 A; 20 A	$0.16 \times 10^{-3} \times P$	
	1.5 W; 6 W	30 mA;	$0.26 \times 10^{-3} W$	
	2.3 W to 20.6 kW	45 Hz to 65 Hz; $PF = 1$ 23 V to 1020 V 30 mA to 20.5 A	$0.32 \times 10^{-3} P$ to $0.48 \times 10^{-3} P$	
	220 W	45 Hz to 65 Hz 220 V; 1 A $PF = 1$	$0.16 \times 10^{-3} \times P$	
	198 W	$PF = 0.9$	$0.18 \times 10^{-3} \times P$	
	110 W	$PF = 0.5$	$0.29 \times 10^{-3} \times P$	
	22 W	$PF = 0.1$	$1.4 \times 10^{-3} \times P$	
	11 W	$PF = 0.05$	$2.7 \times 10^{-3} \times P$	
	10 W to 1 kW	33 V to 330 V 330 mA to < 3 A 45 Hz to 65 Hz $0.05 \leq PF < 1$ Inductive, capacitive	0.22 W	
with clamp connection	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \leq PF \leq 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.4 \times 10^{-3} \times P$	W_{in} is the relative uncertainty of the active power of the single winding. The relative uncertainty of the measurement object W_{DUT} in the measurement circuit and in the stray field of the current-carrying conductor must be taken into account.
Power factor	0. to 0. .04	33 V to 330 V	0.15×10^{-3}	
	> 0.4 to < 1	330 mA to 2.2 A 45 Hz to 65 Hz	$-60 \times 10^{-6} \times P + 0.16 \times 10^{-3}$	
	1		89×10^{-6}	
AC reactive power Meters	0 var to 1 kvar	45 Hz to 65 Hz	$U_P \cdot \text{var}/W$	U_P is the uncertainty of active power

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Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Frequency f Measurement and synthesis	0.01 Hz to 18 GHz		$0.5 \times 10^{-9} \cdot f + U_{TF}$	U_{TF} : Trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 2 ns to 100 s 1 s to 100 h		1.2 ns $1.5 \times 10^{(-6)} \times \Delta t + 50 \text{ ps}$ $14 \times 10^{(-6)} \cdot \Delta t + U_{TF}$	
Rotational speed	0.02 s^{-1} to 18000 s^{-1}		$3.7 \times 10^{(-6)} \cdot f$	
Oscilloscope vertical	0 V to 5 V 5 V 130 V	DC to 10 kHz	$1.1 \times 10^{(-3)} \times U + 66 \mu\text{V}$ $1.2 \times 10^{(-3)} \times U + 44 \mu\text{V}$	U : measured value
Oscilloscope horizontal	1 ns to < 100 ns 100 ns to 20 ms > 20 ms to 5 s		$0.6 \times 10^{(-6)} \times T + 60 \text{ fs}$ $3.1 \times 10^{(-6)} \times T + 11 \text{ fs}$ $1.2 \times 10^{(-3)} \times T^2 + 29 \times 10^{(-6)} \times T$	T = measured value
Oscilloscope bandwidth f (frequency response)	50 kHz > 50 kHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 600 MHz > 600 MHz to 1.1 GHz > 1.1 GHz to 2 GHz > 2 GHz to 4 GHz		$3.3 \times 10^{(-2)} \times f$ $2.5 \times 10^{(-2)} \times f$ $3.1 \times 10^{(-2)} \cdot f$ $5.5 \times 10^{(-2)} \times f$ $6.5 \times 10^{(-2)} \cdot f$ $6.8 \times 10^{(-3)} \cdot f$ $9.5 \times 10^{(-2)} \cdot f$	f = measured value
Frequency f Time base	10 MHz		$0.2 \times 10^{(-6)} \times f$	
Rise time of oscilloscopes	50 ps to 1 ms 1 ns to 1 ms	0.05 V to 1.2 V 0.1 to 3 V	$4 \text{ ps} + 5.7 \times 10^{(-3)} T$ $2.5 \text{ ps} + 5.8 \times 10^{(-3)} T$	
Rise time of generators, pulses	0.5 ns to < 2.5 ns 2.5 ns to 5 ms		$28 \text{ ps} + 14 \times 10^{(-3)} T$ $13 \text{ ps} + 28 \times 10^{(-3)} \cdot T$	
RF power Output power and calibration factor of RF sources	10 μW to 80 mW	DC to 50 MHz 50 MHz to 4 GHz 4 GHz to 12 GHz 12 GHz to 18 GHz	$9.5 \times 10^{(-3)} \cdot P$ $14 \times 10^{(-3)} \cdot P$ $22 \times 10^{(-3)} \cdot P$ $36 \times 10^{(-3)} \cdot P$	N-connector, 50 ohms $ r_{RG} \leq 0.035 f$ $\leq 4 \text{ GHz}$ $ r_{RG} \leq 0.056 f$ $\leq 12 \text{ GHz}$ $ r_{RG} \leq 0.075 f$ $\leq 18 \text{ GHz}$ Other connectors and reflection factors increase the measurement uncertainty
RF voltage U_{HF} sources with RF voltage display relative to 50 Ω	22 mV to 2 V	DC to 18 MHz	$W(U_{HF}) = \frac{W(P)}{2}$	$W(P)$ is the relative uncertainty of the measured power at $Z_0 = 50 \Omega$

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Matrix WM.1 Square-wave voltage

Square-wave voltage [V] \ Frequency [Hz]	0.001	0.01	0.1	0.1	0.5	1	5	10	50	100
10	3.8E-07	512.2E-9	2.44E-06	2.37E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
100	7.4E-07	814.6E-9	2.52E-06	2.46E-06	1.12E-05	2.2E-05	110.4E-6	250.0E-6	1.2E-3	2.3E-3
1000	6.4E-06	6.4E-6	6.99E-06	6.97E-06	1.34E-05	2.4E-05	111.6E-6	251.5E-6	1.2E-3	2.3E-3
10,000	6.3E-05	63.7E-6	6.56E-05	6.56E-05	7.47E-05	8.7E-05	200.5E-6	369.5E-6	1.6E-3	3.2E-3

Matrix WM.2 Replacement leakage current

Normal resistance R_N	1 k Ω		10 k Ω		100 k Ω		1 M Ω		10 M Ω		100 M Ω		1 G Ω	
Nominal voltage	Current expanded measurement uncertainty U in μ A/A										Current U in mA/A			
60 V	60 mA	12	6 mA	12	600 μ A	12	60 μ A	20	6 μ A	71	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		1.1 mA		110 μ A		11 μ A		1.1 μ A			
230 V	230 mA		23 mA		2.3 mA		230 μ A		23 μ A		2.3 μ A			
400 V	400 mA		40 mA		4 mA		400 μ A		40 μ A		4.0 μ A			

Matrix WM.3 AC resistance

Voltage [V] \ Current [A]	0.001 V	0.010 V	0.010 V	0.100 V	0.100 V	1.000 V	1.000 V	10.000 V	10,000 V	100,000 V
2.2×10^{-3} A	1.57E-03	4.66E-04	4.66E-04	3.00E-04	3.00E-04	2.98E-04	2.98E-04	3.00E-04	3.00E-04	3.78E-04
$2.2 \cdot 10^{-2}$ A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
0.22 A	1.55E-03	3.97E-04	3.97E-04	1.75E-04	1.75E-04	1.72E-04	1.72E-04	1.75E-04	1.75E-04	2.89E-04
2.2 A	1.64E-03	6.78E-04	6.78E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	5.76E-04	6.21E-04

Dimensional quantities

Permanent laboratory site in Vienna

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / methods	Expanded measurement uncertainty	Remarks
Length Calipers for external, internal and depth measurements *	0 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	$20 \mu\text{m} + 15 \times 10^{(-6)} /$	l : measured value
Screw gauges *	0 mm to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	$2 \mu\text{m} + 6 \times 10^{(-6)} /$	

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On-site calibration – Electrical quantities

On-site calibration – DC and AC voltage

Measurement quantity / Calibration object	Calibration and measurement capacities (CMC)			Remarks
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
DC voltage	0 V		35 nV	Short-circuit bridge
	0 V to 1 V		$0.46 \times 10^{-(6)} \times U + 0.18 \mu\text{V}$	$U = \text{measured value}$
	> 1 V to 10 V		$0.18 \times 10^{-(6)} \times U + 0.67 \mu\text{V}$	
	> 10 V to 100 V		$0.28 \times 10^{-(6)} \times U - 0.34 \mu\text{V}$	
	> 100 V to 1050 V		$0.24 \times 10^{-(6)} \times U + 64 \mu\text{V}$	
High-voltage sources	1 kV to 10 kV		$7.9 \times 10^{-(6)} \cdot U + 17 \text{ mV}$	$U = \text{measured value}$
	> 10 kV to 60 kV		$46 \cdot 10^{-6} \cdot U + 0.95 \text{ V}$	
AC voltage	2 mV to 10 mV	10 Hz; 12.5 Hz	$26 \times 10^{-6} \cdot U + 0.11 \mu\text{V}$	$U = \text{measured value}$ Calibration on the Josephson voltmeter. When calibrating measuring instruments, the influence of the load impedance and the repeatability must also be taken into account.
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$28 \times 10^{-6} \cdot U + 23 \text{ nV}$	
		48 Hz; 60 Hz; 62.5 Hz	$19 \times 10^{-6} \cdot U + 0.11 \mu\text{V}$	
		625 Hz; 937.5 Hz; 1 kHz	$17 \times 10^{-6} \cdot U + 0.12 \mu\text{V}$	
	> 10 mV to 60 mV	10 Hz; 12.5 Hz	$13 \times 10^{-6} \cdot U + 0.19 \mu\text{V}$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$8.6 \times 10^{-6} \cdot U + 0.16 \mu\text{V}$	
		48 Hz; 60 Hz; 62.5 Hz	$10 \times 10^{-6} \cdot U + 0.16 \mu\text{V}$	
		625 Hz; 937.5 Hz; 1 kHz	$9.1 \times 10^{-6} \cdot U + 0.16 \mu\text{V}$	
	> 60 mV to 7.2 V	10 Hz; 12.5 Hz	$10 \times 10^{-6} \cdot U + 0.14 \mu\text{V}$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$2.2 \times 10^{-6} \cdot U + 0.16 \mu\text{V}$	
		48 Hz; 60 Hz; 62.5 Hz	$4.2 \times 10^{-6} \cdot U + 0.14 \mu\text{V}$	
		625 Hz; 937.5 Hz; 1 kHz	$1.4 \times 10^{-6} \cdot U + 0.16 \mu\text{V}$	
	AC voltage	2 mV to < 22 V	10 Hz to 1 MHz	
10 Hz; 20 Hz; 40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz			$0.29 \times 10^{-(3)} \times U$	
500 kHz			$0.32 \times 10^{-(3)} \cdot U$	
1 MHz		$0.43 \times 10^{-(3)} \cdot U$		
6 mV		10 Hz	$0.16 \times 10^{-(3)} \cdot U$	
		20 Hz	$0.14 \times 10^{-(3)} \cdot U$	

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On-site calibration – DC and AC voltage

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	
AC voltage	6 mV	40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$0.13 \times 10^{(-3)} \times U$	<i>U</i> = measured value Calibration using an AC/DC transfer standard. When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.
		300 kHz	$0.15 \times 10^{(-3)} \cdot U$	
		500 kHz	$0.17 \times 10^{(-3)} \cdot U$	
		1 MHz	$0.22 \times 10^{(-3)} \cdot U$	
	10 mV	10 Hz	$0.13 \times 10^{(-3)} \cdot U$	
		20 Hz	$0.12 \times 10^{(-3)} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$0.10 \times 10^{(-3)} \times U$	
		300 kHz	$0.12 \times 10^{(-3)} \cdot U$	
		500 kHz	$0.16 \times 10^{(-3)} \cdot U$	
		1 MHz	$0.21 \times 10^{(-3)} \cdot U$	
	20 mV	10 Hz	$0.12 \times 10^{(-3)} \cdot U$	
		20 Hz	$0.11 \times 10^{(-3)} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$86 \times 10^{(-6)} \times U$	
		300 kHz	$0.11 \times 10^{(-3)} \cdot U$	
		500 kHz	$0.13 \times 10^{(-3)} \cdot U$	
		1 MHz	$0.17 \times 10^{(-3)} \cdot U$	
	60 mV	10 Hz	$54 \times 10^{(-6)} \cdot U$	
		20 Hz; 40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$32 \times 10^{(-6)} \cdot U$	
		200 kHz; 300 kHz	$46 \times 10^{(-6)} \cdot U$	
		500 kHz	$60 \times 10^{(-6)} \cdot U$	
		1 MHz	$95 \times 10^{(-6)} \cdot U$	
		100 mV	$22 \times 10^{(-6)} \cdot U$	
	100 mV	10 Hz	$22 \times 10^{(-6)} \cdot U$	
		20 Hz; 40 Hz	$20 \times 10^{(-6)} \cdot U$	
55 Hz; 120 Hz		$17 \times 10^{(-6)} \cdot U$		
400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz		$15 \cdot 10^{(-6)} \cdot U$		
200 kHz; 300 kHz		$25 \times 10^{(-6)} \cdot U$		
500 kHz		$34 \times 10^{(-6)} \cdot U$		
1 MHz		$53 \times 10^{(-6)} \cdot U$		
200 mV	10 Hz	$37 \times 10^{(-6)} \cdot U$		
	20 Hz; 40 Hz	$18 \times 10^{(-6)} \cdot U$		
	55 Hz; 120 Hz	$15 \times 10^{(-6)} \cdot U$		

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC voltage	200 mV	400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$12 \times 10^{-(6)} \times U$	<i>U</i> = measured value Calibration using AC/DC transfer standards. When calibrating measuring instruments, the influence of load/terminal impedance and repeatability must be taken into account.
		100 kHz	$13 \times 10^{-(6)} \cdot U$	
		200 kHz; 300 kHz	$23 \times 10^{-6} \cdot U$	
		500 kHz	$33 \times 10^{-(6)} \cdot U$	
		1 MHz	$49 \times 10^{-(6)} V$	
	600 mV	10 Hz	$31 \times 10^{-(6)} V$	
		20 Hz; 40 Hz	$16 \times 10^{-(6)} V$	
		55 Hz; 120 Hz	$13 \times 10^{-(6)} U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$10 \times 10^{-(6)} V$	
		100 kHz	$11 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$21 \cdot 10^{-6} \cdot U$	
		500 kHz	$33 \times 10^{-(6)} U$	
	1 V	10 Hz	$17 \times 10^{-(6)} U$	
		20 Hz; 40 Hz	$11 \times 10^{-(6)} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \times 10^{-(6)} \cdot U$	
		100 kHz	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$13 \times 10^{-6} \cdot U$	
		500 kHz	$17 \times 10^{-(6)} U$	
		1 MHz	$30 \times 10^{-(6)} U$	
	2 V	10 Hz	$38 \times 10^{-(6)} V$	
		20 Hz; 40 Hz	$12 \times 10^{-(6)} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \times 10^{-(6)} \cdot U$	
		100 kHz	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$11 \times 10^{-6} \cdot U$	
500 kHz		$16 \times 10^{-(6)} U$		
1 MHz		$29 \times 10^{-(6)} U$		
4 V; 6 V	10 Hz	$32 \times 10^{-(6)} V$		
	20 Hz; 40 Hz	$13 \times 10^{-(6)} U$		
	55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$9 \times 10^{-(6)} U$		
	200 kHz; 300 kHz	$21 \times 10^{-6} \cdot U$		
	500 kHz	$32 \times 10^{-(6)} \cdot U$		
	1 MHz	$35 \times 10^{-(6)} V$		

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC voltage	8 V; 10 V	10 Hz	$19 \times 10^{(-6)} \cdot U$	<p>U = measured value</p> <p>Calibration using an AC/DC transfer standard. When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.</p>
		20 Hz	$13 \times 10^{(-6)} \cdot U$	
		40 Hz	$10 \times 10^{(-6)} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$8 \times 10^{(-6)} \cdot U$	
		200 kHz; 300 kHz	$15 \times 10^{(-6)} U$	
		500 kHz	$30 \times 10^{(-6)} U$	
		1 MHz	$47 \times 10^{(-6)} V$	
	20 V	10 Hz	$29 \cdot 10^{-6} \cdot U$	
		20 Hz	$14 \times 10^{-6} \cdot U$	
		40 Hz	$11 \times 10^{(-6)} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$9 \times 10^{(-6)} \cdot U$	
		100 kHz	$10 \times 10^{(-6)} U$	
		200 kHz; 300 kHz	$16 \times 10^{(-6)} U$	
		500 kHz	$32 \times 10^{(-6)} U$	
	1 MHz	$49 \times 10^{(-6)} U$		
	12 V; 15 V; 19 V	1 kHz; 10 kHz; 100 kHz	$10 \cdot 10^{-6} \cdot U$	
	> 22 V to 70 V	10 Hz to 300 kHz		
	60 V	10 Hz	$23 \times 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$15 \times 10^{(-6)} U$	
		55 Hz; 120 Hz	$13 \times 10^{(-6)} U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz	$9 \times 10^{(-6)} U$	
		70 kHz	$10 \cdot 10^{-6} \cdot U$	
		100 kHz	$14 \times 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$22 \times 10^{(-6)} V$	
	> 70 V to 110 V 100 V	10 Hz to 200 kHz 10 Hz; 20 Hz	$19 \times 10^{(-6)} \cdot U$	
		40 Hz	$15 \times 10^{(-6)} U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz	$13 \times 10^{(-6)} \cdot U$	
70 kHz		$20 \times 10^{-6} \cdot U$		
100 kHz		$32 \times 10^{(-6)} \cdot U$		
200 kHz		$37 \times 10^{(-6)} V$		

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On-site calibration – DC and AC voltage

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	
AC voltage	> 110 V to 700 V 200 V	10 Hz to 100 kHz		<i>U</i> = measured value Calibration using an AC/DC transfer standard. When calibrating measuring instruments, the influence of the load/terminal impedance and repeatability must be taken into account.
		10 Hz	$27 \times 10^{-4} \times U$	
		20 Hz	$21 \times 10^{-(6)} \cdot U$	
		40 Hz	$16 \times 10^{-(6)} \cdot U$	
		55 Hz; 120 Hz	$15 \times 10^{-(6)} U$	
		400 Hz; 500 Hz; 1 kHz;	$13 \times 10^{-(6)} U$	
	600 V	10 kHz; 20 kHz; 50 kHz	$17 \times 10^{-(6)} U$	
		70 kHz	$20 \times 10^{-(6)} U$	
		100 kHz	$31 \times 10^{-(6)} U$	
		40 Hz	$17 \times 10^{-5} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$14 \times 10^{-(6)} \cdot U$	
		1 kHz; 10 kHz; 20 kHz; 50 kHz	$16 \times 10^{-(6)} U$	
		70 kHz	$25 \times 10^{-(6)} U$	
		100 kHz	$37 \times 10^{-(6)} V$	
> 700 V to 1000 V 1000 V	10 Hz to 100 kHz			
	40 Hz	$16 \times 10^{-6} V$		
	55 Hz; 120 Hz; 400 Hz; 500 Hz;	$14 \cdot 10^{-5} \cdot U$		
	1 kHz; 10 kHz; 20 kHz			
	50 kHz	$25 \times 10^{-(6)} \cdot U$		
High-voltage sources	1 kV to 10 kV	10 Hz to 20 kHz	$50 \times 10^{-(6)} \times U + 2 V$	
		> 20 kHz to 50 kHz	$0.34 \times 10^{-(3)} \cdot U + 1.6 V$	
		> 50 kHz to 100 kHz	$1.6 \times 10^{-3} \cdot U + 0.9 V$	
	> 10 kV to 40 kV	10 Hz to 20 kHz	$0.10 \times 10^{-(3)} \times U + 3.7 V$	
		> 20 kHz to 50 kHz	$0.43 \times 10^{-(3)} \cdot U + 2.1 V$	
		> 50 kHz to 100 kHz	$1.7 \times 10^{-(3)} \cdot U + 0.7 V$	
Measuring instruments	1 kV to 10 kV	45 Hz to 65 Hz	$50 \cdot 10^{-6} \cdot U + 2 V$	
	> 10 kV to 30 kV		$0.10 \times 10^{-3} \times U + 3.7 V$	

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Square-wave voltage	5 mV to 220 mV	1 Hz to 10 kHz	$10 \times 10^{(-6)} \times U + 0.36 \mu\text{V} + 6.4 \times 10^{(-9)} \text{V/Hz} \cdot f$	Sweep procedure on a 10 MΩ load. Range specified in peak-to-peak voltage. U = peak voltage f = frequency The additional influence of different load conditions (such as 50 Ω or 1 MΩ) must be taken into account.
	> 220 mV to 2.2 V		$9.3 \times 10^{(-6)} \times U + 0.35 \mu\text{V} + 7.0 \times 10^{(-9)} \text{V/Hz} \cdot f$	
	> 2.2 V to 22 V		$9.3 \times 10^{(-6)} \cdot U + 0.58 \mu\text{V} + 14 \times 10^{(-9)} \text{V/Hz} \cdot f$	
	> 22 V to 220 V		$12 \times 10^{(-6)} \cdot U + 35 \mu\text{V} + 75 \times 10^{(-9)} \text{V/Hz} \cdot f$	
AC voltage amplitude parameters	5 mV to 5 V	DC to 10 MHz > 10 MHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 1 GHz	$25 \times 10^{(-3)} \times U + 0.2 \mu\text{V}$ $37 \times 10^{(-3)} \text{V} + 0.5 \mu\text{V}$ $44 \times 10^{(-3)} \text{V} + 0.4 \mu\text{V}$ $70 \times 10^{(-3)} \text{V}$	Oscilloscope as standard U = measured value
	> 5 V to 50 V	DC to 2 kHz > 2 kHz to 10 MHz	$12 \times 10^{(-3)} \cdot U + 0.7 \mu\text{V}$ $25 \times 10^{(-3)} \cdot U + 0.7 \mu\text{V}$	
	0 % to 30%	45 Hz to 5 kHz > 5 kHz to 30 kHz	$0.5 \times 10^{(-3)} \times k + 0.012\%$ $0.8 \times 10^{(-3)} \cdot k + 0.012\%$	

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC voltage Harmonic overtones Sources and measuring instruments	RMS value of Fundamental wave	$45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$ $1 \text{ mV} \leq U_n \leq 200 \text{ V}$ $1\% \leq (U_n / U_1) \leq 40\%$ $2 \leq n \leq 100$ $f_n \leq 6 \text{ kHz}$	$20 \times 10^{-6} \cdot U_1$ to $39 \times 10^{-6} \cdot U_1$	Measured value = RMS value of the fundamental wave U_1 = root mean square value of the fundamental wave U_n = RMS value of the nth harmonic f_1 = frequency of the fundamental wave f_n = frequency of the harmonic $n = f_n / f_1, n > 1$ The number of harmonics is limited to one harmonic.
	100 mV to 500 V			
	RMS value of the harmonic	$45 \text{ Hz} \leq f_1 \leq 65 \text{ Hz}$ $100 \text{ mV} \leq U_1 \leq 500 \text{ V}$ $1\% \leq (U_n / U_1) \leq 40\%$ $2 \leq n \leq 100$ $f_n \leq 6 \text{ kHz}$	$0.13 \times 10^{-3} \cdot U_n$ to $1.1 \times 10^{-3} \cdot U_n$ see Matrix VM.17	Measured value = RMS value of the harmonic U_1 = RMS value of the fundamental wave U_n = RMS value of the harmonic f_1 = frequency of the fundamental f_n = frequency of the harmonic $n = f_n / f_1, n > 1$ The number of harmonics is limited to one harmonic.

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
AC current Harmonic overtones Sources and measuring instruments	100 mA to 60 A	45 Hz $\leq f_1 \leq$ 65 Hz	$32 \cdot 10^{-6} \cdot I_1$ to $71 \cdot 10^{-6} \cdot I_1$	Measured value = rms value of the fundamental wave I_1 = RMS value of the fundamental wave I_n = RMS value of the harmonic f_1 = frequency of the fundamental wave f_n = frequency of the harmonic $n = f_n / f_1, n > 1$ The number of harmonics is limited to one harmonic . I_s = peak value of the current signal For measuring instruments with a connected (clamp-on) current transformer, the measurement uncertainty may increase. The measurement range extends to $I_1 \leq 600$ A. The calibration of current transformers is carried out in conjunction with the display unit for the secondary signal.
		$2 \leq n \leq 100$ $I_s \leq 113$ A		
	100 mA	$1 \text{ mA} \leq I_n \leq 4.8$ A $f_n \leq 6$ kHz	$32 \times 10^{-6} \cdot I_1$	
	200 mA	$1 \% \leq I_n / I_1 \leq 30 \%$	$47 \times 10^{-6} \cdot I_1$	
	400 mA		$47 \times 10^{-6} \cdot I_1$	
	800 mA		$47 \times 10^{-6} \cdot I_1$	
	1.6 A		$45 \times 10^{-6} \cdot I_1$	
	4 A		$57 \times 10^{-6} \cdot I_1$	
	5 A		$57 \cdot 10^{-6} \cdot I_1$	
	16 A		$55 \cdot 10^{-6} \cdot I_1$	
30 A	$160 \text{ mA} \leq I_n \leq 18$ A $f_n \leq 3$ kHz	$71 \times 10^{-6} \cdot I_1$		
60 A	$1 \% \leq (I_n / I_1) \leq 30 \%$	$71 \times 10^{-6} \cdot I_1$		

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Alternating current Harmonic overtones Sources and measuring instruments		45 Hz $\leq f_1 \leq$ 65 Hz $2 \leq n \leq 100$ $i_s \leq 113$ A		Measured value = RMS value of the harmonic i_1 = RMS value of the fundamental
	1 mA to 4.8 A	100 mA $\leq i_1 \leq$ 16 A $f_n \leq 6$ kHz $1 \% \leq i_n / i_1 \leq 30 \%$	$0.22 \times 10^{-3} \cdot i_n$ up to $0.46 \times 10^{-3} \cdot i_n$ see matrix VM.18	i_n = rms value of the harmonic f_1 = frequency of the fundamental f_n = frequency of the harmonic $n = f_n / f_1, n > 1$
	160 mA to 18 A	16 A $\leq i_1 \leq$ 60 A $f_n \leq 3$ kHz $1\% \leq (i_n / i_1) \leq 30\%$	$0.22 \times 10^{-3} \cdot i_n$ to $0.46 \times 10^{-3} \cdot i_n$ see Matrix VM.18	The number of harmonics is limited to one harmonic. i_s = peak value of the current signal For measuring instruments with a connected (clamp-on) current transformer, the measurement uncertainty may increase. The measurement range extends to $i_n \leq 200$ A. The calibration of current transformers is carried out in conjunction with the display unit for the secondary signal.

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Flicker Modulation depth sources	0.407% to 4.837%	$1 \text{ min}^{-1} \leq CPM \leq 4800 \text{ min}^{-1}$ $U = 120 \text{ V}; U = 230 \text{ V}$ Square-wave modulation		$\Delta U/U =$ Modulation depth U = RMS value of the modulated AC voltage s-signal $f =$ frequency of the modulated AC signal $CPM =$ Changes per minute The requirements set out in DIN EN 61000-4-15:2011, Table 5, defined combinations of $\Delta U/U$ and CPM .
		$1 \text{ min}^{-1} \leq CPM \leq 39 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$1.0 \times 10^{-3} \%$	
		$CPM = 110 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$3.7 \times 10^{-3} \%$	
		$CPM = 1620 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$12 \times 10^{-3} \%$	
		$CPM = 4000 \text{ rpm};$ $CPM = 4800 \text{ rpm}$ $f = 51 \text{ Hz}; f = 61 \text{ Hz}$	$12 \times 10^{-3} \%$	
Flicker Modulation depth of measuring instruments	0.407% to 4.837%	$1 \text{ min}^{-1} \leq CPM \leq 4800 \text{ min}^{-1}$ $U = 120 \text{ V}; U = 230 \text{ V}$ square-wave modulation		$\Delta U/U =$ Modulation depth U = RMS value of the modulated AC signal s-signal $f =$ frequency of the modulated AC signal $CPM =$ Changes per minute The requirements set out in DIN EN 61000-4-15:2011, Table 5.
		$1 \text{ min}^{-1} \leq CPM \leq 39 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$1.0 \times 10^{-3} \%$	
		$CPM = 110 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$3.7 \times 10^{-3} \%$	
		$CPM = 1620 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$12 \times 10^{-3} \%$	
		$CPM = 4000 \text{ min}^{-1};$ $CPM = 4800 \text{ min}^{-1}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$	$28 \times 10^{-3} \%$	

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On-site calibration – DC and AC voltage

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Flicker Frequency Sources and Measuring instruments	8.3 mHz to 40 Hz	$0.407\% \leq \Delta U/U \leq 4.837\%$ $1 \text{ rpm} \leq CPM \leq 4800 \text{ rpm}$ $U = 120 \text{ V}; U = 230 \text{ V}$ $f = 50 \text{ Hz}; f = 60 \text{ Hz}$ square-wave modulation	$1.0 \times 10^{-6} \cdot f_{\text{Flicker}}$	$\Delta U/U =$ Modulation depth $U = \text{RMS}$ of the modulated alternating voltage s-signal $f =$ frequency of the modulated AC voltage s-signal $CPM =$ changes per minute (changes per minute) $f_{\text{Flicker}} = CPM / 120$ The provisions of DIN EN 61000-4- 15:2011, Table 5, defined combinations of $\Delta U/U$ and CPM .
P_{st} value	only $P_{\text{st}} = 1$		$2.5 \times 10^{(-3)}$	Value for $\Delta U/U$ expressed in $\Delta U/U$ rectangular Flicker
AC voltage Distortion factor k	0 % to 30%	45 Hz to 5 kHz > 5 kHz to 30 kHz	$0.5 \times 10^{(-3)} \times k + 0.012\%$ $0.8 \times 10^{(-3)} \times k + 0.012\%$	Values expressed as % distortion

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Matrix VM.17 – Relative measurement uncertainty of the root mean square value U_n of the harmonic at the frequency $f_1 = 50$ Hz in mV/V

u_1 / V	u_n / V	n													
		2	3	4	5	10	20	30	40	50	60	70	80	90	100
0.10	0.001	1.1	1.1	0.57	0.57	0.50	0.49	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.48
0.10	0.01	0.17	0.17	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.20	0.025	0.17	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1.2	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
8.0	1.0	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
16	4.5	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
30	9.0	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
60	18	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
120	36	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
240	72	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
460	130	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

Matrix VM.18 – Relative measurement uncertainty of the root mean square value I_n of the harmonic at the frequency $f_1 = 50$ Hz in mA/A

i_1 / A	i_n / A	n													
		2	3	4	5	10	20	30	40	50	60	70	80	90	100
0.1	0.01	0.24	0.24	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
0.2	0.025	0.24	0.24	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
0.4	0.05	0.24	0.24	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
0.8	0.1	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
1.6	0.016	0.46	0.46	0.46	0.46	0.32	0.28	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.22
1.6	0.2	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
4	0.5	0.25	0.25	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
8	1	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
16	2	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
30	8	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	-	-	-	-
60	15	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.24	-	-	-	-

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On-site calibration – DC and AC current

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Direct current	0 pA to 10 nA		0.85 fA to 51 fA	I = measured value
	0 pA		12 fA	
	1 pA		$0.85 \times 10^{(-3)} \times I$	
	10 pA		$0.53 \times 10^{(-3)} \times I$	
	100 pA		$75 \times 10^{(-6)} \times I$	
	1 nA		$10 \times 10^{(-6)} \cdot I$	
	10 nA		$5.1 \times 10^{(-6)} \cdot I$	
	> 10 nA to 100 nA		$4.1 \times 10^{(-6)} \cdot I + 10 \text{ fA}$	
	> 100 nA to < 1 µA		$1.4 \times 10^{(-6)} \times I + 0.21 \text{ pA}$	
	1 µA to 10 µA		$1.4 \times 10^{(-6)} \times I + 0.19 \text{ pA}$	
	> 10 µA to 20 µA		$1.4 \times 10^{(-6)} \times I + 1.8 \text{ pA}$	
	20 µA to 200 µA		$1.4 \times 10^{(-6)} \times I + 14 \text{ pA}$	
	200 µA to 2 mA		$0.54 \times 10^{(-6)} \times I + 0.23 \text{ nA}$	
	2 mA to 10 mA		$1.1 \times 10^{(-6)} \times I + 2.4 \text{ nA}$	
	10 mA to 50 mA		$0.90 \times 10^{(-6)} \times I + 25 \text{ nA}$	
50 mA to 200 mA	$0.33 \times 10^{(-6)} \times I + 0.26 \text{ µA}$			
200 mA to 1 A	$12 \times 10^{(-6)} \cdot I$			
1 A to 10 A	$16 \cdot 10^{(-6)} \cdot I$			
10 A to 100 A	$28 \cdot 10^{(-6)} \cdot I$			
100 A to 300 A	$T = (23 \pm 2) \text{ °C}$	$37 \times 10^{(-6)} \cdot I$		
Direct current sources	300 A to 700 A		$27 \times 10^{(-6)} \cdot I + 2.3 \text{ mA}$	
Direct current Current clamps and current clamp converters	0 A to 3000 A	1 to N windings	$\sqrt{W^2 + W^2} \cdot I$ but not less than $8 \cdot 10^{(-6)} \cdot I$ or 6 nA	W_{in} is the relative uncertainty of the current in the single winding. W_{DUT} is the relative uncertainty of the measurement object in the stray field of the current-carrying.

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On-site calibration – DC and AC current

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
Alternating current	100 µA to 100 A	10 Hz to 10 kHz	4.4 nA to 6.5 mA	
	100 µA	10 Hz; 20 Hz	$76 \times 10^{-(6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$44 \cdot 10^{-6} \cdot I$	
		10 kHz	$47 \times 10^{-(6)} \cdot I$	
	200 µA	10 Hz; 20 Hz	$68 \times 10^{-(6)} \cdot I$	
		40 Hz	$39 \times 10^{-(6)} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$36 \times 10^{-(6)} \cdot I$	
		10 kHz	$39 \times 10^{-(6)} \cdot I$	
	0.5 mA	10 Hz; 20 Hz	$64 \times 10^{-(6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz	$28 \times 10^{-(6)} \cdot I$	
		400 Hz; 500 Hz; 1 kHz	$27 \times 10^{-(6)} \cdot I$	
		10 kHz	$32 \times 10^{-(6)} \cdot I$	
	1 mA	10 Hz	$33 \times 10^{-(6)} \cdot I$	
		20 Hz	$30 \times 10^{-(6)} \cdot I$	
		40 Hz; 55 Hz	$26 \times 10^{-(6)} \cdot I$	
		120 Hz; 400 Hz; 500 Hz; 1 kHz	$25 \times 10^{-(6)} \cdot I$	
		10 kHz	$27 \times 10^{-(6)} \cdot I$	

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On-site calibration – DC and AC current

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
Alternating current	2 mA	10 Hz	$32 \times 10^{\wedge}(-6) \times I$	I = measured value f = frequency
		20 Hz	$29 \times 10^{\wedge}(-6) \times I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$24 \times 10^{\wedge}(-6) \cdot I$	
	5 mA	10 Hz	$32 \times 10^{\wedge}(-6) \times I$	
		20 Hz; 40 Hz	$29 \times 10^{\wedge}(-6) \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$24 \times 10^{\wedge}(-6) \cdot I$	
	10 mA	10 Hz	$26 \times 10^{\wedge}(-6) \cdot I$	
		20 Hz	$24 \times 10^{\wedge}(-6) \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \times 10^{\wedge}(-6) \cdot I$	
	20 mA	10 Hz	$25 \times 10^{\wedge}(-6) \times I$	
		20 Hz	$23 \times 10^{\wedge}(-6) \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \times 10^{\wedge}(-6) \cdot I$	
		10 kHz	$19 \times 10^{\wedge}(-6) \cdot I$	
	50 mA	10 Hz	$25 \times 10^{\wedge}(-6) \cdot I$	
		20 Hz; 40 Hz	$23 \times 10^{\wedge}(-6) \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \times 10^{\wedge}(-6) \cdot I$	
		10 kHz	$19 \cdot 10^{-6} \cdot I$	
	100 mA	10 Hz	$26 \times 10^{\wedge}(-6) \cdot I$	
		20 Hz; 40 Hz	$24 \times 10^{\wedge}(-6) \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$18 \times 10^{\wedge}(-6) \cdot I$	
		1 kHz; 10 kHz	$20 \times 10^{\wedge}(-6) \cdot I$	
	200 mA	10 Hz	$27 \times 10^{\wedge}(-6) \cdot I$	
		20 Hz; 40 Hz	$24 \times 10^{\wedge}(-6) \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$18 \cdot 10^{-6} \cdot I$	
		10 kHz	$20 \times 10^{\wedge}(-6) \cdot I$	
	500 mA	10 Hz	$36 \times 10^{\wedge}(-6) \cdot I$	
		20 Hz	$34 \times 10^{\wedge}(-6) \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$31 \times 10^{\wedge}(-6) \cdot I$	

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On-site calibration – DC and AC current

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Alternating current	1 A	10 Hz	$32 \times 10^{(-6)} \times I$	I = measured value f = frequency
		20 Hz	$29 \times 10^{(-6)} \times I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$25 \times 10^{(-6)} \cdot I$	
	2 A	10 Hz; 20 Hz	$40 \times 10^{-6} \times I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$34 \times 10^{(-6)} \cdot I$	
	5 A; 10 A	10 Hz	$39 \times 10^{(-6)} \cdot I$	
		20 Hz	$37 \times 10^{(-6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$32 \times 10^{(-6)} \cdot I$	
	20 A	10 Hz; 20 Hz	$57 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$53 \times 10^{-6} \cdot I$	
	50 A	10 Hz; 20 Hz	$64 \times 10^{(-6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$59 \times 10^{(-6)} \cdot I$	
		1 kHz; 10 kHz	$68 \times 10^{(-6)} \cdot I$	
	100 A	10 Hz; 20 Hz	$75 \times 10^{(-6)} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$65 \cdot 10^{(-6)} \cdot I$	
		1 kHz; 10 kHz	$75 \times 10^{(-6)} \cdot I$	
	100 A to 200 A	QMH Chap. Vlb.1.1 Ver. 5.0	12 mA to 24 mA	
		10 Hz to 10 kHz	$0.13 \times 10^{(-3)} \times I$	

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On-site calibration – DC and AC current

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
AC current sources	200 A to 300 A	10 Hz to 1 kHz	$0.30 \times 10^{(-3)} \times I - 0.53 \text{ mA}$	I = measured value f = frequency
	300 A to 495 A	10 Hz to 65 Hz	$0.48 \times 10^{-3} \times I + 11 \text{ mA}$	
		65 Hz to 100 Hz	$0.49 \times 10^{(-3)} \times I + 11 \text{ mA}$	
		100 Hz to 400 Hz	$0.74 \times 10^{(-3)} \times I + 7.7 \text{ mA}$	
400 Hz to 1 kHz	$1.5 \times 10^{(-3)} \times I + 4.0 \text{ mA}$			
Current clamps and current clamp transducers	10 μ A up to 2400 A	1 to N windings 10 Hz to 1 kHz > 1 kHz to 10 kHz/ N	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot I$ but not less than $90 \times 10^{(-6)} I$ or 8 nA	W_{in} is the relative uncertainty of the current in the single winding. W_{DUT} is the relative uncertainty of the measurement object in the stray field of the current-carrying.
Equivalent leakage current I	0.2 μ A to 200 mA	at R_N up to 1 G Ω	$10 \times 10^{(-6)} \times I$ to $5.8 \times 10^{(-3)} \times I$ see matrix VM.1	Total uncertainty U depends on the relative uncertainty $U(R_N)/R_N$ of the calibration resistor R_N
Charge Q	20 pC to 200 pC		$0.50 \times 10^{(-3)} \times Q + 0.025 \text{ pC}$	rectangular current pulses ≥ 1 s, duration t and rise times $\leq 10 \mu$ s as the product $Q = I \cdot t$; total uncertainty calculated from the relative uncertainty $W(I_{lin})$ of the calibration current.
	> 200 pC to 2 nC		$0.33 \times 10^{(-3)} \times Q + 0.05 \text{ pC}$	
	> 2 nC to 11 C		$60 \times 10^{(-3)} \times Q + 0.5 \text{ pC}$	

Matrix VM.1 “Equivalent leakage current, on-site calibration”

Reference resistance R_N	1 Ω		10 Ω		100 Ω		1 Ω		10 Ω		100 Ω		1 Ω	
	Current expanded measurement uncertainty U in μ A/A						Current U in mA/A							
60 V	60 mA	10	6 mA	10	600 μ A	13	60 μ A	19	6 μ A	70	600 nA	0.6	60 nA	5.8
110 V	110 mA		11 mA		1.1 mA		110 μ A		11 μ A		1.1 μ A		110 nA	
230 V	230 mA		23 mA		2.3 mA		230 μ A		23 μ A		2.3 μ A		230 nA	
400 V	400 mA		40 mA		4 mA		400 μ A		40 μ A		4.0 μ A		400 nA	

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On-site calibration – DC and AC resistance

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC resistance	0 Ω	2-wire short-circuit	0.5 mΩ	R = measured value
		4-wire short circuit	0.35 μΩ	
	10 μΩ up to < 1 GΩ	T = (23 ± 2) °C	1.6 nΩ to 110 Ω	Calibration of measuring instruments to the nominal values of the standards
	10 μΩ 100 μΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10 kΩ 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ	I = 100 A I = 50 A / = 10 A	0.16 × 10 ^{Λ(-3)} × R 34 × 10 ^{Λ(-6)} × R 23 × 10 ^{Λ(-6)} · R 20 × 10 ^{Λ(-6)} · R 5.6 × 10 ^{Λ(-6)} · R 0.43 × 10 ^{Λ(-6)} · R 1.0 · 10 ^{Λ(-6)} · R 0.60 × 10 ^{Λ(-6)} · R 0.57 × 10 ^{Λ(-6)} · R 1.4 × 10 ^{Λ(-6)} · R 1.5 × 10 ^{Λ(-6)} · R 4.2 × 10 ^{Λ(-6)} · R 11.2 × 10 ^{Λ(-6)} · R	
	1 GΩ to 120 TΩ 1 GΩ; 10 GΩ; 100 GΩ; 1 TΩ	Measuring voltage 100 V or 1000 V	88 kΩ to 240 MΩ 88 × 10 ^{Λ(-6)} × R 0.13 × 10 ^{Λ(-3)} × R 0.24 × 10 ^{Λ(-3)} · R	
	> 1 TΩ to 120 TΩ 10 TΩ; 100 TΩ	Measuring voltage 1000 V	0.48 GΩ to 187 GΩ 0.48 × 10 ^{Λ(-3)} × R 1.87 × 10 ^{Λ(-3)} × R	
100 μΩ to 100 Ω	T = (23 ± 2) °C 100 μA ≤ I ≤ 100 A 10 Hz to 10 kHz	13 nΩ to 1.7 mΩ	R = measured value I = current f = frequency	
100 μΩ	10 Hz; 20 Hz	0.17 × 10 ^{Λ(-3)} × R		
	40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	0.14 × 10 ^{Λ(-3)} · R		
	1 kHz; 10 kHz	0.15 × 10 ^{Λ(-3)} · R		
1 mΩ	10 Hz	65 × 10 ^{Λ(-6)} × R		
	20 Hz	63 × 10 ^{Λ(-6)} · R		
	40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	58 × 10 ^{Λ(-6)} · R		
	1 kHz	61 × 10 ^{Λ(-6)} · R		
	10 kHz	64 × 10 ^{Λ(-6)} · R		

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On-site calibration – DC and AC resistance

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
AC resistance (magnitude of impedance)	10 mΩ	10 Hz	$46 \times 10^{\wedge}(-6) \times R$	<i>R</i> = measured value <i>I</i> = current <i>f</i> = frequency
		20 Hz	$43 \times 10^{\wedge}(-6) \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$37 \times 10^{\wedge}(-6) \cdot R$	
		1 kHz; 10 kHz	$35 \times 10^{\wedge}(-6) \cdot R$	
	20 mΩ	10 Hz	$45 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz	$42 \times 10^{\wedge}(-6) \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$36 \times 10^{\wedge}(-6) \cdot R$	
	50 mΩ	10 Hz	$45 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz	$42 \times 10^{\wedge}(-6) \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; kHz	$36 \times 10^{-6} \cdot R$	
	100 mΩ; 200 mΩ	10 Hz	$39 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz	$35 \times 10^{\wedge}(-6) \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$30 \times 10^{\wedge}(-6) \cdot R$	
	0.5 Ω	10 Hz	$36 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz; 40 Hz	$31 \times 10^{\wedge}(-6) \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$26 \cdot 10^{-6} \cdot R$	
	1 Ω	10 Hz	$34 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz	$30 \times 10^{\wedge}(-6) \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$25 \times 10^{\wedge}(-6) \cdot R$	
	2 Ω; 5 Ω	10 Hz	$31 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz; 40 Hz	$26 \times 10^{\wedge}(-6) \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$20 \times 10^{\wedge}(-6) \cdot R$	
		10 kHz	$23 \times 10^{-6} \times R$	
	10 Ω	10 Hz	$30 \times 10^{\wedge}(-6) \cdot R$	
		20 Hz; 40 Hz	$26 \times 10^{\wedge}(-6) \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$21 \times 10^{\wedge}(-6) \cdot R$	
		10 kHz	$23 \times 10^{\wedge}(-6) \cdot \Omega$	
	20 Ω	10 Hz	$29 \times 10^{\wedge}(-6) \cdot \Omega$	
20 Hz; 40 Hz		$25 \times 10^{\wedge}(-6) \cdot R$		
55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz		$19 \cdot 10^{-6} \cdot R$		
10 kHz		$22 \cdot 10^{-6} \cdot \Omega$		

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On-site calibration – DC and AC resistance

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	
AC resistance (magnitude of impedance)	50 Ω	10 Hz	$29 \times 10^{(-6)} \times R$	<i>R</i> = measured value <i>I</i> = current <i>f</i> = frequency
		20 Hz	$25 \cdot 10^{-6} \cdot R$	
		40 Hz	$20 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$19 \times 10^{(-6)} \cdot R$	
		1 kHz	$21 \times 10^{(-6)} \cdot R$	
		10 kHz	$25 \times 10^{(-6)} \cdot R$	
AC resistance (magnitude of impedance)	100 Ω	10 Hz	$29 \times 10^{(-6)} \cdot R$	<i>R</i> = measured value <i>I</i> = current <i>f</i> = frequency
		20 Hz	$25 \times 10^{(-6)} \cdot R$	
		40 Hz; 55 Hz	$19 \times 10^{(-6)} \cdot R$	
		120 Hz; 400 Hz	$18 \cdot 10^{-6} \cdot R$	
		500 Hz	$20 \times 10^{(-6)} \cdot R$	
		1 kHz	$31 \times 10^{(-6)} \cdot R$	
		10 kHz	$75 \times 10^{(-6)} \cdot R$	
	100 μΩ to 10 kΩ	10 Hz to 10 kHz	$\sqrt{U_i^2 + U_U^2} \cdot R$	<i>R</i> = measured value Constant current method <i>u_i</i> is the relative uncertainty of the calibration current <i>u_U</i> is the relative uncertainty of the measured voltage across the resistor
	0 Ω to 10 kΩ	20 Hz to 50 Hz	$2.5 \times 10^{-3} \times R + 3.1 \text{ m}\Omega$	<i>R</i> = measured value, direct measurement method
	> 10 kΩ to 110 MΩ		$2.3 \times 10^{-9} \cdot R2/\Omega + 2.5 \times 10^{-3} \cdot R$	
	0 Ω to 20 kΩ	> 50 Hz to 100 Hz	$1.0 \times 10^{-3} \cdot R + 2.6 \text{ m}\Omega$	
	> 20 kΩ to 110 MΩ		$2.3 \times 10^{-9} \cdot R2/\Omega + 1.3 \times 10^{-3} \cdot R$	
	0 Ω to 50 kΩ	> 100 Hz to 1 kHz	$0.5 \times 10^{-3} \times R + 1.3 \text{ m}\Omega$	
	> 50 kΩ to 110 MΩ		$1.1 \times 10^{-9} \cdot R2/\Omega + 1.2 \times 10^{-3} \cdot R$	
0 Ω to < 50 Ω	> 1 kHz to 30 kHz		$1.1 \times 10^{-3} \cdot R + 1.2 \text{ m}\Omega$	
50 Ω to 20 kΩ		$0.5 \times 10^{(-3)} \times R$		
> 20 kΩ to 110 MΩ		$1.1 \times 10^{-9} \cdot R2/\Omega + 0.79 \times 10^{-3} \cdot R$		
0 Ω to 20 Ω	> 30 kHz to 100 kHz	$1.1 \times 10^{(-3)} \times R + 1.2 \text{ m}\Omega$		
> 20 Ω to 20 kΩ		$0.5 \times 10^{(-3)} \times R$		

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Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	
AC resistance (magnitude of impedance)	> 20 kΩ to 110 MΩ		$1.3 \times 10^{-9} \cdot R^2/\Omega + 1.0 \times 10^{-3} \cdot R$	R = measured value Direct measurement method
	0 Ω to 100 Ω	> 100 kHz to 300 kHz	$1.1 \times 10^{-3} \cdot R + 2.2 \text{ m}\Omega$	
	> 100 Ω to 2 kΩ		$0.5 \times 10^{(-3)} \times R$	
	> 2 kΩ to 110 MΩ		$4.5 \times 10^{-9} \cdot R^2/\Omega + 0.9 \times 10^{-3} \times R$	
	0 Ω to 50 Ω	> 300 kHz to 1 MHz	$1.3 \times 10^{-3} \times R + 3.2 \text{ m}\Omega$	
	> 50 Ω to 2 kΩ		$0.7 \times 10^{(-3)} \cdot R$	
> 2 kΩ to 22 MΩ	$15 \times 10^{-9} \cdot R^2/\Omega + 1.1 \times 10^{-3} \cdot R$			
Energy E Defibrillator tester	5 J to 150 J		$2.3 \times 10^{-3} \times E + 49 \text{ mJ}$	E = Energy Monophasic or biphasic
	> 150 J to 360 J		$1.1 \times 10^{-3} \times E + 0.27 \text{ J}$	
Voltage ratio between bridge standards and measuring instruments	0 mV/V to 100 mV/V	DC voltage (bridge voltage): 1 V to 10 V	0.1 μV/V to 1.6 μV/V – see Matrix VM.2	

Matrix VM.2 'Voltage ratio'

Bridge voltage \ Measured value	10 V	5 V	2 V	1 V
0 mV/V	0.10 μV/V	0.10 μV/V	0.17 μV/V	0.35 μV/V
± 2 mV/V	0.10 μV/V	0.11 μV/V	0.26 μV/V	0.51 μV/V
± 5 mV/V	0.10 μV/V	0.13 μV/V	0.27 μV/V	0.52 μV/V
± 10 mV/V	0.10 μV/V	0.16 μV/V	0.31 μV/V	0.56 μV/V
± 20 mV/V	0.16 μV/V	0.20 μV/V	0.38 μV/V	0.66 μV/V
± 50 mV/V	0.35 μV/V	0.39 μV/V	0.58 μV/V	1 μV/V
± 100 mV/V	0.65 μV/V	0.73 μV/V	1.0 μV/V	1.6 μV/V

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On-site calibration – Electrical power

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
DC power	0 W to 110 kW	0 mV to 1100 V 0 µA to 100 A	$\sqrt{W_u^2 + W_l^2} \cdot P$ but not less than $44 \times 10^{(-6)} P + 5 \text{ fW}$	P = measured value
Power factor sources, measuring instruments	0 to 1	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$	$6,8 \times 10^{-12}$ to $2,1 \times 10^{-3}$	$PF = \cos(\Delta\varphi) =$ power factor $\Delta\varphi = \varphi_U - \varphi_I =$ phase angle U = rms value of the AC voltage I = RMS value of the alternating current The measurement uncertainties apply to sinusoidal signals.
		Additional range for measuring instruments with current clamps/current transformers: $10 \text{ Hz} \leq f \leq 100 \text{ Hz}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $100 \text{ A} \leq I \leq 1 \text{ kA}$	$7,8 \times 10^{-9}$ to $1,5 \times 10^{-4}$	See also matrices VM.21 to VM.25

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On-site calibration – Electrical power

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / procedure	Expanded measurement uncertainty	Comments
AC active power Sources, measuring instruments	0 W to 100 kW	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{(1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$ $0 \leq PF \leq 1$	7.5 pW up to 210 W	$P(U; I; PF)$ $= U \cdot I \cdot PF =$ AC active power $PF = \cos(\Delta\varphi) =$ power factor $\Delta\varphi$ $= \varphi_U - \varphi_I =$ phase angle $U =$ RMS value of the AC voltage $I =$ RMS value of the AC current
	0 W to 1 MW	Additional range for measuring instruments with current clamps/current transformers: $10 \text{ Hz} \leq f \leq 100 \text{ Hz}^{(1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $100 \text{ A} < I \leq 1 \text{ kA}$ $0 \leq PF \leq 1$	Current transformer: $3.8 \times 10^{-4} \times P$ not less than 2 μW Current clamps: $4.6 \times 10^{-3} \times P$ not less than 2 μW	The measurement uncertainties apply to sinusoidal signals. See also matrices VM.26 to VM.35
AC reactive power Sources, measuring instruments	-100 kvar to 100 kvar	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{(1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$ $0 \leq PF \leq 1$	7.5 pvar to 210 var	$Q = U \cdot I \cdot \sin(\Delta\varphi) =$ AC reactive power $PF = \cos(\Delta\varphi) =$ power factor $\Delta\varphi$ $= \varphi_U - \varphi_I =$ phase angle $U =$ RMS value of the AC voltage $I =$ RMS value of the alternating current
	-1 Mvar to 1 Mvar	Additional range for measuring instruments with current clamps/current transformers: $10 \text{ Hz} \leq f \leq 100 \text{ Hz}^{(1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{(1)}$ $100 \text{ A} < I \leq 1 \text{ kA}$ $0 \leq PF \leq 1$	Current transformer: $3.8 \times 10^{-4} \times Q$ not less than 2 μvar Current clamps: $4.6 \times 10^{-3} \times Q$ not less than 2 μvar	The measurement uncertainties apply to sinusoidal signals. See also matrices VM.26 to VM.35

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On-site calibration – Electrical power

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration	Measurement range / span	Measurement conditions /	Expanded measurement	Remarks
AC apparent power Sources, measuring	0 VA to 100 kVA	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}^{1)}$ $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $1 \text{ mA} \leq I \leq 100 \text{ A}$	59 pVA up to 7.6 VA	$S = U \cdot I$ $= P (U; I; PF = 1) =$ AC apparent power $PF = \cos(\Delta\varphi) =$ Power factor $\Delta\varphi = \varphi_U - \varphi_I =$ Phase angle $U =$ RMS value of the AC voltage $I =$ RMS value of the alternating current $P =$ AC active power The measurement uncertainties apply to sinusoidal signals. See also matrices VM.26 to VM.35 for $PF = 1$
	0 VA to 1 MVA	Additional range for measuring instruments with current clamps/current transformers: $1 \text{ mV} \leq U \leq 1 \text{ kV}^{1)}$ $10 \text{ Hz} \leq f \leq 100 \text{ Hz}^{1)}$ $1 \text{ mA} \leq I \leq 1 \text{ kA}$	Current transformer: $3.8 \times 10^{-4} \times S$ Current clamps: $4.6 \times 10^{-3} \times S$	

Matrix VM.21: Absolute measurement uncertainty of the measured quantity **power factor PF**
when calibrating **sources** in the range **2 A < I ≤ 20 A & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10	3.1×10^{-6}	3.0×10^{-6}	2.8×10^{-6}	2.5×10^{-6}	1.9×10^{-6}	1.4×10^{-6}	6.8×10^{-12}
45	9.8×10^{-6}	9.6×10^{-6}	9.0×10^{-6}	7.9×10^{-6}	5.9×10^{-6}	4.3×10^{-6}	6.8×10^{-11}
111	1.9×10^{-5}	1.9×10^{-5}	1.8×10^{-5}	1.5×10^{-5}	1.2×10^{-5}	8.4×10^{-6}	2.6×10^{-10}
1000	1.6×10^{-4}	1.6×10^{-4}	1.5×10^{-4}	1.3×10^{-4}	9.7×10^{-5}	7.1×10^{-5}	1.9×10^{-8}
10,000	1.6×10^{-3}	1.6×10^{-3}	1.5×10^{-3}	1.3×10^{-3}	9.7×10^{-4}	7.1×10^{-4}	1.6×10^{-6}

Matrix VM.22: Absolute measurement uncertainty of the measured quantity **power factor PF**
during the calibration of **sources** in the range **20 A < I ≤ 100 A & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.8	1
10	3.4×10^{-6}	3.4×10^{-6}	3.2×10^{-6}	2.8×10^{-6}	2.1×10^{-6}	1.5×10^{-6}	8.4×10^{-12}
45	1.1×10^{-5}	1.1×10^{-5}	1.0×10^{-5}	9.1×10^{-6}	6.8×10^{-6}	5.0×10^{-6}	9.2×10^{-11}
111	2.4×10^{-5}	2.3×10^{-5}	2.2×10^{-5}	1.9×10^{-5}	1.4×10^{-5}	1.0×10^{-5}	4.0×10^{-10}
1000	2.0×10^{-4}	2.0×10^{-4}	1.9×10^{-4}	1.6×10^{-4}	1.2×10^{-4}	8.8×10^{-5}	2.9×10^{-8}
10,000	2.0×10^{-3}	2.0×10^{-3}	1.9×10^{-3}	1.6×10^{-3}	1.2×10^{-3}	8.8×10^{-4}	2.9×10^{-6}

Matrix VM.23: Absolute measurement uncertainty of the measured quantity **power factor PF**

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for the calibration of **measuring instruments** in the range **2 A < I ≤ 20 A & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10	3,2×10 ⁻⁶	3,2×10 ⁻⁶	2,9×10 ⁻⁶	2,6×10 ⁻⁶	1,9×10 ⁻⁶	1,4×10 ⁻⁶	7,3×10 ⁻¹²
45	1,0 × 10 ⁻⁵	1,0 × 10 ⁻⁵	9,5×10 ⁻⁶	8,3×10 ⁻⁶	6,2×10 ⁻⁶	4,5×10 ⁻⁶	7,6×10 ⁻¹¹
111	2,1×10 ⁻⁵	2,0×10 ⁻⁵	1,9×10 ⁻⁵	1,6×10 ⁻⁵	1,2×10 ⁻⁵	9,0×10 ⁻⁶	3,0×10 ⁻¹⁰
1000	1,7×10 ⁻⁴	1,7×10 ⁻⁴	1,6×10 ⁻⁴	1,4×10 ⁻⁴	1,0×10 ⁻⁴	7,6×10 ⁻⁵	2,1×10 ⁻⁸
10,000	1,7×10 ⁻³	1,7×10 ⁻³	1,6×10 ⁻³	1,4×10 ⁻³	1,0×10 ⁻³	7,6×10 ⁻⁴	2,1×10 ⁻⁶

Matrix VM.24: Absolute measurement uncertainty of the measured quantity **power factor PF**

for the calibration of **measuring instruments** in the range **20 A < I ≤ 100 A & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10	3,6×10 ⁻⁶	3,5×10 ⁻⁶	3,3×10 ⁻⁶	2,8×10 ⁻⁶	2,1×10 ⁻⁶	1,5×10 ⁻⁶	8,9×10 ⁻¹²
45	1,2×10 ⁻⁵	1,2×10 ⁻⁵	1,1×10 ⁻⁵	9,5×10 ⁻⁶	7,1×10 ⁻⁶	5,2×10 ⁻⁶	1,0×10 ⁻¹⁰
111	2,5×10 ⁻⁵	2,4×10 ⁻⁵	2,3×10 ⁻⁵	2,0×10 ⁻⁵	1,5×10 ⁻⁵	1,1×10 ⁻⁵	4,4×10 ⁻¹⁰
1000	2,1×10 ⁻⁴	2,1×10 ⁻⁴	2,0×10 ⁻⁴	1,7×10 ⁻⁴	1,3 × 10 ⁻⁴	9,3 × 10 ⁻⁵	3,3 × 10 ⁻⁸
10,000	2,1×10 ⁻³	2,1×10 ⁻³	2,0×10 ⁻³	1,7×10 ⁻³	1,3×10 ⁻³	9,3×10 ⁻⁴	3,3×10 ⁻⁶

Matrix VM.25: Absolute measurement uncertainty of the measured quantity **power factor PF**

for the calibration of **measuring instruments with current clamps/current transformers** in the range **100 A < I ≤ 1 kA & 15 mV < U ≤ 1 kV**

f (Hz)	PF						
	0	0.2	0.4	0.6	0.8	0.9	1
10 Hz to 100 Hz	1,5×10 ⁻⁴	1,5×10 ⁻⁴	1,4×10 ⁻⁴	1,2×10 ⁻⁴	8,9×10 ⁻⁵	6,5×10 ⁻⁵	7,8×10 ⁻⁹

Matrix VM.26: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$)

and **apparent AC power** $S = U \cdot I$ (see values for PF = 1) when calibrating **sources** with **U = 2 mV and I = 100 μA**

f (Hz)	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
10	48 pW	54 pW	60 pW	68 pW	72 pW	77 hp
1000	34 pW	39 pW	44 pW	51 pW	55 pW	59 pW
10,000	340 pW	310 pW	270 pW	210 pW	160 pW	59 pW

Matrix VM.27: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for

$\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for PF = 1) during the calibration of **measuring instruments** with **U = 2 mV and I = 1 mA**

f (Hz)	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	1.0 nW	1.0 nW	1.1 nW	1.1 nW	1.1 nW	1.2 nW
1000	230 pW	320 pW	400 pW	490 pW	530 pW	580 pW
10,000	2.3 nW	2.1 nW	1.9 nW	1.5 nW	1.1 nW	580 pW

Matrix VM.28: Absolute measurement uncertainty of the measured quantities

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Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 20 \text{ mV}$ and $I = 100 \mu\text{A}$

$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$						
f (Hz)	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
10	7.5 pW	110 pW	170 pW	230 pW	260 pW	280 pW
1000	340 pW	320 pW	290 pW	250 pW	230 pW	190 pW
10,000	3.4 nW	3.1 nW	2.7 nW	2.0 nW	1.5 nW	200 pW

Matrix VM.29: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and

apparent AC power $S = U \cdot I$ (see values for $PF = 1$) when calibrating **measuring instruments** with $U = 20 \text{ mV}$ and $I = 1 \text{ mA}$

$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$						
f (Hz)	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
40	150 pW	730 pW	1.1 nW	1.4 nW	1.6 nW	1.8 nW
1000	2.3 nW	2.3 nW	2.2 nW	2.0 nW	1.9 nW	1.8 nW
10,000	23 nW	21 nW	19 nW	14 nW	10 nW	1.8 nW

Matrix VM.30: Absolute measurement uncertainty of the measured variables

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and

apparent AC power $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 20 \text{ V}$ and $I = 1 \text{ A}$

$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$						
f (Hz)	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
40	140 μW	250 μW	350 μW	440 μW	500 μW	550 μW
1000	2.1 mW	1.9 mW	1.7 mW	1.3 mW	1.0 mW	530 μW
10,000	21 mW	19 mW	17 mW	13 mW	9.1 mW	530 μW

Matrix VM.31: Absolute measurement uncertainty of the measured variables

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for

$\sqrt{1 - PF^2}$) and **apparent AC power** $S = U \cdot I$ (see values for $PF = 1$) during the calibration of **measuring instruments** with $U = 20 \text{ V}$ and $I = 1 \text{ A}$

$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{1 - PF^2}$						
f (Hz)	0 ± 1	0.4 ± 0.92	0.6 ± 0.8	0.8 ± 0.6	0.9 ± 0.44	1 ± 0
40	150 μW	260 μW	350 μW	450 μW	500 μW	550 μW
1000	2.3 mW	2.1 mW	1.9 mW	1.5 mW	1.1 mW	530 μW
10,000	23 mW	21 mW	19 mW	14 mW	10 mW	530 μW

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Matrix VM.32: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$)

and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 20 \text{ V}$ and $I = 20 \text{ A}$

	$\varphi \cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	3.5 mW	9.2 mW	13 mW	17 mW	20 mW	22 mW
1000	65 mW	60 mW	53 mW	43 mW	34 mW	22 mW
10,000	650 mW	590 mW	520 mW	390 mW	280 mW	22 mW

Matrix VM.33: Absolute measurement uncertainty of the measured quantities

AC active power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **AC reactive power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) when calibrating **measuring instruments** with $U = 20 \text{ V}$ and $I = 20 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	3.7 mW	9.3 mW	13 mW	17 mW	20 mW	22 mW
1000	70 mW	65 mW	58 mW	46 mW	36 mW	22 mW
10,000	700 mW	650 mW	560 mW	420 mW	310 mW	22 mW

Matrix VM.34: Absolute measurement uncertainty of the measured quantities

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) when calibrating **sources** with $U = 1 \text{ kV}$ and $I = 100 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	1.0 W	2.8 W	4.1 W	5.4 W	6.0 W	6.7 W
1000	20 W	19 W	17 W	14 W	11 W	7.6 W
10,000	200 W	190 W	160 W	120 W	89 W	7.6 W

Matrix VM.35: Absolute measurement uncertainty of the measured variables

Active AC power $P = U \cdot I \cdot \cos(\varphi)$ (see values for PF) **Reactive AC power** $Q = U \cdot I \cdot \sin(\varphi)$ (see values for $\sqrt{1 - PF^2}$) and **AC apparent power** $S = U \cdot I$ (see values for $PF = 1$) during the calibration of **measuring instruments** with $U = 1 \text{ kV}$ and $I = 100 \text{ A}$

	$\cos(\varphi) = PF \mid \sin(\varphi) = \pm \sqrt{(1 - PF^2)}$					
f (Hz)	0 ±1	0.4 ±0.92	0.6 ±0.8	0.8 ±0.6	0.9 ±0.44	1 ±0
40	1.1 W	2.8 W	4.1 W	5.4 W	6.0 W	6.7 W
1000	21 W	20 W	18 W	14 W	12 W	7.6 W
10,000	210 W	200 W	170 W	130 W	93 W	7.6 W

¹⁾ The specified range applies only if the maximum volt-hertz product, as shown in Figure A of the Operator's Manual for the Multi-Function Calibrator 5700A/5720A Series II, May 1996, Rev. 2, 3/05, is observed.

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On-site calibration – phase angle

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration	Measurement range /	Measurement conditions /	Expanded measurement	Comments
Phase angle between sinusoidal Voltage signal and sinusoidal current signal sources	-180° to 180°	10 Hz ≤ f ≤ 10 kHz mV ≤ U _{rms} ≤ 1 kV		Δφ = φ _U - φ _I = Phase angle
		100 μA ≤ I _{eff.} ≤ 10 mA		I(t) = √2 I _{eff.} sin(2πft + φ _I)
		f = 10 Hz	0.21 m°	U(t) = √2 U _{eff.} sin(2πft + φ _U)
		f = 45 Hz	0.57 m°	
		f = 111 Hz	1.1 m°	f = frequency I _{eff.} = RMS value of the alternating current U _{eff.} = RMS value of the alternating voltage
		1 kHz ≤ f ≤ 10 kHz	360° · f · 27 ns	
		10 mA < I _{rms} ≤ 200 mA		Measurements at voltages ≤ 15 mV in the frequency range 10 Hz to < 1 kHz, as well as deviating measurement conditions, may increase the measurement uncertainty.
		f = 40 Hz	0.37 m°	
		f = 100 Hz	0.72 m°	20 A < I _{eff.} ≤ 20 A
		1 kHz ≤ f ≤ 10 kHz	360° · f · 18 ns	
		200 mA < I _{eff.} ≤ 2 A		20 A < I _{rms} ≤ 100 A
		f = 40 Hz	0.40 m°	
		f = 100 Hz	0.68 m°	f = 10 Hz
		1 kHz ≤ f ≤ 10 kHz	360° · f · 17 ns	
		2 A < I _{eff.} ≤ 20 A		f = 45 Hz
		f = 10 Hz	0.18 m°	
		f = 45 Hz	0.57 m°	f = 111 Hz
		f = 111 Hz	1.1 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 26 ns	f = 10 Hz
		20 A < I _{rms} ≤ 100 A		
f = 10 Hz	0.20 m°	f = 45 Hz		
f = 45 Hz	0.65 m°			
f = 111 Hz	1.4 m°	1 kHz ≤ f ≤ 10 kHz		
1 kHz ≤ f ≤ 10 kHz	360° · f · 32 ns			

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On-site calibration – phase angle

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration	Measurement range / span	Measurement conditions /	Expanded measurement	Remarks
Phase angle between sinusoidal Voltage signal and sinusoidal current signal Measuring instruments	-180° to 180°	10 Hz ≤ f ≤ 10 kHz 1 mV ≤ U _{rms} ≤ 1 kV		$\Delta\varphi = \varphi_U - \varphi_I =$ Phase angle
		1 mA ≤ I _{rms} ≤ 2 A		I(t) =
		f = 40 Hz	0.42 m°	$\sqrt{2} I_{\text{eff.}} \sin(2\pi f t + \varphi_I)$
		f = 100 Hz	0.76 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 19 ns	U(t) =
		2 A < I _{rms} ≤ 20 A		$\sqrt{2} U_{\text{eff.}} \sin(2\pi f t + \varphi_U)$
		f = 10 Hz	0.18 m°	f = frequency
		f = 45 Hz	0.60 m°	I _{eff.} = root mean square value of the alternating current
		f = 111 Hz	1.2 m°	U _{eff.} = RMS value of the AC voltage
		1 kHz ≤ f ≤ 10 kHz	360° · f · 28 ns	
		20 A < I _{rms} ≤ 100 A		
		f = 10 Hz	0.21 m°	Measurements at voltages ≤ 15 mV in the frequency range
		f = 45 Hz	0.68 m°	10 Hz to < 1 kHz, as well as deviating measurement conditions, may increase the measurement uncertainty
		f = 111 Hz	1.4 m°	
		1 kHz ≤ f ≤ 10 kHz	360° · f · 34 ns	

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On-site calibration – inductance and capacitance

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Inductance	0 µH		0.03 µH	2-wire short-circuit
	0 µH to 1.1 H	100 Hz to 10 kHz		<i>L</i> = measured value Absolute value of impedance $50 \text{ m}\Omega \leq Z \leq 11 \text{ k}\Omega$. Minimum declarable fixed measurement uncertainties for direct measurement or substitution on GR 1482 or equivalent models.
	100 µH	100 Hz 1 kHz 10 kHz	$0.65 \times 10^{(-3)} \cdot L$ $0.24 \times 10^{(-3)} \cdot L$ $0.27 \times 10^{(-3)} L$	
	1 mH	100 Hz 1 kHz 10 kHz	$0.14 \times 10^{(-3)} \cdot L$ $0.13 \times 10^{(-3)} \cdot L$ $0.17 \times 10^{(-3)} L$	
	10 mH	100 Hz; 1 kHz 10 kHz	$0.11 \times 10^{(-3)} L$ $0.16 \times 10^{(-3)} \times L$	
	100 mH	100 Hz; 1 kHz 10 kHz	$0.12 \times 10^{(-3)} \cdot L$	
			$0.26 \times 10^{(-3)} \cdot L$	
1 H	100 Hz, 1 kHz	$0.20 \times 10^{(-3)} L$		
Capacitance	0 pF		0.2 pF	Open circuit
	0 pF to 10 µF	100 Hz to 1 MHz		<i>C</i> = measured value Magnitude of impedance $1 \Omega \leq Z \leq 110 \text{ M}\Omega$. fixed-value measurement uncertainties for direct measurement or substitution on HP 16381A or GR 1404 / 1409 or equivalent.
	1 pF	1 kHz 10 kHz	$0.47 \times 10^{(-3)} C$ $0.31 \times 10^{(-3)} C$	
	10 pF	1 kHz 10 kHz; 100 kHz 1 MHz	$84 \times 10^{(-6)} C$ $0.10 \times 10^{(-3)} C$ $0.13 \times 10^{(-3)} C$	
	100 pF	1 kHz	$56 \times 10^{(-6)} C$	
	1 nF	1 kHz 100 kHz	$58 \times 10^{(-6)} C$ $0.11 \times 10^{(-3)} C$	
	10 nF	100 Hz 1 kHz 10 kHz	$0.21 \times 10^{(-3)} C$	
			$0.14 \times 10^{(-3)} \cdot C$ $0.13 \times 10^{(-3)} C$	
	100 nF	100 Hz; 1 kHz; 10 kHz	$0.16 \times 10^{(-3)} C$	
1 µF	100 Hz; 1 kHz 10 kHz	$0.12 \times 10^{(-3)} C$ $0.21 \times 10^{(-3)} C$		

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On-site calibration – time and frequency

Calibration and measurement capabilities (CMC)				
Measured quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Frequency f Measurement and synthesis	0.01 Hz to 40 GHz		$0.5 \times 10^{-9} \cdot f + u_{TF}$	f : measured value u_{TF} : trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 0 ns to 200 s 1 μ s to 100 h		1.3 ns $1.5 \times 10^{(-6)} \times \Delta t + 50$ ps $10 \times 10^{(-9)} \times \Delta t + 1$ μ s	
	1 s to 100 h		$13 \times 10^{-6} \times \Delta t + 0.82$ s	
Rate deviation	0 s/d to 100 s/d		$1.3 \times 10^{(-7)} = 0.011$ s/d	Electronic or mechanical watches
Rotational speed	0.02 s^{-1} to 3500 s^{-1}		$3.7 \times 10^{(-6)} \times f$	f : measured value

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On-site calibration – high-frequency and radiation quantities On-site

calibration – high-frequency quantities

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Vertical oscilloscopes	1 mV to 5 V 5 mV to 200 V	DC to 10 kHz	$1.2 \times 10^{(-3)} \times U + 12 \mu\text{V}$	U : measured value 50 Ω 1 MΩ
Oscilloscope horizontal	25 ps to 40 s		$0.12 \times 10^{(-6)} \cdot T + 0.1 \text{ ps}$	T : measured value
Bandwidth f (frequency response)	40 Hz to 6 GHz		$6.3 \times 10^{(-3)} \times f^2/\text{GHz}$ $+ 20 \times 10^{(-3)} \times f$	f = measured value
	> 6 GHz to 40 GHz		$75 \cdot 10^{(-3)} \cdot f$	
Acceleration time	30 ps to 45 ps > 45 ps –1 ms	0.1 V –3 V	5 ps $10 \times 10^{(-3)} \times T + 3 \text{ ps}$	Fluke 9500/9550
	70 ps to 85 ps > 85 ps to 310 ps > 310 ps to 650 ps > 650 ps to 1 ms	0.1 V to 3 V	$78 \times 10^{(-3)} \times T$ $67 \times 10^{(-3)} \times T$ $58 \times 10^{(-3)} \times T$ $56 \times 10^{(-3)} \times T$	calculated from the 3 dB bandwidth T : measured value
Frequency f Time base	10 MHz		$0.2 \times 10^{(-6)} \times f$	
Burst generator output voltage Peak value U_s	100 V to 4 kV	under 50 Ω or 1 kΩ load	$48 \times 10^{(-3)} \cdot U_s$	
Rise time and pulse duration T_r	3 ns to 1 μs		$41 \cdot 10^{(-3)} \cdot T_r$	
Burst duration and burst period T	10 μs to 1 s		$5 \cdot 10^{(-3)} \cdot T$	
Pulse frequency f	100 Hz to 500 kHz		$1 \cdot 10^{(-3)} \cdot f$	
Surge voltage generator				
Rise time t_{r,U_s} of the open-circuit voltage	15 ns to 100 ms		$3\% \cdot t_{r,U_s} + 1 \text{ ns}$	
Rise time t_{r,I_s} of the short-circuit current	100 ns to 100 ms		$3\% \cdot t_{r,I_s} + 2 \text{ ns}$	
Rise time t_H of the waveform	0.5 μs to 100 ms		$5\% \cdot t_H$	
Peak value of the open-circuit voltage U_s	0.1 kV to 7 kV		$3.3\% \cdot U_s$	
RMS value of the short-circuit current I_s	10 A to 5 kA		$3.5\% \cdot I_s$	
	> 5 kA to 10 kA		$3.8\% \cdot I_s$	

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On-site calibration – high-frequency measurement quantities

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Pulsed measured quantities * Measuring receiver Display behaviour for pulses Amplitude relationship (absolute calibration)	9 kHz to 150 kHz	EN 55016-1-1:2015	0.35 dB	Band A
	> 150 kHz to 30 MHz			Band B
	> 30 MHz to 300 MHz		0.40 dB	Band C
	> 300 MHz to 1 GHz			Band D
Change in display with the pulse frequency (relative calibration)	Pulse repetition frequency		0.30 dB	Band A
	0.1 Hz –2 kHz			Band B
	0.1 Hz to 50 kHz		0.35 dB	Band C and Band D
0.1 Hz to 1 MHz				

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On-site calibration – high-frequency measurement parameters

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)				Comments
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty		
RF power Input power and calibration factor of RF power meters	10 fW to < 100 fW	DC to 2 GHz	$21 \times 10^{(-3)} \cdot P$	PC Type N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz	
		> 2 GHz to < 5 GHz	$26 \times 10^{(-3)} \times P$		
		5 GHz to < 9 GHz	$34 \times 10^{(-3)} \cdot P$		
		9 GHz to < 12 GHz	$40 \times 10^{(-3)} \cdot P$		
		12 GHz to 15 GHz	$48 \times 10^{(-3)} \cdot P$		
		> 15 GHz to 18 GHz	$54 \times 10^{(-3)} P$		
	100 fW to 1 pW	DC to 100 MHz	$18 \cdot 10^{-3} \cdot P$	*) Other connectors increase the measurement uncertainty. P = measured value (W)	
		> 100 MHz to 2 GHz	$20 \times 10^{-3} \times P$		
		> 2 GHz to 8 GHz	$22 \times 10^{-3} \cdot P$		
		> 8 GHz to 12 GHz	$24 \times 10^{(-3)} \cdot P$		
		> 12 GHz to 40 GHz	$29 \times 10^{(-3)} P$		
	> 1 pW to 10 pW	DC to 100 MHz	$13 \times 10^{(-3)} \cdot P$		
		> 100 MHz to 2 GHz	$15 \times 10^{(-3)} \cdot P$		
		> 2 GHz to 8 GHz	$18 \times 10^{(-3)} \cdot P$		
		> 8 GHz to 12 GHz	$20 \cdot 10^{-3} \cdot P$		
		> 12 GHz to 26.5 GHz	$26 \times 10^{(-3)} \cdot P$		
		> 26.5 GHz to 40 GHz	$29 \times 10^{(-3)} P$		
	> 10 pW to 1 nW	DC to 100 MHz	$12 \times 10^{(-3)} \cdot P$		
		> 100 MHz to 2 GHz	$14 \times 10^{(-3)} \cdot P$		
		> 2 GHz to 8 GHz	$17 \times 10^{-3} \cdot P$		
		> 8 GHz to 12 GHz	$20 \times 10^{(-3)} \cdot P$		
		> 12 GHz to 40 GHz	$22 \cdot 10^{-3} \cdot P$		
	> 1 nW to 100 nW	DC to 2 GHz	$10 \times 10^{(-3)} P$		
		> 2 GHz to 8 GHz	$12 \times 10^{-3} \cdot P$		
> 8 GHz to 12 GHz		$13 \times 10^{-3} \cdot P$			
> 12 GHz to 40 GHz		$15 \times 10^{-3} \cdot P$			

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On-site calibration – high-frequency measurement quantities

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
RF power Input power and calibration factor of RF power meters	> 100 nW to 10 µW	DC to 100 MHz	$7.1 \times 10^{(-3)} \cdot P$	PC Type-N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz *) Other connectors increase the measurement uncertainty. P = measured value (W)
		> 100 MHz to 2 GHz	$9.4 \times 10^{(-3)} \times P$	
		> 2 GHz to 8 GHz	$11 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 12 GHz	$13 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 40 GHz	$15 \times 10^{(-3)} \cdot P$	
	> 10 µW to 100 mW	DC to 100 MHz	$6.1 \times 10^{(-3)} \cdot P$	*) Other connectors increase the measurement uncertainty. P = measured value (W)
		> 100 MHz to 2 GHz	$7.9 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$9.3 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 12 GHz	$11 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 40 GHz	$13 \times 10^{(-3)} \cdot P$	
RF power Output power and calibration factor of RF sources	1 mW	50 MHz	$5 \times 10^{(-3)} \cdot P$	Substitution
	0.1 pW to < 10 pW	50 MHz	$27 \times 10^{(-3)} \cdot P$	PC Type-N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz *) Other connectors increase the measurement uncertainty.
		10 MHz to 2 GHz	$30 \times 10^{(-3)} \times P$	
		> 2 GHz to 3 GHz	$35 \times 10^{(-3)} \cdot P$	
	10 pW to < 1 nW	50 MHz	$21 \cdot 10^{(-3)} \cdot P$	*) Other connectors increase the measurement uncertainty.
		10 MHz to 2 GHz	$25 \times 10^{(-3)} P$	
		> 2 GHz to 3 GHz	$31 \times 10^{(-3)} \cdot P$	
	1 nW to < 100 nW	50 MHz	$17 \times 10^{(-3)} P$	$f \leq 5$ GHz: $ \Gamma G \leq 0.025$ 5 GHz < $f \leq 20$ GHz: $ \Gamma G \leq 0.1$ 20 GHz < $f \leq 33$ GHz: $ \Gamma G \leq 0.15$ 33 GHz < $f \leq 40$ GHz: $ \Gamma G \leq 0.3$
		10 MHz to 2 GHz	$21 \times 10^{(-3)} P$	
		> 2 GHz to 4 GHz	$25 \times 10^{(-3)} \cdot P$	
		> 4 GHz to 12 GHz	$38 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 18 GHz	$71 \cdot 10^{(-3)} \cdot P$	
	100 nW to < 1 µW	> 18 GHz to 26.5 GHz	$93 \cdot 10^{(-3)} \cdot P$	$f =$ frequency (Hz) P = measured value (W) $ \Gamma G =$ reflection coefficient of the calibration object
		8 kHz to < 10 MHz	$28 \times 10^{(-3)} P$	
		10 MHz to 50 MHz	$13 \times 10^{(-3)} \cdot P$	
		> 50 MHz to 4 GHz	$14 \times 10^{(-3)} \cdot P$	
		> 4 GHz to 5 GHz	$17 \times 10^{(-3)} \cdot P$	
		> 5 GHz to 12 GHz	$25 \times 10^{(-3)} \cdot P$	
		> 12 GHz– 20 GHz	$28 \cdot 10^{(-3)} \cdot P$	
		> 20 GHz to 33 GHz	$37 \cdot 10^{(-3)} \cdot P$	
> 33 GHz to 40 GHz	$90 \times 10^{(-3)} \cdot P$			

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On-site calibration – high-frequency measurement quantities

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
RF power Output power and calibration factor of RF sources	1 μW to < 10 μW	8 kHz to < 10 MHz	$18 \times 10^{(-3)} \times P$	PC Type-N *) up to 18 GHz PC-3.5 mm *) up to 33 GHz PC-2.92 mm *) up to 40 GHz *) Other connectors increase the measurement uncertainty.
		10 MHz to 50 MHz	$13 \times 10^{(-3)} \times P$	
		> 50 MHz to 4 GHz	$14 \times 10^{(-3)} \cdot P$	
		> 4 GHz to 5 GHz	$17 \times 10^{(-3)} \cdot P$	
		> 5 GHz to 12 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 20 GHz	$25 \times 10^{(-3)} \cdot P$	
		> 20 GHz to 33 GHz	$37 \times 10^{(-3)} \cdot P$	
	10 μW to < 100 μW	DC to < 10 MHz	$9.0 \times 10^{-3} P$	$f \leq 5$ GHz: $ \Gamma G \leq 0.025$ 5 GHz < $f \leq 20$ GHz: $ \Gamma G \leq 0.1$ 20 GHz < $f \leq 33$ GHz: $ \Gamma G \leq 0.15$ 33 GHz < $f \leq 40$ GHz: $ \Gamma G \leq 0.3$
		10 MHz to 100 MHz	$10 \times 10^{(-3)} \cdot P$	
		>100 MHz to 2 GHz	$12 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$13 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 10 GHz	$15 \times 10^{(-3)} \cdot P$	
		> 10 GHz to 12 GHz	$16 \times 10^{(-3)} \cdot P$	
		> 12 GHz to 30 GHz	$20 \times 10^{-3} \cdot P$	
		> 30 GHz to 33 GHz	$37 \cdot 10^{-3} \cdot P$	
	100 μW to 0.1 W	DC to < 10 MHz	$5.6 \times 10^{-3} P$	$f =$ frequency (Hz) $P =$ measured value (W) $ \Gamma G =$ Reflection coefficient of the calibration object
		10 MHz to 100 MHz	$7.5 \times 10^{(-3)} \cdot P$	
		>100 MHz to 2 GHz	$10 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 8 GHz	$11 \times 10^{(-3)} \cdot P$	
		> 8 GHz to 10 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 10 GHz to 12 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 30 GHz	$19 \times 10^{(-3)} \cdot P$	
		> 30 GHz to 33 GHz	$39 \cdot 10^{-3} \cdot P$	
	> 0.1 W to 1 W	DC to 50 MHz	$11 \times 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$13 \times 10^{(-3)} \cdot P$	
		> 2 GHz to 4 GHz	$16 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$30 \times 10^{(-3)} \cdot P$	
> 1 W to 70 W	DC to 3 GHz	$38 \times 10^{-3} \cdot P$		
> 70 W to 250 W	DC to 500 MHz	$37 \times 10^{-3} \cdot P$		

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On-site calibration – high-frequency measurement parameters

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
RF voltage ^{UHF} sources with HF voltage display relative to 50 Ω	2.2 μV to 220 μV	DC to 3 GHz	$^{HF} 2$	$W(P)$ is the relative uncertainty of the measured power at $z_0 = 50 \Omega$ **)
	220 μV to 7 V	DC to 18 GHz		
	2.2 μV up to 220 μV	DC to 3 GHz		
	2.2 mV to 2 V	DC to 40 GHz		
RF voltage ^{UHF} Measuring instruments and receivers with RF voltage display relative to 50 Ω		DC to 18 GHz	$W(U) \frac{W(P_{inc})}{2}$	$W(P_{inc})$ is the relative uncertainty of the injected power with respect to $z_0 = 50 \Omega$ **) ***)
	0.7 μV to 2 V			
	2.2 mV to 2 V			
RF power Receiver noise indicator	DC to 40 GHz		1.6 dB	Performance > -170 dB (1 mW) relative to a 1 Hz bandwidth
	Signal level difference	0 dBc to 100 dBc	100 Hz to 26.5 GHz 100 Hz to 40 GHz	1.3 dB 2.7 dB

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On-site calibration – high-frequency measurement quantities

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Filter bandwidth	1 Hz to 10 MHz		0.5%	Signal-to-noise ratio (SNR) ≥ 70 dB
Form factor	> 1:1 up to 5:1 > 5:1 up to 10:1 > 10:1 up to 20:1		3% 6% 12%	Signal-to-noise ratio (SNR) ≥ 15 dB
Switching deviation			0.02 dB	
Display linearity	0 dB up to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB > 80 dB up to 100 dB > 100 dB to 110 dB	100 kHz to 500 MHz	0.06 dB 0.07 dB 0.09 dB 0.1 dB 0.2 dB	SNR ≥ 50 dB $ r_{L,DUT} \leq 0.05$ $f \leq 500$ MHz
Input attenuator or intermediate frequency amplifier	0 dB to 30 dB > 30 dB up to 60 dB > 60 dB to 80 dB > 80 dB up to 100 dB > 100 dB to 110 dB	100 kHz to 500 MHz	0.06 dB 0.07 dB 0.09 dB 0.1 dB 0.2 dB	Comparison with external step attenuator $ r_{L,DUT} \leq 0.05$ $f \leq 500$ MHz
	0 dB up to 30 dB > 30 dB up to 60 dB > 60 dB up to 80 dB	100 kHz to 500 MHz	0.04 dB 0.06 dB 0.08 dB	Step-by-step display comparison: SNR ≥ 50 dB, Receiver linearity < (0.01 dB + 0.005 dB/10 dB)
RF gain (amplifier)	0 dB up to 70 dB	DC to 100 MHz > 100 MHz to 2 GHz > 2 GHz to 4 GHz > 4 GHz to 18 GHz	0.19 dB 0.26 dB 0.3 dB 0.5 dB	BNC connector up to max. 2 GHz N-connector and BNC connector, 50 Ω; other connectors increase the measurement uncertainty
	0 dB up to 70 dB	DC to 100 MHz > 100 MHz to 4 GHz > 4 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	0.21 dB 0.3 dB 0.6 dB 0.7 dB	2.92 mm compatible connector, 50 Ω; other connectors increase the measurement uncertainty
RF current Clamp meters	100 μA up to 50 mA	40 Hz to 10 MHz > 10 MHz to 30 MHz > 30 MHz to 65 MHz	$14 \times 10^{(-3)} \times f$ $18 \times 10^{(-3)} \times f$ $20 \times 10^{(-6)} f^2 \times f$	Tektronix 015-0601-50. In conjunction with oscilloscope f: measured value f: Frequency in MHz
Non-linearity of RF power meters	10 nW to 1 W	50 MHz	$5.5 \times 10^{(-3)} (0.024 \text{ dB})$	R&S NRVC-B2 60 dB max.

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On-site calibration – high-frequency measurement quantities

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
HF reflection coefficient * Magnitude $ \Gamma $	0. to 0. .1	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0)	0.003 to 0.013 See Matrix VM.3	N-connector, 50 Ω ; other connectors increase the measurement uncertainty Measurement uncertainty in units of the magnitude of the reflection coefficient
	0 to 1	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0)	0.003 to 0.016 See Matrix VM.4	3.5 mm connector Measurement uncertainty in units of the magnitude of the reflection coefficient
	0. to 0. .1	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0)	0.004 to 0.017 See Matrix VM.5	2.92 mm connector Measurement uncertainty in units of the magnitude of the reflection factor
RF reflection coefficient * Phase angle φ	-180° to +180°	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0)	0.2° to 4.7° See Matrix VM.6	N-connector, 50 Ω ; other connectors increase the measurement uncertainty
	-180° to +180°	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0)	0.3° to 5.8° See Matrix VM.7	3.5 mm connector
	-180° to +180°	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0)	0.3° to 6.3° See Matrix VM.8	2.92 mm connector
RF attenuation Attenuators	0 dB up to 30 dB	100 kHz to 10 GHz > 10 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	0.03 dB 0.05 dB 0.09 dB 0.10 dB	L is the measured attenuation, ****) $ \Delta UT \leq 0.01$ $f \leq 500$ MHz $ r_{r,DUT} \leq 0.05$ 500 MHz < $f \leq 10$ GHz $ r_{r,DUT} \leq 0.08$
	> 30 dB up to 60 dB	100 kHz to 10 GHz > 10 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	0.01 dB/dB · L 0.02 dB + 0.001 dB/dB · L 0.10 dB + 0.001 dB/dB · L 0.11 dB + 0.001 dB/dB · L	10 GHz < $f \leq 18$ GHz $ r_{r,DUT} \leq 0.1$ 18 GHz < $f \leq 40$ GHz

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On-site calibration – high-frequency measurement quantities

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / methods	Expanded measurement uncertainty	Comments
HF attenuation Attenuators	> 60 dB to 70 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.07 dB 0.10 dB	$ r_{L,DUT} \leq 0.01$ $f \leq 500 \text{ MHz}$ $ r_{L,DUT} \leq 0.05$ $500 \text{ MHz} < f \leq 3 \text{ GHz}$
	> 70 dB to 80 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.08 dB 0.2 dB	
	> 80 dB to 100 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.1 dB 0.3 dB	
RF attenuation *	0 dB to 60 dB	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0)	0.01 dB to 0.09 dB See Matrix VM.9	N-connector, 50 Ω ; other connectors increase the measurement uncertainty
	0 dB to 60 dB	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0)	0.01 dB to 0.22 dB See Matrix VM.10	3.5 mm connector
	0 dB to 60 dB	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0)	0.01 dB to 0.32 dB See Matrix VM.11	2.92 mm connector
RF attenuation * Phase angle φ	-180° to +180°	9 kHz to 18 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0)	0.2° to 0.8° See Matrix VM.12	N-connector, 50 Ω ; other connectors increase the measurement uncertainty
	-180° to +180°	9 kHz to 33 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0)	0.2° to 1.8° See Matrix VM.13	3.5 mm connector
	-180° to +180°	45 MHz to 45 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0)	0.2° to 2.5° See Matrix VM.14	2.92 mm connector

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Matrix VM.3 “RF reflection coefficient, magnitude $|\Gamma|$; N-connector 50 Ω ”

Measurement uncertainty expressed in units of the magnitude of the reflectance.

Absolute value $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0	0.003 to 0.004	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.1	0.003 to 0.005	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.2	0.003 to 0.005	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.3	0.003 to 0.006	0.003 to 0.004	0.003 to 0.008	0.008 to 0.009
0.4	0.003 to 0.005	0.004	0.003 to 0.008	0.008 to 0.009
0.5	0.003 to 0.006	0.004	0.004 to 0.009	0.008 to 0.009
0.6	0.004 to 0.006	0.004 to 0.005	0.004 to 0.009	0.009
0.7	0.004 to 0.006	0.005	0.005 to 0.010	0.009 to 0.010
0.8	0.004 to 0.006	0.005 to 0.006	0.005 to 0.010	0.010
0.9	0.004 to 0.007	0.006	0.005 to 0.011	0.011 to 0.012
1	0.003 to 0.006	0.004 to 0.006	0.004 to 0.012	0.011 to 0.013

Matrix VM.4 ‘RF reflection coefficient, magnitude $|\Gamma|$; 3.5 mm connector’

Measurement uncertainty in units of the magnitude of the reflection coefficient.

Absolute value $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0	0.003 to 0.004	0.003	0.003 to 0.004	0.004 to 0.005	0.005 to 0.008	0.008 to 0.010
0.1	0.003 to 0.005	0.003	0.003 to 0.004	0.004 to 0.005	0.005 to 0.008	0.008 to 0.010
0.2	0.003 to 0.006	0.003 to 0.004	0.004 to 0.005	0.004 to 0.005	0.005 to 0.008	0.008 to 0.010
0.3	0.003 to 0.006	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.011
0.4	0.004 to 0.005	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.011
0.5	0.004 to 0.006	0.004 to 0.005	0.004 to 0.005	0.005 to 0.006	0.005 to 0.008	0.008 to 0.011
0.6	0.004 to 0.006	0.005	0.005 to 0.006	0.006	0.006 to 0.009	0.009 to 0.012
0.7	0.004 to 0.006	0.005 to 0.006	0.005 to 0.006	0.006 to 0.007	0.006 to 0.010	0.009 to 0.013
0.8	0.004 to 0.007	0.005 to 0.006	0.005 to 0.007	0.006 to 0.007	0.006 to 0.010	0.010 to 0.014
0.9	0.004 to 0.007	0.006 to 0.007	0.006 to 0.008	0.007 to 0.008	0.007 to 0.011	0.011 to 0.015
1	0.004 to 0.006	0.005 to 0.006	0.005 to 0.008	0.006 to 0.009	0.007 to 0.012	0.011 to 0.016

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Matrix VM.5 'RF reflection coefficient, magnitude $|\Gamma|$; 2.92 mm connector'

Measurement uncertainty in units of the magnitude of the reflection coefficient.

Absolute value $ \Gamma $	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0	0.004	0.004	0.004	0.004	0.004 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.1	0.004	0.004	0.004	0.004	0.004 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.2	0.004	0.004	0.004	0.004	0.004 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.3	0.004	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.4	0.004	0.004	0.004 to 0.005	0.005	0.005 to 0.008	0.008 to 0.010	0.010	0.010 to 0.011
0.5	0.004 to 0.005	0.005	0.005	0.005	0.005 to 0.008	0.008 to 0.010	0.010	0.010 to 0.012
0.6	0.005	0.005	0.005 to 0.006	0.005 to 0.006	0.005 to 0.009	0.008 to 0.011	0.010 to 0.011	0.010 to 0.012
0.7	0.005 to 0.006	0.005	0.005 to 0.006	0.006	0.006 to 0.009	0.009 to 0.012	0.011 to 0.012	0.011 to 0.013
0.8	0.005 to 0.006	0.006	0.006 to 0.007	0.006 to 0.007	0.006 to 0.010	0.009 to 0.013	0.012 to 0.013	0.012 to 0.014
0.9	0.005 to 0.007	0.006 to 0.007	0.006 to 0.008	0.007 to 0.008	0.007 to 0.011	0.010 to 0.014	0.013 to 0.014	0.013 to 0.015
1	0.005 to 0.007	0.005 to 0.006	0.005 to 0.008	0.007 to 0.008	0.006 to 0.012	0.011 to 0.015	0.014 to 0.015	0.014 to 0.017

Matrix VM.6 "HF reflection coefficient, phase angle ϕ ; N-connector 50 Ω "

Magnitude $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0.1	1.4° to 2.2°	1.5° to 1.9°	1.5° to 4.5°	4.4° to 4.7°
0.2	0.7° to 1.4°	0.8° to 1.0°	0.8° to 2.3°	2.2° to 2.4°
0.3	0.5° to 1.0°	0.6° to 0.7°	0.6° to 1.5°	1.5° to 1.6°
0.4	0.4° to 0.7°	0.5° to 0.6°	0.5° to 1.2°	1.2°
0.5	0.4° to 0.6°	0.4° to 0.5°	0.4° to 1.0°	1.0°
0.6	0.4° to 0.5°	0.4° to 0.5°	0.4° to 0.9°	0.9°
0.7	0.3° to 0.5°	0.4°	0.4° to 0.8°	0.8°
0.8	0.3° to 0.5°	0.4°	0.4° to 0.8°	0.7° to 0.8°
0.9	0.3° to 0.4°	0.4°	0.4° to 0.8°	0.7° to 0.8°
1	0.2° to 0.4°	0.3° to 0.4°	0.3° to 0.7°	0.7° to 0.8°

Matrix VM.7 "HF reflection coefficient, phase angle ϕ ; 3.5 mm connector"

Magnitude $ \Gamma $	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0.1	1.5° to 2.6°	1.6° to 1.7°	1.7° to 2.3°	2.3° to 2.6°	2.4° to 4.2°	4.1° to 5.8°
0.2	0.8° to 1.5°	0.9	0.9° to 1.2°	1.2° to 1.4°	1.3° to 2.2°	2.2° to 3.0°
0.3	0.6° to 1.1°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.0°	1.0° to 1.6°	1.6° to 2.1°
0.4	0.5° to 0.8°	0.5° to 0.6°	0.6° to 0.8°	0.7° to 0.9°	0.8° to 1.3°	1.3° to 1.7°
0.5	0.5° to 0.7°	0.5°	0.5° to 0.7°	0.7° to 0.8°	0.8° to 1.2°	1.1° to 1.5°
0.6	0.4° to 0.6°	0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.1°	1.1° to 1.4°
0.7	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.3°
0.8	0.3° to 0.5°	0.4° to 0.5°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.3°
0.9	0.3° to 0.5°	0.4° to 0.5°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.3°
1	0.3° to 0.4°	0.3° to 0.4°	0.3° to 0.5°	0.5° to 0.7°	0.7° to 1.0°	0.9° to 1.2°

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Matrix VM.8 “HF reflection coefficient, phase angle ϕ ; 2.92 mm connector”

Magnitude $ \Gamma $	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0.1	2.0° to 2.1°	2.0°	2.0° to 2.3°	2.2° to 2.3°	2.2° to 4.2°	4.2° to 5.3°	5.3° to 5.4°	5.3° to 6.3°
0.2	1.0° to 1.1°	1.0° to 1.1°	1.0° to 1.2°	1.2°	1.2° to 2.2°	2.1° to 2.7°	2.7°	2.7° to 3.2°
0.3	0.7° to 0.8°	0.7	0.7° to 0.9°	0.8° to 0.9°	0.8° to 1.5°	1.5° to 1.9°	1.9°	1.9° to 2.2°
0.4	0.6°	0.6°	0.6° to 0.7°	0.7°	0.7° to 1.2°	1.1° to 1.5°	1.5°	1.5° to 1.7°
0.5	0.5° to 0.6°	0.5	0.5° to 0.6°	0.6	0.6° to 1.0°	1.0° to 1.3°	1.2° to 1.3°	1.3° to 1.5°
0.6	0.4° to 0.5°	0.5	0.5° to 0.6°	0.5° to 0.6°	0.6° to 0.9°	0.9° to 1.1°	1.1° to 1.2°	1.1° to 1.3°
0.7	0.4° to 0.5°	0.5	0.5° to 0.6°	0.5° to 0.6°	0.5° to 0.8°	0.8° to 1.1°	1.0° to 1.1°	1.1° to 1.2°
0.8	0.4° to 0.5°	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.5° to 0.8°	0.8° to 1.0°	1.0°	1.0° to 1.2°
0.9	0.3° to 0.5°	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.5° to 0.8°	0.8° to 1.0°	1.0°	1.0° to 1.2°
1	0.3° to 0.4°	0.3° to 0.4°	0.3° to 0.5°	0.5°	0.5° to 0.8°	0.7° to 1.0°	0.9° to 1.0°	0.9° to 1.2°

Matrix VM.9 ‘HF attenuation; N-connector 50 Ω ’

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0 dB	0.01 dB	0.01 dB to 0.02 dB	0.01 dB to 0.02 dB	0.02 dB
3 dB	0.04 dB to 0.05 dB	0.05 dB	0.05 dB	0.05 dB
6 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB
10 dB	0.05 dB	0.05 dB	0.06 dB	0.05 dB to 0.06 dB
20 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB
30 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB
40 dB	0.05 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.06 dB to 0.07 dB
50 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB
60 dB	0.05 dB to 0.09 dB	0.08 dB to 0.09 dB	0.07 dB to 0.09 dB	0.08 dB to 0.09 dB

Matrix VM.10 “HF attenuation; 3.5 mm connector”

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0 dB	0.01 dB	0.01 dB to 0.02 dB	0.01 dB to 0.02 dB	0.02 dB	0.02 dB	0.02 dB
3 dB	0.04 dB to 0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB
6 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB
10 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB
20 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB
30 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB
40 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.07 dB
50 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.09 dB	0.08 dB to 0.10 dB
60 dB	0.05 dB to 0.09 dB	0.07 dB to 0.09 dB	0.07 dB to 0.09 dB	0.08 dB to 0.09 dB	0.08 dB to 0.19 dB	0.15 dB to 0.22 dB

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Matrix VM.11 “HF attenuation; 2.92 mm connector”

Absolute attenuation	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0 dB	0.01 dB	0.01 dB to 0.02 dB	0.01 dB to 0.02 dB	0.02 dB	0.02 dB	0.02 dB	0.02 dB to 0.04 dB	0.03 dB
3 dB	0.04 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB
6 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB
10 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB
20 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB	0.07 dB to 0.08 dB
30 dB	0.05 dB	0.05 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.07 dB	0.07 dB	0.07 dB to 0.08 dB
40 dB	0.05 dB	0.05 dB to 0.06 dB	0.05 dB to 0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.07 dB	0.07 dB to 0.08 dB	0.08 dB to 0.09 dB
50 dB	0.05 dB	0.06 dB	0.06 dB	0.06 dB to 0.07 dB	0.06 dB to 0.09 dB	0.08 dB to 0.10 dB	0.09 dB to 0.10 dB	0.10 dB to 0.13 dB
60 dB	0.06 dB	0.08 dB to 0.09 dB	0.07 dB to 0.09 dB	0.08 dB to 0.09 dB	0.08 dB to 0.18 dB	0.15 dB to 0.22 dB	0.17 dB to 0.22 dB	0.20 dB to 0.32 dB

Matrix VM.12 “RF attenuation; phase angle ϕ ; N-connector 50 Ω ”

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz
0 dB	0.2°	0.2°	0.2° to 0.4°	0.4° to 0.6°
3 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
6 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
10 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
20 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
30 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
40 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°
50 dB	0.4°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°
60 dB	0.4° to 0.6°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 0.8°

Matrix VM.13 “HF attenuation; phase angle ϕ ; 3.5 mm connector”

Absolute Attenuation	9 kHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz
0 dB	0.2°	0.2°	0.2° to 0.4°	0.4° to 0.6°	0.6° to 0.9°	0.9° to 1.0°
3 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
6 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
10 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
20 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
30 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°
40 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°
50 dB	0.4° to 0.5°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°
60 dB	0.4° to 0.6°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 0.8°	0.8° to 1.5°	1.3° to 1.8°

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Matrix VM.14 "HF attenuation; phase angle ϕ ; 2.92 mm connector"

Absolute attenuation	45 MHz to 1 GHz	1 GHz to 3 GHz	3 GHz to 12 GHz	12 GHz to 18 GHz	18 GHz to 26.5 GHz	26.5 GHz to 33 GHz	33 GHz to 40 GHz	40 GHz to 45 GHz
0 dB	0.2°	0.2°	0.2° to 0.4°	0.4° to 0.6°	0.6° to 0.9°	0.9° to 1.0°	1.0° to 1.2°	1.2° to 1.4°
3 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
6 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
10 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
20 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
30 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 0.9°	0.9° to 1.1°	1.1° to 1.3°	1.3° to 1.5°
40 dB	0.4°	0.4°	0.4° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°	1.2° to 1.3°	1.3° to 1.5°
50 dB	0.4°	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 1.0°	1.0° to 1.2°	1.2° to 1.4°	1.4° to 1.7°
60 dB	0.4° to 0.5°	0.5° to 0.6°	0.6° to 0.7°	0.7° to 0.8°	0.8° to 1.5°	1.3° to 1.8°	1.6° to 1.9°	1.8° to 2.5°

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On-site calibration – Radiometry

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Optical radiation power Fibre-optic power meters	1 μ W to 0.5 mW	1310 nm, 1550 nm	1.3%	FC, ST, SC, SMA or HMS-10 connectors, or adaptable. Different wavelengths (780 nm, 635 nm, 1625 nm) interpolated
		850 nm	2.2%	
		654 nm	2.2%	
Non-linearity of fibre-optic radiation receivers	10 nW to 160 μ W	Wavelengths: 1310 nm, 1550 nm, 850 nm	$1.8 \times 10^{(-3)}$ (0.008 dB)	Addition method
	0.1 nW up < 0.32 nW 0.32 nW to < 3.2 nW 3.2 n up 0.5 μ W to up to		$20 \times 10^{(-3)}$ (0.085 dB) $7.1 \times 10^{(-3)}$ (0.031 dB) $6.0 \times 10^{(-3)}$ (0.026 dB)	Comparison method
Attenuation or gain of fibre-optic components	0 dB up 50 dB > 50 dB to 60 dB > 60 dB up 70 dB to up to	Wavelengths: 1310 nm, 1550 nm, 850 nm Reference power: approx. 0.5 mW	$6.0 \times 10^{(-3)}$ (0.026 dB) $7.1 \times 10^{(-3)}$ (0.031 dB) $20 \times 10^{(-3)}$ (0.085 dB)	
	350 nm to < 700 nm 700 nm to <1250 nm 1250 nm up 1700 nm to		0.5 nm 2.5 pm 2 pm	

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On-site calibration – photometry

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Expanded measurement uncertainty	Remarks
	Measurement range / Measurement span	Measurement conditions / Method			
Transmission filter	16 % to 60%	QMH Chapter XXXIV v4.0 Nominal values in the turbidity values of the standard		0.65%	
Transmission T	> 60% up to 76%			0.70%	
	> 76% to < 100%			0.80%	
Turbidity level N	> 0% to < 24%			0.80%	
	24% to < 40%			0.70%	
	40% to 84%			0.65%	
Turbidity coefficient k	Measuring chamber length 0.43 m > 0 m ⁻¹ to 4.3 m ⁻¹		0.020 m ⁻¹ to 0.050 m ⁻¹	Turbidity coefficient k calculated from the turbidity level N . Uncertainty interval $U(k)$ calculated from the uncertainty interval of the turbidity value $U(N)$. Other measurement chamber lengths increase the measurement uncertainty.	

- **) N-connector 50 Ω; other connectors and reflection factors increase the measurement uncertainty
- ***) 2.92 mm connector;
- ****) > 18 GHz 3.5 mm or 2.92 mm connector

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On-site calibration – Dimensional measurements

On-site calibration – Length

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Calipers for external, internal and depth measurements *	0 mm to 1000 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	$20 \mu\text{m} + 15 \times 10^{(-6)} /$	/: measured value
Micrometers *	to 300 mm > 300 mm to 1000 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$2 \mu\text{m} + 6 \times 10^{(-6)} /$ $0.30 \mu\text{m} + 12 \times 10^{(-6)} /$	
Steel circumference measuring tapes Diameter	150 mm up to 300 mm > 300 mm to 400 mm up to	QMH-L.VIII.2 Section 3 Version 1.0	0.71 mm 0.104 mm	Calibration to the nominal values of the standards
Circumference	470 mm to 950 mm > 950 mm up to 1257 mm		0.22 mm 0.328 mm	
Standard cylindrical rings * Diameter	1 mm to 90 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3	$0.9 \mu\text{m} + 10 \times 10^{(-6)} \times d$	<i>d</i> is the measured diameter
Mandrels * Diameter	1 mm to 120 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3	$0.6 \mu\text{m} + 1.8 \times 10^{(-6)} \times d$	
Test pins * Diameter	1 mm to 20 mm	VDI/VDE/DGQ 2618 Sheet 4.2:2006 Option 1	$0.6 \mu\text{m} + 1.8 \times 10^{(-6)} \times d$	

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On-site calibration - Length

Measured quantity / Calibration object	Calibration and measurement capabilities (CMC)			Expanded measurement uncertainty	Remarks
	Measuring range / Measurement span	Measurement conditions / Method			
Thread gauges * (single- and multi-start cylindrical external and internal threads with straight flanks, symmetrical profile, nominal pitch and nominal profile angle) External thread Simple flank diameter	1 mm to 120 mm	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Option 1 Three-wire method (perpendicular to thread axis)		$2.9 \mu\text{m} + 7.7 \times 10^{-6} \times d$	<i>d</i> is the measured thread pitch diameter
Internal thread Simple flank diameter	3 mm to 90 mm	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Option 1 Two-sphere method (perpendicular to the thread axis)		$2.6 \mu\text{m} + 5.5 \times 10^{-6} \times d$	
Length measuring instrument gauge	0 mm to 75 mm	QMH-L.VIII.3 Section 2.1 Version 1.0 External measurement		31 μm	Assumed Temperature range: 20 °C \pm 1 K
	> 75 mm to 150 mm			37 μm	
	0 mm to 150 mm	QMH-L.VIII.3 Section 2.2 Version 1.0 Internal measurement		36 μm	Assumed thermal expansion coefficient: $\alpha = 11.5 \times 10^{-6} \text{ K}^{-1}$ Deviating Ambient conditions and the materials of the gauges to be calibrated increase the measurement uncertainty.
	0 mm to 150 mm	QMH-L.VIII.3 Section 2.3 Version 1.0 Depth measurement		39 μm	
	0 to 75 mm	QMH-L.VIII.3 Section 2.4 Version 1.0 Step measurement		55 μm	
	> 75 mm to 150 mm			76 μm	

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Abbreviations used:

AA	Work instruction (in-house procedure) of esz AG
CMC	Calibration and measurement capabilities DIN German Institute for Standardisation
DKD-R	Guideline of the German Calibration Service (DKD), issued by the Physikalisch-Technische Bundesanstalt
EN	European standard
EURAMET	European Association of National Metrology Institutes
QMH	Quality Management Manual (in-house procedure) of esz AG

German Accreditation Body

Annex to the Accreditation Certificate D-K-15019-01-02 in accordance with DIN EN ISO/IEC 17025:2018

Valid from: 20 November 2025

Date of issue: 20 November 2025

This annex to the certificate forms part of the accreditation certificate D-K-15019-01-00.

Holder of the accreditation certificate:

**esz AG calibration & metrology
Max-Planck-Straße 16, 82223 Eichenau**

with the following sites

**esz AG calibration & metrology
Max-Planck-Straße 16, 82223 Eichenau**

**esz AG calibration & metrology Nordostpark
12, 90411 Nuremberg**

**esz AG calibration & metrology Ladehofstraße
26, 93046 Regensburg**

**esz AG calibration & metrology Webereistraße
3, 48565 Steinfurt**

**esz AG calibration & metrology Lemböckgasse
49, A-1230 Vienna, AUSTRIA**

*This certificate was issued by Deutsche Akkreditierungsstelle GmbH and is digitally sealed.
This applies only in conjunction with the written certificate and reflects the status as at the date of issue. The current status of valid and monitored accreditation can be found in the database of accredited bodies maintained by the German Accreditation Body (www.dakks.de)*

Abbreviations used: see last page

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The calibration laboratory meets the requirements of DIN EN ISO/IEC 17025:2018 to carry out the conformity assessment activities listed in this annex. Where applicable, the calibration laboratory meets additional legal and normative requirements, including those in relevant sectoral programmes, provided these are expressly confirmed below.

The management system requirements in DIN EN ISO/IEC 17025 are written in language relevant to calibration laboratories and are, overall, in accordance with the principles of DIN EN ISO 9001.

Calibrations in the following areas:

Thermodynamic quantities

Temperature quantities

- Block calibrators ^{a)}
- Direct-reading thermometers ^{a)}
- Climate chambers (temperature) ^{a)}
- Temperature display devices and -simulators ^{a)}
- Thermocouples ^{a)}
- Resistance temperature detectors ^{a)}

Humidity measurement parameters

- Climate chambers (humidity) ^{a)}
- Absolute humidity measuring instruments ^{a)}
- Relative humidity measuring instruments ^{a)}

Mechanical parameters

- Torque ^{a)}
- Pressure ^{a)}
- Force ^{a)}
- Mass ^{b)}
- Scales ^{a)}

Measuring instruments in the automotive industry

- Exhaust gas measuring instruments for spark-ignition engines ^{b)}
- Exhaust gas measuring instruments for compression-ignition engines ^{a)}
- Mounting surfaces for headlamp alignment testers (ASEP) ^{b)}
- Disc brake test benches ^{b)}
- Roller brake test benches ^{b)}
- Headlamp alignment testers (SEP) ^{b)}

Flow measurement parameters

- Gas flow ^{a)}

^{a)} including on-site calibration

^{b)} on-site calibration only

For the measurement quantities/calibration objects marked with *), the calibration laboratory is permitted to apply the standards/calibration guidelines listed here in different editions without the need for prior notification to or approval from DAkkS.

The calibration laboratory maintains an up-to-date list of all standards/calibration guidelines within the flexible scope of accreditation.

Calibration and measurement capabilities

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, Eichenau

Mechanical quantities – , Eichenau

Permanent Laboratory – Eichenau site

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration	Measurement range /	Measurement conditions	Expanded measurement uncertainty	Remarks
Pressure Absolute pressure p_{abs} *)	> 0 bar to 3.0 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$2.9 \times 10^{-5} \cdot p_{abs} + 15 \mu\text{bar}$	Pressure medium: Gas The measurement uncertainty of the U_{baro} barometer must be taken into account.
	> 3.0 bar to 21 bar		$3.4 \times 10^{-5} \cdot p_{abs} + 0.19 \text{ mbar}$	
	> 21 bar to 101 bar		$3.9 \times 10^{-5} \cdot p_{abs} + 0.44 \text{ mbar} + U_{baro}$	
	> 101 bar to 251 bar		$5.1 \times 10^{-5} \cdot p_{abs} + 30 \text{ mbar} + U_{baro}$	
Absolute pressure p_{abs}	900 mbar to 1000 mbar	esz QMH XXIII.4.2 v5.0	$2.9 \times 10^{-5} \cdot p_{abs} + 15 \mu\text{bar}$	Reference value: ($p_{abs} = p_{amb}$) Single-point measurement at current
Absolute pressure p_{abs} *)	1 bar; 2 bar to 71 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$7.8 \times 10^{-5} \cdot p_{abs} + 0.36 \text{ mbar} + U_{baro}$	Reference value ($p_{abs} = p_{amb}$) Pressure medium: oil The measurement uncertainty of the barometer U_{baro} must be taken
	> 71 bar to 701 bar		$8.2 \times 10^{-5} \cdot p_{abs} + 0.72 \text{ mbar} + U_{baro}$	
Absolute pressure p_{abs} *)	> 0 bar to 301 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$5.1 \times 10^{-5} \cdot p_{abs} + 30 \text{ mbar} + U_{baro}$	Pressure medium: water The measurement uncertainty of the barometer U_{baro} must be taken
	> 301 bar to 1001 bar		$7.4 \times 10^{-5} \cdot p_{abs} + 40 \text{ mbar} + U_{baro}$	
Positive and negative overpressure p_e *)	-200 mbar to 200 mbar	DKD-R 6-1:2014 Calibration method: $p_e = p_{abs} - p_{amb}$	25 μbar	Pressure medium: gas The measurement uncertainty of the U_{baro} barometer must be taken into account.
	> -1 bar to 2 bar		$2.3 \times 10^{-5} \cdot p_e + 55 \mu\text{bar} + U_{baro}$	
	> 2 bar to 20 bar		$3.7 \times 10^{-5} \cdot p_e + 0.19 \text{ mbar} + U_{baro}$	
	> 20 bar to 100 bar		$3.9 \times 10^{-5} \cdot p_e + 0.44 \text{ mbar}$	
	> 100 bar to 150 bar		$9 \times 10^{-5} \cdot p_e + 23 \text{ mbar}$	
	> 150 bar to 250 bar		$5.1 \times 10^{-5} \cdot p_e + 30 \text{ mbar}$	
Gauge pressure p_e *)	0 bar; 1 bar to 70 bar	DKD-R 6-1:2014	$7.8 \times 10^{-5} \cdot p_e + 0.36 \text{ mbar}$	Reference value ($p_e = 0 \text{ bar}$)
	> 70 bar to 700 bar		$8.2 \times 10^{-5} \cdot p_e + 0.72 \text{ mbar}$	Pressure medium: oil
Gauge pressure p_e *)	> 0 bar to 300 bar	DKD-R 6-1:2014	$5.1 \times 10^{-5} \cdot p_{abs} + 30 \text{ mbar}$	Pressure medium: water
	> 300 bar to 1001 bar		$7.4 \times 10^{-5} \cdot p_{abs} + 40 \text{ mbar}$	

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Mechanical measurement parameters – Flow

measurement parameters Permanent laboratory –

Eichenau site

Calibration and measurement capacities (CMC)				
Measurement quantity / Calibration object	Measurement range / Measurement span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
Volume flow rate Q of flowing gases Flow meter or controller with a display or transmitter with an electronic interface	5 mL/min to 50 L/min	Volumeter as standard	$0.3\% \cdot Q + 0.02 \text{ mL/min}$	$Q = \text{measured value}$
	10 mL/min to 200 mL/min	Laminar flow elements as standard	$0.5\% \cdot Q + 0.02 \text{ mL/min}$	Calibration medium: dry air (relative humidity < 10%) Measurement ranges based on dry air at 0 °C, 1013.25 mbar
	> 0.2 L/min to 3.2 L/min		$0.5\% \cdot Q + 0.32 \text{ mL/min}$	
	> 3.2 L/min to 40 L/min		$0.5\% \cdot Q + 4 \text{ mL/min}$	
	> 40 L/min to 620 L/min		$0.5\% \cdot Q + 0.06 \text{ L/min}$	

Mechanical parameters – Force

Permanent Laboratory – Eichenau site

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Force Measuring instruments and transducers *)	50 N to 50 kN	Tensile and compressive force in accordance with DKD-R 3-3:2018	0.05%	

Mechanical parameters – Torque Permanent laboratory

– Eichenau site

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Torque Manually operated Torque - Screwdriving tools *)	0.2 N·m to < 1 N·m	DIN EN ISO 6789-2:2017	0.9 %	Torque
	1 N·m to 10 N·m		0.5%	Screwdriver
	0.4 N·m to < 4 N·m		0.7 %	Torque wrench
	4 N·m to 1110 N·m		0.5%	

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Mechanical quantities – mass Permanent laboratory

– Eichenau site

Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Comments
Mass or conventional weight value *)	10 mg	OIML R111-01:2004	0.025 mg	for weights in accordance with OIML R 111-1:2004 in accordance with Class F ₂
	20 mg		0.03 mg	
	50 mg		0.04 mg	
	100 mg		0.016 mg	for weights of OIML R 111-1:2004 in accordance with Class F ₁
	200 mg		0.020 mg	
	500 mg		0.025 mg	
	1 g		0.03 mg	
	2 g		0.04 mg	
	5 g		0.05 mg	
	10 g		0.06 mg	
	20 g		0.08 mg	
	50 g		0.10 mg	
	100 g		0.16 mg	
	200 g		0.3 mg	
	500 g		2.5 mg	for weight pieces in accordance with OIML R 111-1:2004 in accordance with Class F ₂
	1 kg		5.0 mg	
	2 kg		30 mg	for weights in accordance with OIML R 111-1:2004 in accordance with Class M ₁
	5 kg		25 mg	for weights of OIML R 111-1:2004 in accordance with Class F ₂
	10 kg		0.5 g	for weights of OIML R 111-1:2004 in accordance with Class M ₂
	20 kg		0.3 g	for weights in accordance with OIML R 111-1:2004 in accordance with Class M ₁
50 kg	0.8 g			
10 mg to 20 mg	OIML R111-01:2004	0.03 mg	Free nominal values	
> 20 mg to 100 mg		0.04 mg		
> 100 mg to 200 mg		0.02 mg		

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Permanent Laboratory – Eichenau site

Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Remarks
Mass or conventional weight value *)	> 200 mg to 500 mg	OIML R111-01:2004	0.025 mg	Free nominal values
	> 500 mg to 1 g		0.03 mg	
	> 1 g to 2 g		0.04 mg	
	> 2 g to 5 g		0.05 mg	
	> 5 g to 10 g		0.06 mg	
	> 10 g to 20 g		0.08 mg	
	> 20 g to 50 g		0.10 mg	
	> 50 g to 100 g		0.16 mg	
	> 100 g to 200 g		0.3 mg	
	> 200 g to 500 g		2.5 mg	
	> 500 g to 1 kg		5.0 mg	
	> 1 kg to 2 kg		30 mg	
	> 2 kg to 5 kg		25 mg	
	> 5 kg to 10 kg		0.5 g	
	> 10 kg to 20 kg		0.3 g	
	> 20 kg to 50 kg		0.8 g	
> 50 kg to 65 kg	1.6 g			

Mechanical measurement parameters – Scales

Permanent Laboratory – Eichenau site

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / procedure	Expanded measurement uncertainty	Remarks
Balances Non-automatic electronic balances *)	≤ 50 kg	EURAMET cg-18:2015 DKD-R 7-2:2018	$1 \cdot 10^{-6}$	With weights Accuracy class E ₂ according to OIML R111-1:2004
	≤ 150 kg		2×10^{-5}	Using weights of accuracy class F ₂ in accordance with OIML R111-1:2004

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Thermodynamic quantities – Temperature quantities Permanent

laboratory – Eichenau site

Calibration and measurement capacities (CMC)

Measurement quantity / Calibration	Measurement range / span	Measurement conditions /	Expanded measurement	Remarks
Resistance thermometer, direct-reading	0.01 °C	DKD-R 5-1:2018 Triple point of water	15 mK	Calibration at temperature fixed point
Thermometer with resistance sensor *)	-80 °C to < -40 °C	DKD-R 5-1:2018 in an ethanol bath	45 mK	Comparison with Standard resistance thermometer T: Temperature in °C
	-40 °C to < 0 °C		25 mK	
	0 °C to 100 °C	DKD-R 5-1:2018 in a silicone oil bath	20 mK	
	> 100 °C to 180 °C		25 mK	
	> 180 °C up to 200 °C		35 mK	
	> 200 °C up to 300 °C		50 mK	
	> 300 °C to 400 °C	DKD-R 5-1:2018 in the block calibrator	80 mK	
	> 400 °C up to 570 °C		$(1.6 \times 10^{(-3)}) T/^\circ\text{C} - 0.56$ K	
	> 570 °C to 700 °C		350 mK	
Base metal thermocouples, direct-reading thermometers with base metal thermocouple sensor *)	-80 °C to < -35 °C	DKD-R 5-3:2018 in an ethanol bath	$(-1.2 \times 10^{(-3)}) T/^\circ\text{C} + 0.13$ K	Comparison with standard resistance thermometer T: temperature in °C
	-35 °C to < 0 °C		$(-1.2 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.09$ K	
	0 °C to 35 °C	DKD-R 5-3:2018 in a silicone oil bath	0.09 K	
	> 35 °C to 300 °C		$(0.5 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.072$ K	
	> 300 °C to 700 °C	DKD-R 5-3:2018 in the block calibrator	$(0.6 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.07$ K	
	> 700 °C to 1210 °C	DKD-R 5-3:2018 in the block calibrator	$(1.4 \times 10^{(-3)}) T/^\circ\text{C} + 1.3$ K	
Precious metal thermocouples, direct-reading thermometers with precious metal thermocouple sensor *)	0 °C to 35 °C	DKD-R 5-3:2018 in a silicone oil bath	0.21 K	Comparison with standard resistance thermometer T: Temperature in °C
	> 35 °C to 300 °C		$(0.3 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.2$ K	
	> 300 °C to 400 °C	DKD-R 5-3:2018 in the block calibrator	$(0.3 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.2$ K	
	> 400 °C up to 700 °C		$(0.7 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.25$ K	
	> 700 °C to 1210 °C	DKD-R 5-3:2018 in the block calibrator	$(1.4 \times 10^{(-3)}) \times T/^\circ\text{C} + 1.3$ K	
Block calibrators *)	-80 °C to 0 °C	DKD-R 5-4:2018	0.10 K	Comparison with standard resistance thermometer T: Temperature in °C
	> 0 °C to 50 °C		0.056 K	
	> 50 °C to 700 °C		$(0.21 \times 10^{(-3)}) \times T/^\circ\text{C} + 0.045$ K	

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Permanent Laboratory – Eichenau site

Calibration and measurement capabilities (CMC)

Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments		
Temperature display devices and simulators for resistance thermometers *) Pt100	-199 °C	DKD-R 5-5:2018 Artifact calibration	1.0 mK	T: Temperature in °C		
	0 °C		2.4 mK			
	239 °C		4.8 mK			
	-200 °C to 800 °C	$(12 \times 10^{-3} \times T/^{\circ}\text{C} + 4)$ mK				
Pt25	-200 °C to -150 °C	DKD-R 5-5:2018	2.3 mK			
	> -150 °C to 800 °C		$(19 \times 10^{(-3)} \times T/^{\circ}\text{C} + 10)$ mK			
Pt500	-200 °C to 300 °C		$(13 \times 10^{(-3)} \times T/^{\circ}\text{C} + 3.5)$ mK			
	> 300 °C to 800 °C		$(18 \times 10^{(-3)} \times T/^{\circ}\text{C} + 5.4)$ mK			
Pt1000	-200 °C to 800 °C	$(17 \times 10^{(-3)} \times T/^{\circ}\text{C} + 3.8)$ mK				
for base metal thermocouples *) Type K	-200 °C to < 0 °C	DKD-R 5-5:2018 without reference point compensation	$(-85 \times 10^{(-3)} \times T/^{\circ}\text{C} + 11)$ mK	T: Temperature in °C		
	0 °C to 1300 °C		$(5.7 \times 10^{(-6)} \times (T/^{\circ}\text{C})^2 + 0.17 \times 10^{(-3)} \times T/^{\circ}\text{C} + 11)$ mK			
Type J	-200 °C to < 0 °C		$(-61 \times 10^{(-3)} \times T/^{\circ}\text{C} + 8)$ mK			
	0 °C to 1200 °C		$(5.6 \times 10^{(-3)} \times T/^{\circ}\text{C} + 8)$ mK			
Type T	-200 °C to < 0 °C		$(-80 \times 10^{(-3)} \times T/^{\circ}\text{C} + 11)$ mK			
	0 °C to 400 °C		11 mK			
Type E	-200 °C to < 0 °C		$(-56 \times 10^{(-3)} \times T/^{\circ}\text{C} + 7)$ mK			
	0 °C to 1000 °C		$(4.4 \times 10^{(-3)} \times T/^{\circ}\text{C} + 7)$ mK			
Type N	-200 °C to < 0 °C		$(-0.12 \times T/^{\circ}\text{C} + 16)$ mK			
	0 °C to 1300 °C		$(12 \times 10^{(-6)} \times (T/^{\circ}\text{C})^2 + 10 \times 10^{(-3)} \times T/^{\circ}\text{C} + 16)$ mK			
for precious metal thermocouples *) Type R, Type S	0 °C to 500 °C		DKD-R 5-5:2018 without reference point compensation		$(-64 \times 10^{-3} \times T/^{\circ}\text{C} + 75)$ mK	T: temperature in °C
	> 500 °C to 1768 °C				45 mK	
Type B	50 °C to 1200 °C	$(26 \times 10^{-3} \times (T/^{\circ}\text{C})^{-0.85})$ mK				
	> 1200 °C to 1820 °C	60 mK				
for thermocouples *)	-200 °C to 1500 °C	DKD-R 5-5:2018 with reference point compensation	$\frac{U_{TC}^2}{\sqrt{\left(\quad\right) + 602}}$ mK	U _{TC} = Uncertainty of the display device or simulator for thermocouples without reference junction in mK		
Measurement points in climatic chambers *)	-80 °C to 180 °C	DKD-R 5-7:2018 Method C	0.50 K			
	> 180 °C to 300 °C		0.70 K			
Climate chambers *)	-80 °C to 100 °C	DKD-R 5-7:2018 Method A or B	0.55 K			
	> 100 °C to 180 °C		0.75 K			
	> 180 °C to 300 °C		1.0 K			

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Thermodynamic measurement quantities – Humidity measurement

quantities Permanent calibration laboratory – Eichenau site

Calibration and measurement capabilities (CMC)

Measurement quantity / Calibration	Measurement range / span	Measurement conditions /	Expanded measurement	Comments
Dew point temperature Dew point hygrometer	-28 °C to 24.8 °C	QMH XIV.5 Version 7.0 Airflow temperature: 10 °C to 25 °C relative humidity: 5% to 98%	0.080 K	Comparison with Dew point mirror hygrometer in Climate generator or climate chamber
	-17 °C to 44.8 °C	QMH XIV.5 Version 7.0 Airflow temperature: > 25 °C to 45 °C Relative humidity: 5% to 98%	0.10 K	
	-3 °C to 59.8 °C	QMH XIV.5 Version 7.0 Air flow temperature: > 45 °C to 60 °C Relative humidity: 5% to 98%	0.15 K	
	17 °C to 89.8 °C	QMH XIV.5 Version 7.0 Air flow temperature: > 60 °C to 90 °C relative humidity: 10% to 98%	0.3 K	Comparison with Dew point range hygrometer in Climate chamber
relative humidity humidity meters and transducer	5% – 20%	QMH XIV.5 Version 7.0 Airflow temperature: 10 °C to 25 °C Dew point temperature _{td} : -28 °C to 24.8 °C	0.25%	Comparison with Dew point range in climate generator or Climate chamber
	> 20% to 40%		0.50%	
	> 40% to 60%		0.75%	
	> 60% to 80%		1.0%	
	> 80% to 98%	QMH XIV.5 Version 7.0 Air flow temperature: > 25 °C to 45 °C Dew point temperature _{td} : -17 °C to 44.8 °C	1.2%	Measurement uncertainty expressed as the absolute value of relative humidity
	5% to 20%		0.65%	
	> 20% to 40%		0.90%	
	> 40% to 60%		1.2%	
	> 60% to 80%	QMH XIV.5 Version 7.0 Air flow temperature: > 45 °C to 60 °C Dew point temperature _{td} : -3 °C to 59.8 °C	1.4%	
	> 80% to 98%		1.6	
	5% to 20%		0.85%	
	> 20% to 40%		1.1%	
	> 40% to 60%	QMH XIV.5 Version 7.0 Airflow temperature: > 60 °C to 90 °C Dew point temperature _{td} : 17 °C to 89.8 °C	1.4%	
	> 60% to 80%		1.6%	
	> 80% to 98%		1.8	
	10% to 20%		1.7%	
> 20% e to 40%		1.9%	Comparison with Dew point level in Climate chamber	
> 40% to 60%		2.1%		
> 60% h e to 80%		2.3%	Measurement uncertainty expressed as Absolute value of relative humidity	
> 80% to 98%		2.5%		

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Permanent calibration laboratory – Eichenau site

Calibration and measurement capacities (CMC)

Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Measurement locations in climate chambers with recirculating air *)	5% to 30%	DKD-R 5-7:2018 Method C Airflow temperature: 10 °C to 90 °C Dew point temperature _{td} : -28 °C to 89.8 °C	1.0%	The humidity reference value is calculated from the dew point temperature and the air flow temperature at the measurement point. Measurement uncertainty expressed as the absolute value of the relative humidity
	> 30% to 60%		1.5%	
	> 60% to 80%		2.0%	
	> 80% to 98%		2.5%	
Climate cabinets with recirculation *)	5% to 30%	DKD-R 5-7:2018 Method A or B Airflow temperature: 10 °C to 90 °C Dew point temperature _{td} : -28 °C to 89.8 °C	1.5	The humidity reference value is calculated from the dew point temperature and the air flow temperature at the measurement point. Measurement uncertainty expressed as the absolute value of the relative humidity
	> 30% to 60%		2.0%	
	> 60% to 80%		2.5%	
	> 80% to 98%		3.0%	

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Nuremberg site

Permanent Laboratory – Nuremberg site

Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration	Measurement range /	Measurement conditions /	Expanded measurement	Comments
Temperature				
Resistance thermometer meters, direct-reading Thermometer with	-40 °C to 0 °C	DKD-R 5-1:2018 in block calibrator	$(-1.8 \times 10^{-3} \times \frac{t}{\text{°C}} \pm 0.063) \text{ K}$	Comparison with Standard resistance thermometers. t: temperature in °C.
Resistance sensor *)	> 0 °C to 155 °C		$(0.3 \times 10^{-3} \times \frac{t}{\text{°C}} \pm 0.063) \text{ K}$	
Torque				
Manual Torque screwdriving tools *)	0.2 N·m to < 1 N·m	DIN EN ISO 6789-2:2017	0.9%	Torque screwdriver
	1 N·m to 10 N·m		0.5%	
	0.4 N·m to < 4.0 N·m		0.7 %	Torque wrench
	4 N·m to 1100 N·m		0.5%	

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Regensburg site

Permanent Laboratory – Regensburg site

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Expanded measurement uncertainty	Comments
	Measurement range / Measurement span	Measurement conditions / Method			
Exhaust gas analysers for compression-ignition engines Particle number concentration Particle generators and measuring instruments (aerosol)	5 × 10 ³ cm ⁻³ to 50 × 10 ³ cm ⁻³	AA0399 Version 1.0 Traffic Bulletin 2021 Issue 11, No. 133		20 %	The mean particle size must be in the range of 10 nm to 200 nm.
	> 50 × 10 ³ cm ⁻³ to 3 × 10 ⁶ cm ⁻³			13%	
Particle concentration reduction factor (PCRF)	1:1 to 1:30,000	AA0398 Version 1.0		9 %	The particle size must be in the range from 10 nm to 200 nm.
Particle measuring instruments *)	1000 cm ³ to 30,000 cm ⁻³	10 nm to 200 nm ISO 27891:2015-03		11%	

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Steinfurt site

Permanent laboratory – Steinfurt site

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Temperature Resistance thermometers meters, Direct-reading thermometers with resistance sensor *)	-40 °C to 0 °C	DKD-R 5-1:2018 in the block calibrator	$(-1.8 \times 10^{-3} \times \frac{t}{^{\circ}\text{C}} \pm 0.063) \text{ K}$	Comparison with Standard resistance thermometers. t: Temperature in °C
	> 0 °C to 155 °C		$(0.3 \times 10^{-3} \times \frac{t}{^{\circ}\text{C}} \pm 0.063) \text{ K}$	
Pressure Absolute pressure p_{abs} *)	0 bar to 21 bar	DKD-R 6-1:2014 Calibration method: $p_{\text{abs}} = p_e + p_{\text{amb}}$	$45 \cdot 10^{-6} \cdot p_{\text{abs}} + 0.6 \text{ mbar} + U_{\text{baro}}$	Pressure medium: gas The measurement uncertainty of the U_{baro} barometer must be taken into account
	> 21 bar to 700 bar		$79 \cdot 10^{-3} \cdot p_{\text{abs}} + U_{\text{baro}}$	Pressure medium: water The measurement uncertainty of the U_{baro} barometer must be taken into account
negative and positive overpressure p_e *)	-200 mbar to 200 mbar	DKD-R 6-1:2014	$25 \cdot 10^{-3} \text{ mbar}$	Pressure medium: gas
	-1 bar to 2 bar		$33 \cdot 10^{-6} \cdot p_e + 0.25 \text{ mbar}$	
	> 2 bar to 20 bar		$45 \times 10^{-6} \cdot p_e + 0.6 \text{ mbar}$	
	> 20 bar to 700 bar		$79 \times 10^{-3} \cdot p_e$	Pressure medium: water

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Vienna site

Permanent Laboratory – Vienna site

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Temperature Resistance thermometers, direct-reading thermometers with resistance sensor *)	-20 °C to 100 °C	DKD-R 5-1:2018 in silicone oil bath	0.047 K	Comparison with standard resistance thermometers. t: temperature in °C.
Pressure Absolute pressure p_{abs} *)	0 bar to 21 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$45 \cdot 10^{-6} \cdot p_{abs} + 0.46 \text{ mbar} + U_{baro}$	Pressure medium: gas The measurement uncertainty of the U_{baro} barometer is must be taken into account
	> 21 bar to 200 bar		$2.9 \times 10^{-4} \cdot p_{abs} + 27 \text{ mbar} + U_{baro}$	
	> 200 bar to 1000 bar		$9.7 \times 10^{-4} \cdot p_{abs} + 59 \text{ mbar} + U_{baro}$	Pressure medium: water The measurement uncertainty of the U_{baro} barometer must be taken into account
negative and positive overpressure p_e *)	-400 mbar to 400 mbar	DKD-R 6-1:2014	0.10 mbar	Pressure medium: gas The measurement uncertainty of the U_{baro} barometer must be taken into account
	-1 bar to 20 bar		$45 \times 10^{-6} \cdot p_e + 0.46 \text{ mbar}$	
	> 20 bar to 200 bar		$2.9 \times 10^{-4} \cdot p_e + 27 \text{ mbar}$	Pressure medium: water
	> 200 bar to 1000 bar		$9.7 \times 10^{-4} \cdot p_e + 59 \text{ mbar}$	
Volume flow rate Q of flowing gases Flow meter or regulator with a display or transmitter with an electronic interface	0.005 L/min to 0.03 L/min	QMH Chapter XXV.6: Version 7	0.3 mL/min	Q = measured value Calibration medium: air (relative humidity < 10%) Measurement ranges based on dry air at 0 °C, 1013.25 mbar
	> 0.03 L/min to 200 L/min	Laminar flow elements as standard	$1 \% \cdot Q$	
	> 200 L/min to 500 L/min	MFC as standard	$0.89 \times 10^{(-2)} \times Q + 0.52 \text{ L/min}$	

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On-site calibration

Thermodynamic variables – Temperature variables

On-site calibration

Measurement quantity / Calibration	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range / span	Measurement conditions /	Expanded measurement	
Resistance thermometer, direct-reading thermometer with resistance sensor *)	0 °C	DKD-R 5-1:2018 Freezing point	20 mK	Comparison with standard resistance thermometer T: Temperature in °C
	-40 °C to 100 °C	DKD-R 5-1:2018 in the block calibrator	50 mK	
	> 100 °C to 200 °C		75 mK	
	> 200 °C up to 400 °C		80 mK	
	> 400 °C up to 570 °C		$(1.6 \times 10^{(-3)} T/°C - 0.56) K$	
	> 570 °C to 700 °C		350 mK	
Base metal thermocouples, direct-reading thermometers with base metal thermocouple sensor *)	-40 °C to 200 °C	DKD-R 5-3:2018 in block calibrator	$(0.8 \times 10^{(-3)} \times T/°C + 0.1) K$	Comparison with standard resistance thermometers T: Temperature in °C
	> 200 °C to 400 °C		$(1.0 \times 10^{(-3)} \times T/°C + 0.08) K$	
	> 400 °C to 700 °C		$(0.6 \times 10^{(-3)} T/°C + 0.07) K$	
	> 700 °C to 1210 °C		$(1.4 \times 10^{(-3)} T/°C + 1.3) K$	Comparison with standard thermocouple T: Temperature in °C
Precious metal thermocouples, direct-reading thermometers with precious metal thermocouple sensor *)	0 °C to 100 °C	DKD-R 5-3:2018 in block calibrator	0.22 K	Comparison with standard resistance thermometer T: Temperature in °C
	> 100 °C to 200 °C		0.25 K	
	> 200 °C to 400 °C		$(0.3 \times 10^{(-3)} \times T/°C + 0.2) K$	
	> 400 °C to 700 °C		$(0.7 \times 10^{(-3)} T/°C + 0.25) K$	
	> 700 °C to 1210 °C		$(1.4 \times 10^{(-3)} \cdot T/°C + 1.3) K$	Comparison with standard thermocouple T: Temperature in °C
Block calibrators *)	-80 °C to 0 °C	DKD-R 5-4:2018	0.10 K	Comparison with standard resistance thermometer T: Temperature in °C
	> 0 °C to 50 °C		0.056 K	
	> 50 °C to 700 °C		$(0.21 \times 10^{(-3)} \times T/°C + 0.045) K$	

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On-site calibration

Calibration and measurement capabilities (CMC)						
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments		
Temperature display devices and simulators for resistance thermometers *)	-199 °C	DKD-R 5-5:2018 Artifact calibration	1.0 mK	T: Temperature in °C		
	0 °C		2.4 mK			
	239 °C		4.8 mK			
Pt100	-200 °C to 800 °C	DKD-R 5-5:2018 without reference point compensation	$(12 \times 10^{-3} \times T/^{\circ}\text{C} + 4)$ mK	T: temperature in °C		
Pt25	-200 °C to -150 °C		2.3 mK			
	> -150 °C to 800 °C		$(19 \times 10^{(-3)} \times T/^{\circ}\text{C} + 10)$ mK			
Pt500	-200 °C to 300 °C		$(13 \times 10^{(-3)} \cdot T/^{\circ}\text{C} + 3.5)$ mK			
	> 300 °C to 800 °C		$(18 \times 10^{(-3)} T/^{\circ}\text{C} + 5.4)$ mK			
Pt1000	-200 °C to 800 °C		$(17 \times 10^{(-3)} T/^{\circ}\text{C} + 3.8)$ mK			
for base metal thermocouples *)	-200 °C to < 0 °C		DKD-R 5-5:2018 without reference point compensation		$(-85 \times 10^{-3} \times T/^{\circ}\text{C} + 11)$ mK	T: temperature in °C
Type K	0 °C to 1300 °C				$(5.7 \times 10^{-6} \times (T/^{\circ}\text{C})^2 + 0.17 \times 10^{(-3)} \times T/^{\circ}\text{C} + 11)$ mK	
Type J	-200 °C to < 0 °C				$(-61 \times 10^{(-3)} \cdot T/^{\circ}\text{C} + 8)$ mK	
	0 °C to 1200 °C				$(5.6 \times 10^{(-3)} T/^{\circ}\text{C} + 8)$ mK	
Type T	-200 °C to < 0 °C	$(-80 \times 10^{-3} \times T/^{\circ}\text{C} + 11)$ mK				
	0 °C to 400 °C	11 mK				
Type E	-200 °C to < 0 °C	$(-56 \times 10^{(-3)} T/^{\circ}\text{C} + 7)$ mK				
	0 °C to 1000 °C	$(4.4 \times 10^{(-3)} T/^{\circ}\text{C} + 7)$ mK				
Type N	-200 °C to < 0 °C	$(-0.12 \times 10^{(-3)} \times T/^{\circ}\text{C} + 16)$ mK				
	0 °C to 1300 °C	$(12 \times 10^{(-6)} \times (T/^{\circ}\text{C})^2 + 10 \cdot 10^{(-3)} \cdot T/^{\circ}\text{C} + 16)$ mK				
for precious metal thermocouples *)	0 °C to 500 °C	DKD-R 5-5:2018 without reference point compensation	$(-64 \times 10^{(-3)} \times T/^{\circ}\text{C} + 75)$ mK	T: temperature in °C		
Type R, Type S	> 500 °C to 1768 °C		45 mK			
Type B	50 °C to 1200 °C		$(26 \times 10^{-3} \times (T/^{\circ}\text{C})^{-0.85})$ mK			
	> 1200 °C to 1820 °C		60 mK			
for thermocouples *)	-200 °C to 1500 °C	DKD-R 5-5:2018 with reference point compensation	$\sqrt{\frac{U_{TC}^2}{\text{mK}} + 602}$ mK	U _{TC} = Uncertainty of the display device or simulator for thermocouples without reference point in mK		
Measurement points in climatic chambers *)	-80 °C to 180 °C	DKD-R 5-7:2018 Method C	0.50 K			
	> 180 °C to 300 °C		0.70 K			
Climate chambers *)	-80 °C to 100 °C	DKD-R 5-7:2018 Method A or B	0.55 K			
	> 100 °C to 180 °C		0.75 K			
	> 180 °C to 300 °C		1.0 K			

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Thermodynamic parameters – Humidity parameters

On-site calibration

Measurement variable / Calibration	Calibration and measurement capabilities (CMC)			Expanded measurement	Remarks
	Measurement range /	Measurement conditions /			
Dew point temperature Dew point hygrometer	-28 °C to 24.5 °C	QMH XIV.5 Version 7.0 Airflow temperature: 10 °C to 25 °C Relative humidity: 5% to 95%		0.080 K	Comparison with Dew point mirror in the climate generator
	-17 °C to 44 °C	QMH XIV.5 Version 7.0 Airflow temperature: > 25 °C to 45 °C relative humidity: 5% to 95%		0.10 K	
	-3 °C to 58 °C	QMH XIV.5 Version 7.0 Air flow temperature: > 45 °C to 60 °C Relative humidity: 5% to 90%		0.15 K	
relative humidity Humidity measuring instruments and transmitters	5% to 20%	QMH XIV.5 Version 7.0 Air flow temperature: 10 °C to 25 °C		0.25%	Measurement uncertainty expressed as absolute value of relative humidity Comparison with the dew point mirror in Climate generator
	> 20% to 40%			0.50%	
	> 40% to 60%			0.75%	
	> 60% to 80%	Dew point temperature _{td} : -28 °C to 24.5 °C		1.0%	
	> 80% to 95%			1.2%	
	5% to 20%	QMH XIV.5 Version 7.0 Air flow temperature: > 25 °C to 45 °C Dew point temperature _{td} : -17 °C to 44 °C		0.65%	
	> 20% to 40%			0.90%	
	> 40% to 60%			1.2%	
	> 60% to 80%			1.4%	
	> 80% to 95%			1.6%	
	5% to 20%	QMH XIV.5 Version 7.0 Air flow temperature: > 45 °C to 60 °C Dew point temperature _{td} : -3 °C to 58 °C		0.85%	
	> 20% to 40%			1.1%	
	> 40% to 60%			1.4%	
	> 60% to 80%			1.6%	
> 80% to 90%			1.8		

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On-site calibration

Calibration and measurement capabilities (CMC)				
Measurement quantity / Calibration object	Measurement range / span	Measurement conditions / Method	Expanded measurement uncertainty	Comments
Measurement locations in Climate chambers with Recirculated air *)	5 % to 30%	DKD-R 5-7:2018 Method C Air flow temperature: 10 °C to 90 °C Dew point temperature _{td} : -28 °C to 89.8 °C	1.0%	Measurement uncertainty expressed as
	> 30 % to 60 %		1.5%	Absolute value of relative humidity
	> 60% to 80%		2.0%	Humidity reference value is calculated from the dew point temperature and air flow temperature at the measurement point
	> 80% to 98%		2.5%	
Climate chambers with forced air circulation *)	5% to 30%	DKD-R 5-7:2018 Method A or B Air flow temperature: 10 °C to 90 °C Dew point temperature _{td} : -28 °C to 89.8 °C	1.5%	Measurement uncertainty expressed as
	> 30% to 60%		2.0%	Absolute value of relative humidity
	> 60% to 80%		2.5%	Humidity reference value is calculated from the dew point temperature and air flow temperature at the measurement point
	> 80% to 98%		3.0%	

On-site calibration

Calibration and measurement capabilities (CMC)				
Measurement variable / Calibration object	Measurement range / span	Measurement conditions / Methods	Expanded measurement uncertainty	Remarks
Volume flow rate <i>Q</i> of flowing gases Flow meter or controller with a display or	0.005 L/min to 0.03 L/min	Laminar flow elements as standard	0.3 mL/min	<i>Q</i> = measured value calibration medium dry air (relative humidity < 10%) Measuring ranges based on
	> 0.03 L/min to 200 L/min		$1 \cdot 10^{-2} \cdot Q$	
Transmitter with electronic Interface	> 200 L/min to 500 L/min	MFC as standard	$0.89 \cdot 10^{-2} \cdot Q + 0.52 \text{ L/min}$	to dry air of 0 °C, 1013.25 mbar

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Mechanical parameters – pressure

On-site calibration

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Remarks
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
Pressure Absolute pressure p_{abs} *)	> 0 bar to 21 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$5.0 \times 10^{-5} \times p_{abs} + 1.2 \text{ mbar} + U_{baro}$	Pressure medium: Gas The measurement uncertainty of the barometer U_{baro} must be taken into account.
	> 21 bar to 251 bar		$5.1 \times 10^{-5} \times p_{abs} + 30 \text{ mbar} + U_{baro}$	
Absolute pressure p_{abs} *)	1 bar; 2 bar to 71 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$7.8 \times 10^{-5} \times p_{abs} + 0.36 \text{ mbar} + U_{baro}$	Reference value: ($p_{abs} = p_{amb}$) Pressure medium: oil. The measurement uncertainty of the U_{baro} barometer must be taken into account.
	> 71 bar to 701 bar		$8.2 \times 10^{-5} \times p_{abs} + 0.72 \text{ mbar} + U_{baro}$	
Absolute pressure p_{abs}	900 mbar to 1100 mbar	esz QMH XXIII.4.2 v5.0	$2.9 \times 10^{-5} \times p_{abs} + 15 \mu\text{bar}$	Reference value: ($p_{abs} = p_{amb}$) Single-point measurement at current ambient
Absolute pressure p_{abs} *)	> 0 bar to 301 bar	DKD-R 6-1:2014 Calibration method: $p_{abs} = p_e + p_{amb}$	$5.1 \times 10^{-5} \times p_{abs} + 30 \text{ mbar}$	Pressure medium: Water The measurement uncertainty of the U_{baro} barometer must be taken into account.
	> 301 bar to 1001 bar		$7.4 \times 10^{-5} \times p_{abs} + 40 \text{ mbar}$	
Positive and negative overpressure p_e *)	-200 mbar to 200 mbar	DKD-R 6-1:2014	25 μbar	Pressure medium: Gas
	-1 bar to 2 bar		$3.3 \times 10^{-5} \times p_e + 0.25 \text{ mbar}$	
	> 2 bar to 20 bar		$4.3 \times 10^{-5} \times p_e + 0.61 \text{ mbar}$	
	> 20 bar to 100 bar		$9.0 \times 10^{-5} \times p_e + 3.7 \text{ mbar}$	
	> 100 bar to 300 bar		$5.1 \times 10^{-5} \times p_e + 30 \text{ mbar}$	
Gauge pressure p_e *)	0 bar; 1 bar to 70 bar	DKD-R 6-1:2014	$7.8 \times 10^{-5} \times p_e + 0.36 \text{ mbar}$	Reference value: ($p_e = 0 \text{ bar}$)
	> 70 bar to 700 bar		$8.2 \times 10^{-5} \times p_e + 0.72 \text{ mbar}$	Pressure medium: oil
Gauge pressure p_e *)	> 0 bar to 300 bar	DKD-R 6-1:2014	$5.1 \times 10^{-5} \times p_{abs} + 30 \text{ mbar}$	Pressure medium: water
	> 300 bar to 1000 bar		$7.4 \times 10^{-5} \times p_{abs} + 40 \text{ mbar}$	

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Mechanical quantities – Force

On-site calibration

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
Force Measuring instruments and transducers *)	50 N to 50 kN	Tensile and compressive force in accordance with DKD-R 3-3:2018	0.05%	

Mechanical quantities – Torque

On-site calibration

Measurement variable / Calibration	Calibration and measurement capabilities (CMC)			Comments
	Measurement range /	Measurement conditions /	Expanded measurement	
Torque Manually operated Torque - Screwdriving tools *)	0.2 N·m to < 1 N·m	DIN EN ISO 6789-2:2017	0.9 %	Torque Screwdrivers
	1 N·m to 10 N·m		0.5 %	
	0.4 N·m to < 4 N·m		0.7%	Torque wrench
	4 N·m to 1110 N·m		0.5%	
Torque Torque transducers in test benches	0 N·m to 100 N·m	AA0397 Version 1.0 (16 August 2023)	$0.001 \cdot M + 0.025 \text{ N·m}$	M: measured value in N·m Bending moments and transverse forces acting on the calibration device must be taken into account.
	> 100 N·m to 10 kN·m		$0.002 \cdot M + 0.050 \text{ N·m}$	

Mechanical measurement quantities – scales

On-site calibration

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measuring range / Measurement span	Measurement conditions / Method	Expanded measurement uncertainty	
Scales Non-automatic electronic scales *)	≤ 50 kg	EURAMET cg-18:2015 DKD-R 7-2:2018	$1 \cdot 10^{-5}$	With weights Accuracy class E2 according to OIML R111-1:2004
	≤ 150 kg		2×10^{-5}	

Mechanical measurement quantities – Measuring instruments in the automotive sector (MIK)

On-site calibration

Calibration and measurement capacities (CMC)

Measured quantity / Calibration object	Measurement range /	Measurement conditions /	Expanded measurement	Comments
Roller brake test benches	0 N up to < 2 kN	Traffic Bulletin 2016 Volume 14 No. 115	19 N	F: force displayed on the brake test bench Measurement system: force transducer with load frame
	2 kN to 4 kN		$0.46\% \cdot F + 7 \text{ N}$	
	> 4 kN to 8 kN		$0.43\% \cdot F + 8 \text{ N}$	
	> 8 kN to 40 kN	QMH Chapter XXVII.1.2: Version 5	$0.70\% \cdot F$	
	0 kN to 4 kN	Comparison method: XXVII.1.2.1 Mass-lever method: XXVII.1.2.2	$0.40\% \cdot F + 4 \text{ N}$	F: force displayed on the brake test bench
	> 4 kN to 8 kN		$0.65\% \cdot F$	Measurement system: Lever with mass blocks
	> 8 kN to 40 kN		$0.90\% \cdot F$	
Disc brake test benches	0 N up to < 2 kN	Traffic Bulletin 2016 Volume 14 No. 115	$0.20\% \cdot F + 12 \text{ N}$	F: force displayed on the brake test bench
	2 kN to 10 kN	QMH Chapter XXVII.1.2: Version 5	$0.70\% \cdot F + 2 \text{ N}$	Measurement system: Force transducer
Headlamp Adjustment Testers (SEP) Tilt	0% to 6%	Traffic Bulletin 2016 Volume 14, No. 115 Traffic Bulletin 2018 Volume 23, No. 174 QMH Chapter: XXIX. 3 Version 6.0	0.1%	Stating the measurement uncertainty as an absolute value of the slope
Installation surfaces for headlamp alignment test equipment (ASEP) Slope	0% to 10%	Traffic Bulletin 2018 Volume 23, No. 174 QMH Chapter: XXIX. 3 Version 6.0	0.038%	Statement of measurement uncertainty as an absolute value of the slope
Parking areas for motor vehicles Slope	0 m up to 10 m 0% to 10% up	Traffic Bulletin 2018 Volume 23, No. 174 QMH Chapter: XXIX. 3 Version 6.0	0.23 mm/m $+ 0.53 \text{ mm/L}$	Measuring system: Self- levelling line laser DIN 18202:2013
Flatness	0 mm to 50 mm		0.53 mm $+ 0.23 \text{ mm/m} \cdot R$	L: measured length in metres R: Grid point spacing in metres

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Mechanical measurement parameters – measuring instruments in the automotive sector (MIK)

On-site calibration

Measurement quantity / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / span	Measurement conditions / procedure	Expanded measurement uncertainty	
Exhaust gas analysers for spark-ignition engines Propane gas concentration C _{3H₈}	80 ppm vol 200 ppm vol 2000 ppm vol	Traffic Bulletin 2018, Issue 11, No. 100 QMH Chapter 26-7 XXX	2 ppm by volume 3 ppm vol 24 ppm vol	ppm vol = 10 ⁻⁶ · m ³ /m ³ % vol = 10 ⁻² · m ³ /m ³
Carbon dioxide CO ₂	3% vol 6% vol 14% vol		0.039% vol 0.072% vol 0.17% vol	
Carbon monoxide CO	0.1% vol 0.5% vol 3.5% vol		0.0039% vol 0.0070% vol 0.042% vol	
Oxygen O ₂	20.9% vol		0.31% vol	
Exhaust gas analysers for compression-ignition engines Opacity	10%; 30%; 50%; 70%		0.9%	
Turbidity coefficient	0.25 m ⁻¹	0.02 m ⁻¹	The turbidity coefficient is calculated from the turbidity level.	
	0.83 m ⁻¹	0.03 m ⁻¹		
	1.61 m ⁻¹	0.04 m ⁻¹		
	2.80 m ⁻¹	0.07 m ⁻¹		

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On-site calibration

Measurement variable / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measurement range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	
Exhaust gas analysers for compression-ignition engines	$5 \times 10^3 \text{ cm}^{-3}$ to $50 \times 10^3 \text{ cm}^{-3}$	AA0399 Version 1.0 Traffic Bulletin 2021 Issue 11, No. 133	20 %	The mean particle size must be in the range from 10 nm to 200 nm.
Particle number concentration				
Particle generators and measuring instruments (aerosol)	$> 50 \times 10^3 \text{ cm}^{-3}$ to $3 \times 10^6 \text{ cm}^{-3}$		13%	

Abbreviations used:

- AA Work instruction (in-house developed procedure) of esz AG
- CMC Calibration and measurement capabilities (calibration and measurement capabilities) DIN German Institute for Standardisation
- DKD-R Guideline of the German Calibration Service (DKD), issued by the Physikalisch-Technische Bundesanstalt
- EN European standard
- EURAMET European Association of National Metrology Institutes
- OIML International Organisation of Legal Metrology
- QMH Quality Management Manual (in-house procedure) of esz AG